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## International Conference on Industry, Engineering, and Management Systems

March 8-10, 2010

Dear Conference Participants:

It is with pleasure that we present to you the Proceedings of the 2010 International Conference on Industry, Engineering and Management Systems (IEMS). The papers presented this year were of consistently high quality in their respective fields. The papers cover a wide range of topics in the business and engineering disciplines, integrating concepts that further the mission of the IEMS Conference.

We present this Proceedings to you in the spirit of continuous improvement. Your comments and suggestions regarding the continued improvement of the Proceedings are always welcomed.

These proceedings would not have been made possible without the valuable contributions of our Track Chairs for the time and effort they spent reviewing all the papers; and for our Administrative Coordinator, Elki Issa, whose work behind the scenes helps make our Conference a success.

We look forward to seeing you at IEMS 2011!

Warm Regards,

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# Inventory Control of a Manufacturing/Remanufacturing System Using Neural Network

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## Abstract

This paper considers the inventory control problem for a single product stochastic manufacturing/remanufacturing system. The aim of this study is to characterize the optimal inventory policies for this recoverable system under several cost configurations and different lead time cases for manufacturing and remanufacturing operations. Characterizing a policy means to define the control parameters that describe the policy. In this study, a neural network is used in order to find the inventory policy characterizations. The proposed heuristic method is illustrated through a comprehensive numerical study. Results show that the policy characterizations provided by the neural network represent the optimal inventory policies very well, having only small deviations from optimal cost.

## 1. Introduction

In recent years, there has been a growing attention among manufacturers regarding the product recovery activities. Many manufacturers have started to take back their products from customers after their consumption due to either responsibilities stemming from environmental regulations or concerns, or the potential economical benefits that the product recovery may provide [1]. With product recovery, the considerable value incorporated in the used product is regained resulting in energy, material and labor savings. Reuse of products also

provides considerable savings in disposal costs that have increased significantly in recent years due to depletion of incineration and land filling capacities.

This paper considers the inventory control of a recoverable manufacturing system where remanufacturing is used to recover the returned products. Remanufacturing recovers the product as a whole, the resulting product being usually like-new product that has the same quality as a newly manufactured product. Examples of remanufacturable products include mostly high-value components such as aircraft or automobile engines, aviation equipment, medical equipment, copiers, computers, toner cartridges, cellular phones, single-use cameras, etc.

The production planning and inventory control of recoverable manufacturing systems are more difficult compared with the traditional manufacturing-only systems. When returns of goods and remanufacturing options have to be taken into consideration in inventory control situations, two additional sources of complexity appear. First, an additional stochastic impact has to be considered due to the uncertainty of the returns. Second, remanufacturing being a second supply of serviceable goods, the coordination with the regular model of procurement is required [1].

The challenges faced when dealing with returns in the context of production planning and inventory control have recently gained considerable attention in the literature. Two main approaches are observed in the literature

regarding the inventory control of stochastic manufacturing/remanufacturing systems. One, rarely used, approach is to investigate analytically the structure of the optimal control policy using dynamic programming approaches [2, 3]. A second approach is to find optimal or near-optimal values for the parameters of a predetermined control policy structure [4-10]. While the latter approach is widely used, it has the drawback of considering a pre-determined policy which is not guaranteed to be optimal, and to our knowledge, explicit numerical evaluation of these predetermined policies compared with the optimal policy has not been done.

Ahiska and King [11] recently considered the inventory control problem for a manufacturing/remanufacturing system with and without set up costs and different lead times for manufacturing and remanufacturing. By observing the optimal manufacturing and remanufacturing decisions found through Markov Decision Analysis for different cost scenarios, they suggested several robust, easily implementable inventory policy structures. They conclude that the existence of set up cost for either manufacturing or remanufacturing has a significant effect on the optimal policy structure. Hence, the appropriate policy structure for a recoverable system should be determined based on its set up cost structure.

This paper extends the work by Ahiska and King [11] by suggesting a neural network-based heuristic method to characterize the optimal inventory policies for this recoverable system under several cost configurations and different lead time cases for manufacturing and remanufacturing operations. Characterizing a policy means to define the control parameters that describe the policy. A neural network is used in order to find the inventory policy characterizations. The neural network can determine a functional relationship between the cost parameters of the system and the policy parameters, which enables quick computation of

the policy parameter values for new cost configurations of the system. The proposed heuristic method is illustrated through a comprehensive numerical study.

## 2. The manufacturing/remanufacturing system

This paper considers a one-product stochastic manufacturing/remanufacturing system, which is illustrated in figure 1. The system consists of two stocking points, recoverable inventory and serviceable inventory, and two supply modes, manufacturing and remanufacturing. Product demands as well as returns are stochastic. Returned products that join the recoverable inventory are considered for remanufacturing. Remanufactured products are considered as 'like new' items, which have the same quality and the same price as the new ones. Demand is satisfied from serviceable inventory, which includes newly manufactured items as well as remanufactured items. Backordering is allowed up to a certain level, beyond which unsatisfied demand is lost. Disposal of returned items is considered if, upon arrival, recoverable inventory is full. It is assumed that returned items that are not acceptable for remanufacturing are identified prior to inclusion in recoverable inventory.

We investigate the system under three lead time cases: the manufacturing lead time ( $l_p$ ) and the remanufacturing lead time ( $l_m$ ) are both one period in the first case. In the second and third cases, one has a one-period lead time and the other has a two-period lead time.

The inventory optimization problem for this system is defined as to find the optimal manufacturing and remanufacturing strategies that minimize the long run expected system cost per period. The total system cost consists of the fixed and variable manufacturing and remanufacturing cost, holding costs for serviceable and recoverable inventories, backordering, lost sales and disposal cost. In

order to find the optimal policy, the problem is formulated as a discrete-time Markov decision process (MDP) and solved using a variant of Howard’s policy iteration algorithm [12] that integrates the fixed successive approximation method [13] for computational efficiency. The MDP formulations for this problem can be found in [11].

### 3. Neural network and numerical experimentation

We investigate whether a neural network can provide good inventory policy characterizations for the recoverable system under different cost configurations and different lead time cases. A neural network is a technique that searches for a functional relationship between the input variables (i.e. the cost parameters of the system) and the output variables of the problem (i.e. the control parameters of the inventory policy).

For the experiments to illustrate the performance of the neural network, a factorial analysis is designed with five cost parameters: unit holding cost for serviceable items, unit holding cost for recoverable items, unit backordering cost, set up cost for manufacturing and set up cost for remanufacturing. These cost parameters have been previously found as relevant in affecting the optimal inventory policy [11]. For each cost parameter, three levels of value are considered, which are reported in table 1. The values of the other system parameters are kept fixed during the experiments, which can be found in table 2.

In this work, the neural net tool of the software SAS JMP 7 is used. The problem is modeled as a three-layer network: the input, hidden and output layers. The input layer includes five input nodes, which represent the following cost parameters, respectively: unit holding cost for serviceable items, unit holding cost for recoverable items, unit backordering cost, manufacturing set up cost and remanufacturing set up cost. The output layer

includes the output nodes, each representing a policy parameter, i.e.  $L$ ,  $S$ ,  $M$  or  $r$ . The hidden layer includes a number of hidden nodes that play a significant role in the performance of the neural network. The appropriate number of hidden nodes for the problem under consideration is not known a priori, but determined through experimentation [14].

Neural network analysis involves two main phases: training and testing. Training is the process of exposing the network to known results, i.e. to known policy characterizations under several cost configurations. The training data are used in order to determine the formulae (or functions) that calculate the policy parameter values using cost parameters. Testing is the process of evaluating the performance of the neural network, i.e. the quality of the prediction it provides for input/output pairs that are not used for training. In this phase, a policy for each testing scenario is found using the formulae determined in the training process. This policy is referred as the predicted policy, hereafter. Then, the quality of this predicted policy is evaluated.

The training and testing data that are used to feed the network and for performance evaluation purpose are created using the following MDP-based characterization technique: Initially, an appropriate policy structure for the scenario under consideration is determined considering the set up cost structure of the system. One shall note that in a recent study [11], the set up cost structure of the system is found to be the key factor in determining the appropriate policy structure for that system. The appropriate policy structures corresponding to different set up cost structures are reported in table 3. Refer to tables 4 and 5 for the definitions of the various policy structures. Then, the optimal inventory policy is found by solving the MDP model of the system, and an intelligent search procedure, which uses the optimal policy in finding the relevant ranges of policy parameter values, is employed in order to find a good policy characterization for the

system. One can refer to [15] for the details on the MDP-based characterization technique.

For the scenarios considered in the factorial analysis for three different lead time cases, i.e. 729 scenarios in total, the MDP-based characterization technique performed well. The cost of the policy found by this technique deviated from optimal cost by only 0.21% on average, and 1.64% at maximum.

The inventory policies found through the MDP-based characterization technique, which are used as the training and testing data for the neural network analysis, have one of the following six policy structures: the  $(L, M)$  policy, the  $(L, S, M)$  policy, the  $(L, M, r)$  policy, the  $L$  policy, the  $(L, S, M, r)$  policy and the  $(L, S)$  policy. It would not be efficient to perform the neural network analysis six times by classifying the data into six groups, each group having the same policy structure. Further, if we had classified them into so many groups, we would not have a sufficient number of data for both training and testing purposes in each group, and the performance of the neural network would be poor. Note that any of the six policy structures can be written either in the  $(L, S, M)$  policy format or the  $(L, S, M, r)$  policy format, with simple adjustments. Hence, in order to perform an efficient analysis, the scenarios are classified into two groups instead of six:

- Group 1 data includes all the scenarios for which  $S_M=0$  (i.e., 81 scenarios): the policies found for these scenarios are either an  $(L, S, M)$  policy or an  $(L, M)$  policy, which can be written in the  $(L, S, M)$  policy format by setting  $S=L$ .
- Group 2 data includes all the scenarios for which  $S_M>0$  (i.e., 162 scenarios): the policies found for these scenarios are either an  $(L, S, M, r)$  policy or a policy that can be generated from the  $(L, S, M, r)$  policy, such as the  $(L, M, r)$  policy (by setting  $S=L$ ), the  $(L, S)$  policy (by setting  $M=I_{min}$  and  $r=any$  value), or the  $L$  policy

(by setting  $S=L$ ,  $M=I_{min}$  and  $r=any$  value),  $I_{min}$  being the lowest value the inventory is allowed to take.

For each lead time case and for each group of data described above, the following steps of the neural network are performed [14]:

1. Start with a small number of hidden nodes.
2. Train and test the network, and calculate the performance measures.
3. Increase the number of nodes by 1 and repeat Step 2 until a desired or acceptable level of performance is achieved or no significant improvement is obtained.

Table 6 provides information regarding the quality of the predicted policies for each group of scenarios in each lead time case, separately. The primary performance criteria used to evaluate the performance are the maximum and average percentage deviations of the predicted policy cost from the cost of the best policy found by the MDP-based characterization technique. We compared the costs of the predicted policies to the costs of these policies, because these policies were used in the experiments in order to feed and test the network. On the other hand, as secondary performance criteria, the maximum and average percentage deviations from optimal cost are considered in order to see how far a predicted policy provided by the neural network is from the optimal policy.

As can be observed from Table 6, in each lead time case, for each group of data, the cost of the predicted policies deviated from the best cost found by the MDP-based characterization technique by 1% at maximum and the average deviation was within 0.11%. Further, the maximum and average deviations from optimal cost were less than 1.7% and 0.5%, respectively.

#### 4. Conclusion

This paper considers the inventory control problem of a recoverable manufacturing system

where customer demand is met through manufacturing of new items or remanufacturing of returned items. The aim of this study is to characterize the optimal inventory policies for this system under several cost configurations and different lead time cases for manufacturing and remanufacturing operations. In this study, a neural network heuristic is used in order to find the inventory policy characterizations. The neural network determines a functional relationship between the cost parameters of the system and the policy parameters, which enables quick computation of the policy parameter values for new cost configurations of the system. The training and testing data used to feed the network and for performance evaluation purpose are created using a Markov Decision Process-based characterization technique that is shown to provide near-optimal inventory policies, if not optimal. The proposed heuristic method is illustrated through numerical experiments. Results show that the policy characterizations provided by the neural network represent the optimal inventory policies very well, having only small deviations from optimal cost.

## 5. Acknowledgements

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dissertation, North Carolina State University, Raleigh, NC, 2008.

**Table 1. Cost parameters and their respective values considered in the experiments**

Cost parameters	Values (\$)		
Unit holding cost per period for serviceable inventory, $C_{HS}$	3	5	10
Unit holding cost per period for recoverable inventory, $C_{HR}$	1	3	5
Unit backordering cost per period, $C_{BO}$	5	15	25
Set up cost for manufacturing, $S_P$	0	50	100
Set up cost for remanufacturing, $S_M$	0	50	100

**Table 2. System parameters that are kept unchanged during the experiments**

Other system parameters	Value
Unit disposal cost, $C_{DISP}$	\$2
Unit lost sales cost, $C_{LS}$	\$30
Unit manufacturing cost, $C_P$	\$10
Unit remanufacturing cost, $C_M$	\$4
Serviceable inventory capacity, $I_{max}$	30 units
Maximum allowed backordered demand, $-I_{min}$	10 units
Recoverable inventory capacity, $J_{max}$	4 units
$P_{max}$ , manufacturing capacity	50 units
$M_{max}$ , remanufacturing capacity	20 units
Demand distribution	$P(D = d) = \begin{cases} \frac{d}{30} & \text{for } 1 \leq d \leq 5 \\ \frac{11-d}{30} & \text{for } 5 < d \leq 10 \\ 0 & \text{otherwise} \end{cases}$
Return distribution	$P(R = r) = \begin{cases} \frac{r+1}{9} & \text{for } 0 \leq r \leq 2 \\ \frac{5-r}{9} & \text{for } 2 < r \leq 4 \\ 0 & \text{otherwise} \end{cases}$

**Table 3. Appropriate policy structures with respect to set up cost structure of the system**

Class	Set up cost structure	Appropriate policy structures
1	$S_p=S_M=0$	$(L, M)$ policy
2	$S_p>0, S_M=0$	$(L, S, M)$ policy
3	$S_p=0, S_M>0$	$(L, M, r)$ policy, or $L$ policy (for relatively very high $S_M$ )
4	$S_p>0, S_M>0$	$(L, S, M, r)$ policy, or $(L, S)$ policy (for relatively very high $S_M$ )

**Table 4. The descriptions of the policy structures**

Policy Type	Policy Description*
$(L, M)$ policy	$m = \begin{cases} \min\{J_t, M - RIP_t^m\} & \text{for } RIP_t^m < M \\ 0 & \text{otherwise} \end{cases}, p = \begin{cases} L - RIP_t^p & \text{for } RIP_t^p < L \\ 0 & \text{otherwise} \end{cases}$
$(L, S, M)$ policy	$m = \begin{cases} \min\{J_t, M - RIP_t^m\} & \text{for } RIP_t^m < M \\ 0 & \text{otherwise} \end{cases}, p = \begin{cases} S - RIP_t^p & \text{for } RIP_t^p < L \\ 0 & \text{otherwise} \end{cases}$
$(L, M, r)$ policy	$m = \begin{cases} J_t & \text{for } RIP_t^m < M \text{ and } J_t \geq r \\ 0 & \text{otherwise} \end{cases}, p = \begin{cases} L - RIP_t^p & \text{for } RIP_t^p < L \\ 0 & \text{otherwise} \end{cases}$
$(L, S, M, r)$ policy	$m = \begin{cases} J_t & \text{for } RIP_t^m < M \text{ and } J_t \geq r \\ 0 & \text{otherwise} \end{cases}, p = \begin{cases} S - RIP_t^p & \text{for } RIP_t^p < L \\ 0 & \text{otherwise} \end{cases}$
$L$ policy	$m = 0, p = \begin{cases} L - RIP_t^p & \text{for } RIP_t^p < L \\ 0 & \text{otherwise} \end{cases}$
$(L, S)$ policy	$m = 0, p = \begin{cases} S - RIP_t^p & \text{for } RIP_t^p < L \\ 0 & \text{otherwise} \end{cases}$

\*  $I_t$  and  $J_t$  represent the serviceable and recoverable inventory level at the beginning of period  $t$ , respectively. The policy structures are not different for different lead time cases considered, but the relevant inventory position definitions for manufacturing and remanufacturing decisions are different. Here,  $RIP_t^p$  and  $RIP_t^m$  represent the relevant inventory positions for manufacturing and remanufacturing decisions for the current period  $t$ , respectively. The definitions of  $RIP_t^p$  and  $RIP_t^m$  under the three lead time cases considered in this paper are reported in Table 5.

**Table 5. The relevant inventory position definitions for manufacturing and remanufacturing decisions under different lead time cases**

Lead Time Cases	Relevant Inventory Position Information for*	
	Manufacturing Decision ( $RIP_t^p$ )	Remanufacturing Decision ( $RIP_t^m$ )
$l_m=l_p=1^a$	$I_t+m$	$I_t$
$l_m=2, l_p=1^b$	$I_t+Z_t$	$I_t+Z_t+p$
$l_m=1, l_p=2^a$	$I_t+Z_t+m$	$I_t+Z_t$

\*  $I_t$  and  $Z_t$  represent the serviceable inventory level and the work-in-process at the beginning of period  $t$ , respectively.

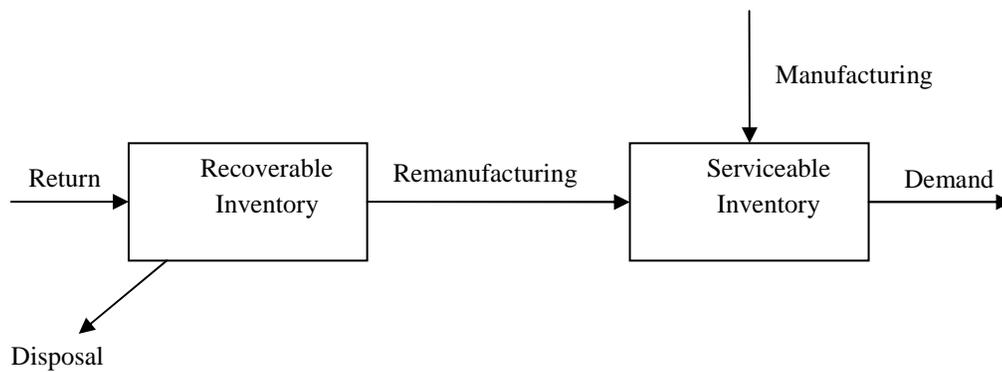
<sup>a</sup> remanufacturing decision ( $m$ ) is made first in this lead time case, <sup>b</sup> manufacturing decision ( $p$ ) is made first in this lead time case.

**Table 6. The performance of the neural network for each data group and lead time case**

Lead Time Case	Data Group No	Deviation from best cost <sup>a</sup> (%)		Deviation from optimal cost <sup>b</sup> (%)	
		max	average	max	average
$l_p=l_m=1$	Group 1	0.4142	0.0402	1.4558	0.2745
$l_p=l_m=1$	Group 2	0.1483	0.0162	1.6799	0.2919
$l_m=2, l_p=1$	Group 1	0.4455	0.0649	1.4846	0.2838
$l_m=2, l_p=1$	Group 2	0.9918	0.0864	1.0369	0.1625
$l_p=2, l_m=1$	Group 1	0.1573	0.0216	0.8267	0.2269
$l_p=2, l_m=1$	Group 2	0.8823	0.1045	1.2603	0.4331

<sup>a</sup> Best cost is the cost of the policy found by the MDP-based characterization technique.

<sup>b</sup> Optimal cost is the cost of the optimal policy found by solving the MDP model.



**Figure 1. The manufacturing/remanufacturing system**

# Force Depletion Mechanics as an Evaluation Tool for Mobile Agents

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## Abstract

We propose the use of force expenditure measurement to analyze mobile agent performance and network cost. This mechanism allows the ranking and optimization of agents with differing algorithms but similar goals, as well as detecting excessive replication, hung processes, and network anomalies.

## 1. Introduction

Mobile agents are a specific type of software agent. The term agent refers to an entity that performs a task on behalf of a user and exhibits characteristics such as autonomy, social ability, reactivity, and pro-activeness. Generally, agents reside in a construct referred to as an agency. [1] Mobile agents are all these things, but in addition have the capability to chose suspend execution and transfer themselves to another machine, while acting on behalf of an entity. [2] This choice is the chief distinguishing factor between mobile agents and other types of mobile code.

There are many advantages and disadvantages inherent to the concept of mobile agents. Advantages include a reduction in network traffic, asynchronous nature, adaptability, tolerance, reduced maintenance, portability, and scalability. Disadvantages include security, authentication, trust, efficiency, and complexity. Additionally, there are few standards for mobile agents, the recent Object Management Group (OMG) work on a Mobile Agent System Interoperability Facility (MASIF)

specification can be regarded as a step toward a unified distributed mobile object middleware, which enables technology and location transparent interactions between static and mobile objects [3]. In spite of that, there is no clearly dominate standard, nor are there any well known analysis tools. There is a strong need for a mechanism to evaluate and analyze mobile agents, in order to properly weigh the advantages and disadvantages they bring to a problem. Also, the ability to compare and evaluate agents without detailed by-line analysis would also be useful from a network administration point of view. Specifically, detecting broken, misbehaving, or simply overly expensive agents, for the purpose of resource regulation. This paper is organized as follows: in section 2 we discuss our proposed algorithm for evaluating agents, section 3 provides an interpretation of the values provided by our algorithm and results, and lastly we present our conclusions and future work in section 4.

## 2. Agent Force Algorithm

We propose the introduction of a 'force' concept to mobile agents. Force in this case is an abstraction of the cost of an agent performing various actions. Performance is defined as a ratio between force expended, and the agent's successes. This requires some notion of how successful the agent has been; with respect to a certain class of agents. That is, given two agents that are designed to gather weather data: each piece of data found might constitute a point, and

the act of returning the payload might constitute another point.

Force was defined above as the cost of actions. It is necessary to define a force cost for each action, and thus it is also possible to vary the force cost to emphasize certain actions which might be more expensive, or worrisome. An example might be replication; a potentially very expensive action with regards to network resources. Additionally, it is possible to further subdivide actions into computational and movement actions. Computational actions  $C(e)$  are those which do not require network communication or resources. Movement actions  $M(e)$  are those that do require network resources, such as movement, communication, or replication.

Node cost refers to the force expended on a network node over time. Formally it is defined as  $N(n) = M(n) + C(n)$ . In order to define Movement or Computational costs we first must define the term *Int*, which is an arbitrary interval of time. Additionally, *Count* refers to the number of intervals that elapsed during the measurement. Thus the total duration of the measurement could be defined approximately as

$$Int * Count.$$

Movement cost is defined as the sum of the movement force expended upon the node divided by the number of Intervals over which the count took place:

$$M(n) = \frac{\sum M(e, n)}{Count}$$

Similarly, computational cost is defined as the sum of the computational force:

$$C(n) = \frac{\sum C(e, n)}{Count}$$

Network force is the sum of all the node forces for the nodes that exist within the network:

$$Network(N) = \sum N(a, n)$$

Additionally, it is useful to measure just the movement costs of a network by:

$$NetworkMovementCost(N) = \sum M(n)$$

It is also possible to define these values with respect to agents. An agent's computational cost is given by:

$$C(a) = \frac{\sum C(e, a)}{Count}$$

While an agents movement cost is given by:

$$M(a) = \frac{\sum M(e, a)}{Count}$$

It is possible to compute an agent's performance by the formula

$$P(a) = \frac{\frac{S(a)}{Count}}{C(a) + M(a)}$$

where  $S(a)$  is the total number of successes for an agent, a user-defined variable.

The actual measurement of force depletion as follows:

1. Define interval Int
2. For N runs of Count(Int)=X
  - a. Sum all defined force costs
3. Divide the Sum of each cost measurement by N to provide an estimated value.

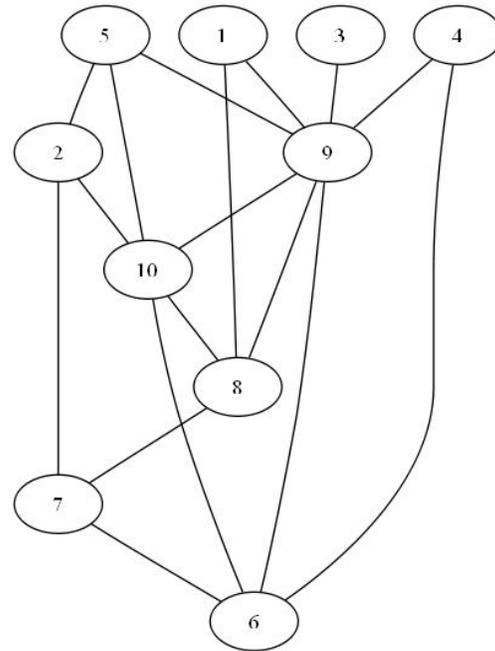
Once force costs are satisfactorily defined it is possible to measure them to provide averages. These averages can be used to analyze network data in real time. This can be done by first classifying agents into groups based on similar result and performance values. Then it is possible to have an estimated node cost for a given class of agents. Given this estimated node cost, if the average current node cost is significantly greater or lesser than the estimated, it might indicate that an agent should replicate itself. This significance can be defined in terms of a threshold value, over which replication is prudent. Thus it is theoretically possible for these values to factor into agent itinerary management.

### 3. Analysis

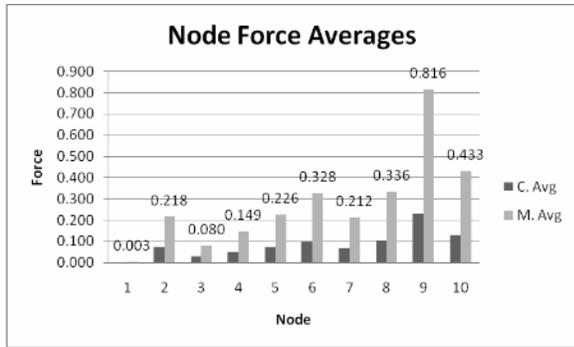
In this section some examples of how to interpret these measurements are presented. All measurements in this section were created by running agents in the mobile agent and network simulator known as Mobile Agent Simulator.[4] Slight modifications were made to the simulator for the purposes of measuring the values discussed in the preceding section. The agents run in this simulator are a variety of agents created for the purpose of network exploration.

The node force values computed above can be used to infer the topology of the network. That is to say, nodes with movement force values above the average might constitute bottlenecks, while nodes that fall below the average are indicative that they fall on the 'edges' of the graph. Similarly, the computational force of a node is indicative of its popularity or importance. Of course, this assumes that there are not issues related to the agents themselves creating this discrepancy, such as an agent stuck in an infinite loop or otherwise broken. The graph in Figure 1 depicts a small randomly generated network, while the bar graph in Table 1 shows the node force

measurements for this network. A few things of note about these results: for illustrative purposes this is a relatively tiny network, and the 'agents' in question were designed to explore the network until it was fully explored. Once fully explored, their behavior is not clearly defined, but would generally revolve around randomly visiting nodes. This likely explains the huge amount of force expended on node 9; in this network it is relatively easy to reach, and in randomly visiting nodes it would be easy to hit. This actually matches the assumption above; that excessive force expenditures might indicate an issue. The simplistic 'test' agents do not terminate, and should, so they could be said to be 'misbehaving.' Additionally, the values reported for node 1 are rather small. Again this is probably an artifact of the small network and population size; the rest of the measurements match the expected values.



**Figure 1: Graph representation of the network node force measurements (Table 1) were taken from.**



**Table 1: Node Force Averages for the network depicted in Figure 1.**

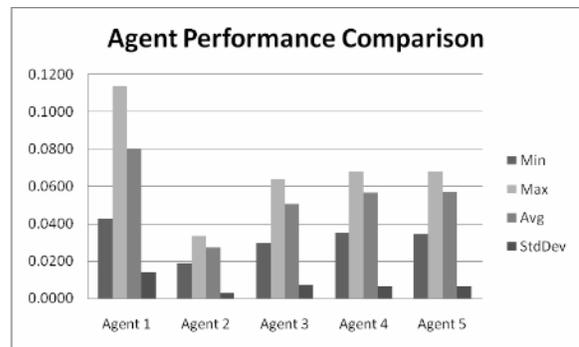
As mentioned above, agent performance can be calculated. Successes is user defined, but for the test corresponds to 'unique node visits'. The agents tested, types 1 through 5, are all designed for this purpose. The following table shows their average success rates over 1000 12 second trials on a randomly generated network of 100 nodes and 150 links. Agent type 1's performance is the poorest, and it is indeed the 'simplest' algorithm. If the trial duration had been longer, the performance differences would have been more dramatic, although even type 1 catches up eventually. The performance of Types 2 and 3 are fairly similar, while 4 and 5 are also fairly similar.



**Table 2: Average Success rate for agent types 1-5.**

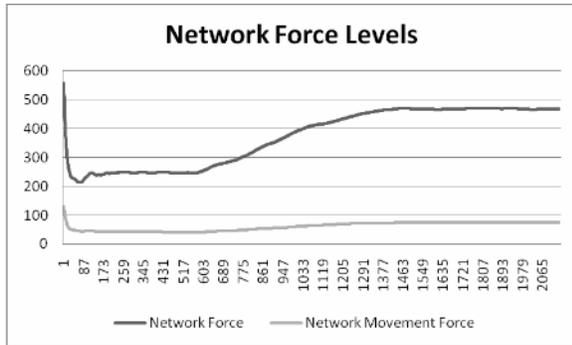
The following bar graph illustrates the performance values for the above agent types; measured over the same series of trials. This bar graph illustrates a pitfall of the performance calculation: the fact that algorithms can only be compared to algorithms that perform similarly, with any degree of meaningfulness. At first

glance, type 1 seems to be the most efficient; and indeed, it is. It is very simplistic, with minimal logic. This costs it in performance, in the long run. Comparing type 2 and type 3 agents, we see that type 2 agents perform practically the same, but much less efficiently than type 3 agents. Type 4 and 5 agents perform practically identically on both graphs, and this is not unexpected since they are very similar. Type 4 agents are a significant refinement in the algorithm of type 3 agents, and type 5 agents are a further, but obviously not terribly significant refinement of type 4 agents.

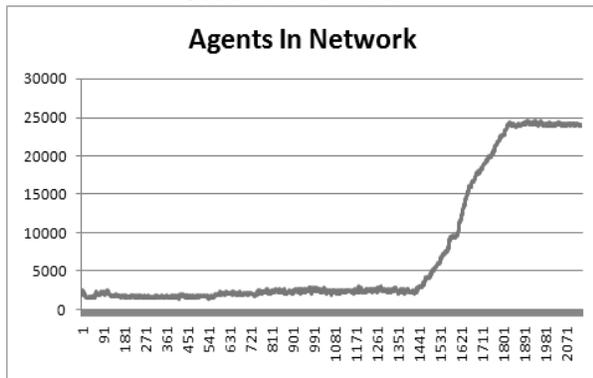


**Table 3: Performance comparison of agent types 1-5.**

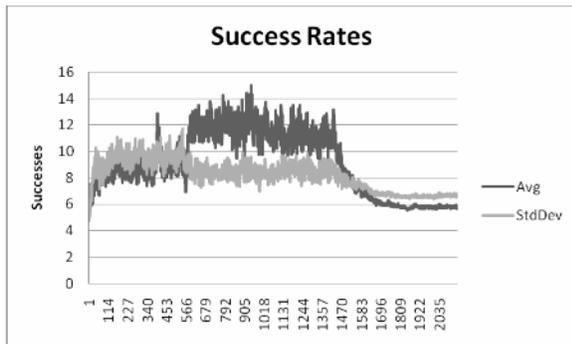
It is possible to distinguish between movement and computational force; and this might lead eventually to meaningful results such as the determination whether an agent's algorithm is processor bound or movement constrained. This is currently hampered by the difficulty of distinguishing between 'movement' actions and 'computational' actions. Many actions fall into a middle area; such as array operations. They might relate to itinerary management, such as a history of visited nodes, or to computational problems.



**Table 4: Network Force Levels over 2000 12 Second Intervals.**



**Table 5: Number of agents in network.**



**Table 6: Average success rate of agents in network.**

There remains one measurement that has not yet been discussed: network force. Network force can be considered the average force expended on the network as a whole. There is observational evidence, shown in the graph below, that indicates network force is usually stable, and only changes when the nature of the agents executing upon the network changes. This could

be indicative of a malfunction, nefarious behavior, or changing trends in network usage. The graph of the networks population shows that the actual numbers of agents did not affect the force; because the agents were using the network in practically the same way. The network force did change; however, and this is most likely related to the shift in the predominate algorithm present in the population, as illustrated by the change in the average success rate; thus, the network was being used differently.

#### 4. Conclusions

We have presented a mechanism to measure current agent performance, and estimate future performance; in addition to node and network performance. From the agent side of things, these estimates can be used to prevent uncontrolled replication via capping the maximum force used. Also, excessive force use might be indicative of hung network processes. To take a look at the network side of things, these measurements can be used to detect network anomalies, bottlenecks, or even as a quick abstraction of network topology. That is to say, to consider the network as a graph, the 'edges' of the graph, or nodes that are not trafficked heavily, will have considerably lower force costs than the 'inner' nodes. Also, nodes that experience dramatic dips or increases in force cost might be indicative of an anomaly in that area of the graph, such as a malfunctioning piece of hardware. Lastly, the above mentioned 'real-time' analysis could be used as a decision support system for agent algorithms; although this would need to be studied further.

There are some advantages and disadvantages associated with our approach. The advantages are that we provide a mechanism for measuring mobile agents; a decidedly nontrivial task due to network flux and the mobility aspect. This measurement can be thought of as an analogy to a "Big-O" value. Unfortunately, there are also some disadvantages to our approach. The values

worked with are measurements of past actions, and estimates of future actions. Due to this, they will never be completely accurate. Additionally, at best, these values represent a "snapshot" of the environment, and rapid network change can invalidate these values, leading to incorrect decisions.

There are some areas that we have failed to address due to time considerations and scope, but are nonetheless important. Firstly, the 'training' or measurement stage of our algorithm relies upon the assumption that processes do not hang or replicate uncontrollably or excessively. We provide no mechanism for detecting this at this time, although ideas do present themselves such as doing initial measurements in the absence of failure; such as in simulation, or simply by observation and culling invalid values from the sample population. Once these initial 'no failure' samples are completed, measure again while reintroducing failure and cap the samples at a percentage of the original values. An additional potential method would be clustering the samples to remove outliers, or other data mining techniques. More investigation into this is needed; and planned for the future. There is another major assumption in this work worth pointing out, and it is that the agents in question are actually capable of adequately performing their task. That is to say, as we define performance, it gives a measure of how 'efficient' in terms of resource usage to successes they were, but if their overall performance is poor, this might skew the results in their favor.

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## Yahoo v. Google: Usability Testing

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### Abstract

A usability study was conducted to identify usability strengths, weaknesses and recommendations for improvements for the websites Yahoo! and Google. This report discusses the usability testing of search engines Yahoo! and Google on ten test subjects, who were all university students and were ages 18 or over, to determine if the tasks asked of the test subjects were reasonable in the sense that they were simple and memorable. Each participant was given general instructions of the test, a consent form, a pre-survey to determine their demographics and skill level of using Yahoo! and Google, the survey giving out instructions for each of the tasks and a post-survey to provide feedback of the search engines and any other comment they had pertaining towards the test. This usability study tested for email use, search results of texts, images, and videos for each search engine, and the differences of the interface of each site. Each participant was under observation of the experimenter that maintained an observation log consisting of time keeping of each subject for each task. The average testing time for subjects was fifteen minutes. The results of this study are presented along with a heuristic evaluation of each search engine which was conducted by the researchers.

### Introduction

Technology has continuously been changing and improving since the dawn of time. In our time, we (meaning our generation) have grown quite accustomed to the computer age. In this age, people were introduced to modern technology into their everyday lives. As the computer technology has evolved, with the vast use of the internet, many people wanted an easier and more convenient way to discover information desired with the click of a mouse.

Thus, the introduction of websites, search engines and email systems emerged.

A usability study was conducted because the experimenters wanted to know how the participants interacted with the search engines, Yahoo! and Google. The test measured the length of time to do specific tasks geared towards the study and also provided the users to make comments and give useful feedback, whether it was positive or negative and give recommendations to improve the search engines usability. This study contained seven users who were between the ages of 18 and 35. All of the participants were Florida Tech students consisting of different education levels of undergraduates and graduates and different educational backgrounds ranging from business to engineering majors. The two websites that were the focus of the study were [www.yahoo.com](http://www.yahoo.com) and [www.google.com](http://www.google.com). Each participant was given a pre-survey to determine demographics and level of familiarity of the websites being tested, instructions on each task to perform on these websites, and a post-survey along with a debriefing session to gain feedback from each participant. The results are presented along with the heuristics evaluation for each search engine.

### Literature Review

#### Usability Testing

With nearly any product or service provided with the user in mind, it is always essential for the designer to think of his users and their own abilities. A designer has to take into account that not all users are the same. For instance, with the diverse set of user skills, he would have to think about what motivates users to choose one site or feature over another [10]?

If a user finds a site too difficult to use at their skill level, cannot find the desired result, product or service, then the user will typically leave the site [10]. This means that it is a necessity for the designer to conduct usability tests for their users [12] so that they can have a design that accommodates and thus pleases the user. Therefore, the designer must think about what disabilities a user may have first and then accommodate the user so that their device is more usable (creating a variety of options for the search engine's interface) (i.e. if a user has a visual, tactile or hearing disability or if there is a language barrier)[13]. When conducting these tests the designer must know about usability. "Usability is the most traditional concept of study in human-computer interaction (HCI) research" [10]. "Usability has been defined as the measure of the quality of a user's experience when interacting with a product or system..." [10]; this refers to the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [12]. Thus, web usability can be defined as making the design simple enough so that goal-driven users can achieve their task as quickly and painlessly as possible [10]. "Usability testing is a core skill because it is the principal means of finding out whether a system meets its intended purpose. All other skills that we deploy or cultivate, aim to make usability (and, ultimately, use) successful" [7]. With usability testing it is pertinent to prepare by understanding the collection of interacting and interdependent parts that are organized to meet some purpose in other words, a system [7]. Additionally, by planning out the tasks for the participants and the collection of data used to gather the test's results. Next, it's important to present the information to the user by explaining the content and context of the test and also it is significant to establish a good rapport with the user so they feel comfortable during the study. Most

importantly, allow the user to verbalize their feedback as they perform the tasks so that the experimenter can have a better understanding of the participant's thoughts and could gain even more feedback from the test. Lastly, always acknowledge and thank the user for their time and contribution towards the study and provide them with follow-up information towards the system tested so that they know that their feedback and comments were greatly appreciated.

### **Search Engines**

Since the dawn of man, people have always tried to provide order and structure to their everyday lives and surroundings. The use and design of search engines proves that it is only human nature to organize categories of data to be easily and readily found by any user in front of a computer screen. With the help of a friendly user interface and hypermedia features of the web, this has attracted a significant number of users as well as providers and as a result, the web has acquired infinite amounts of data, thus causing more than two dozen companies and institutions to quickly act on finding a design to solve mass data overload and to set up an organized structure to find, retrieve and display data from users queries [8]. There are several different human computer interaction case studies that have been tested, studied and evaluated focused on the usability of websites and search engines. "...the web has gained popularity and become the second most widely used application of the internet...The publicity web has gained is so great that many people naively equate it with the internet" [8]. As noted from the study, one of the major occupations of internet users is to gather information from the World Wide Web by using search engines and in a web usage survey conducted in 2000 it estimated that 300 million users frequently used the internet to search for information using search engines [4]. First, let's look at the core

definition of a search engine. “A search engine is a web application that gathers information items from the web according to different strategies (using crawlers or spiders) and then performs the basic retrieval task, the acceptance of a query, a comparison of the query with each of the records in a database, and the production of a retrieval set as output”[4]. Next, understanding the mechanism of how a search engine works is beneficial. “The creators of each search engine try to develop mechanisms that would allow their search engine to work more efficiently than others and, thus, make it more popular among the users. However, there are some general rules that apply to the way every search engine works” [4]. There are three general rules or main tasks that are performed in every search engine. First, it searches web pages available and stores information about them. Second, it indexes the retrieved information found and creates a database from the data. The data is arranged in order of relevance to the users input. Lastly, it allows the user to search its database through an interface providing search facilities and options the user can use at his discretion [4].

### **Background of Companies**

It is important to consider the history of these search engines’ companies and look at where they were and are now according to their purpose. First, let’s look at Yahoo!’s history and purpose as a search engine and company. Yahoo! was founded in 1994 by David Filo and Jerry Yang. Yahoo!’s main goal and purpose in the mid 90s was a networking and global communications site. Yahoo! was a catalogue style tool [8]. Yahoo! Inc. mission states, “Yahoo! powers and delights our communities of users, advertisers, and publishers - all of us united in creating indispensable experiences, and fueled by trust”[13]. Yahoo! has developed the way of communication between people and has established a relationship and partnership

amongst nonprofit organizations to assist those in need. Yahoo! has also worked on improving some of their features such as the storage capacity of their email system known as Yahoo! Mail to 100MB. Yahoo! has also worked alongside Plaxo, an online address book and social networking service that embeds and integrates Yahoo! Search in Microsoft’s Outlook and Outlook Express [6].

Next, it is also pertinent to look at Google’s history and purpose as a company and what goals they want to achieve. Google was founded in 1998 by Larry Page and Sergey Brin. Google’s mission states, “Google’s mission is to organize the world’s information and make it universally accessible and useful” [3]. Google was intended to be an actual search engine. The founders even built Google based on the play of words googol, which is the mathematical term for a 1 followed by 100 zeros. This name reflects the immense volume of information that is in existence and encompasses the scope of Google’s purpose [3]. Google has also tried to enhance its search engine by having its mail system contain a capacity of 1GB and adding Google Groups to compete alongside Yahoo! Groups. Google has also opened up to the notion of allowing advertisements via AdSense through third-party websites, thus making Google more graphical like Yahoo! [6].

Overall, it is quite clear that Yahoo! is trying to be more like Google as a search engine and Google is trying to be more like Yahoo! by using more networks. In the past year, Yahoo! has “cleaned up” its appearance to resemble Google in the sense of being more of a search engine. Search is a core component to companies’ financial status, stability and revenue [6]. One analyst, Michael Zeman stated, “Yahoo! stands for content and Google stands for search” [11]. He also said that research has shown little to no difference in the demographics of users to both websites [11].

## Methodology

In order to conduct this study in a proper manner, all of the measures had to be planned and thought out in advance before the actual experiment could occur. A ten step process was made for the experiment so everything would run as expected and smoothly. Step 1: Selecting a technology to test. This was an easy, yet very thoughtful step since it was important to keep in mind the parameters of the potential participants being tested and also the prior knowledge the experimenters have of this technology. Step 2: Gathering all documents for the IRB form to present to the university's research committee. These documents included information on how the experiment would be conducted, consent forms signed by the experimenters stating and qualifying that none of the test subjects would be harmed, and samples of pre-survey data to be collected and tested. Once these documents were approved, it was simple to perform all of the following steps. Step 3: Making up all of the questions for the surveys and giving instructions for the tasks in the test were documented. There were several different types of questions that were in the surveys due to finding different information from each participant. The Likert scale and Semantic Differential scale were used to determine a measure for the participant's answer to certain opinion-based questions, while other questions only needed a yes/no response. Step 4: Running the test on experimenters to measure the amount of time to perform out all of the tasks along with being able to determine the difficulty of those tasks to figure out if some tasks could be altered before the actual experiment runs on the participants. Step 5: Running a pilot test to debug and troubleshoot any errors found within the experiment. This helps determine what parts need amendment due to incorrect questions, level of difficulty of tasks, and the length of the whole experiment, which should run for 15 to 20 minutes for each

participant. Step 6: If flaws are found in the experiment, editing and revising took place to correct those mistakes, so that the test would have clarity for both the tester and the participant. Step 7: Afterwards run the tests again to make sure all mistakes are corrected. Step 8: Recruit the participants for the test. Step 9: Give general information about the test so that the participants are cohesive and committed to the study in addition to them knowing everything about the purpose of the study and how it will be conducted so that they are aware. It is important to have people who fit the parameters of the research study not only according to the University's research committee, but also to the nature of the study. Additionally, it is imperative to the study to have participants who will dedicate themselves to the study in order to have accurate results from the data. Step 10: Run the experiment to collect data from the research study and receive feedback from all of the users being tested in the study to attain knowledge in order to analyze the results from the test this was done through the survey and post-survey in the study.

## Results

It was discovered that all of the participants had some knowledge and degree level of each of the search engines, Yahoo! and Google and each of their email systems from looking at figure 1 and figure 2. The participants were all college students and this group consisted of 8 undergraduate students and 2 graduate student and 6 males and 4 females.

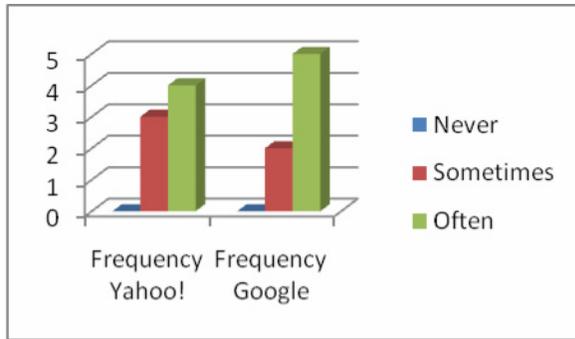


Figure 1: Number of Participants Frequency of Using Yahoo! And Google Search Engines

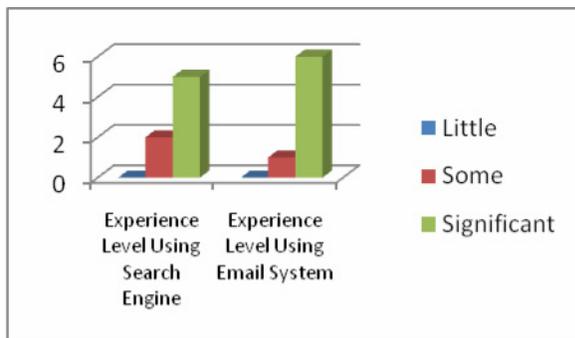


Figure 2: Number of Participants Experience Level of Using Search Engines and Email Systems

The participants consisted of different ethnicities. In this case, they were 10% Hispanic, 30% Middle Eastern, 40% Caucasian and 20% African American. Each student was tested in his natural environment, his own home and computer. Some of the participants were savvy enough with the subject being tested, that they used their own email names instead of the designated email written in the survey. Table 1: displays the percentage of the participants that liked or disliked the specific usability features of Yahoo! and Google.

Table 1: Percent of Participants That Liked or Disliked Specific Usability Features

Usability Feature	Yahoo! Like (Percent of participants that liked a specific usability feature)	Google Like (Percent of participants that liked a specific usability feature)
Color used on the website	100%	86%
Font used on the website	100%	86%
Page Layout of the search screen	100%	86%
Layout of the available information	100%	57%
Ease of using the website	100%	86%
Website consistency from one screen to another	100%	100%
Feedback message given to users	100%	100%
Amount of information the user is given about the requested information	100%	86%
Amount of information the users are required to remember on their own from using the website	100%	86%
Amount of control the user feels they have on the website	86%	86%

The data gathered shows whether or not the user agreed or disagreed about the specific usability features and organizes the comments of each participant about their likes and dislikes of each search engine, Yahoo! and Google. All of the feedback, comments, recommendations and

suggestions that were received from the users were acknowledged in this study. One participant gave their opinion and recommendation for Yahoo! saying that they should minimize the use of icons on the homepage. Some participants had more to critique about Google. Another participant said, "Google should put in more search options and use more icons to make the searching experience easier". Two participants agreed that the email system in Google needs improvement so that it is easier for the users.

100% of the participants agreed about Yahoo!'s and Google's usability features pertaining towards the website design to prevent user error and also that these websites permitted easy reversal of any action they performed for any task. 71% of the participants gave feedback consisting of comments and recommendations of their likes and dislikes for each search engine.

For Yahoo! they said that they liked the homepage's interface, email system, variety of entertainment choices, and its overall simplicity of appearance and use. Although most of the participants had provided positive feedback, there was also some negative feedback from 29% of the participants. They said that they did not like the homepage because it had too many features and icons and they did not like the results for searches in this search engine. Yet, 43% of the participants did not find anything negative about Yahoo! 1 participant provided a recommendation that Yahoo! should have less icons for their homepage.

Next the positive and negative feedback for Google was considered. The participants said that they liked Google for its simple use, ease of searching and browsing for information, the mapping and navigation system, and the email system. However, 71% of the participants had criticism towards Google compared to Yahoo! They disliked the interface of the

homepage and the hidden icons and the management of the email system. 3 of the participants recommended that Google should display their icons on the homepage, improve their email system to provide more ease for the user.

## **Conclusion**

This study was performed to determine the usability of the search engines Yahoo! and Google. This study consisted of seven random participants to perform three different sets of tasks pertaining to the websites. Their demographics were noted and analyses were conducted to determine the length of time, the interface of the sites, and the ease of use for each search engine. This exercise identified what features were favorable and unfavorable to each participant. In addition, it was necessary to look into the background of usability and the companies that developed these search engines to know their true identity and purpose and to see what each site thought was important to them and their clientele. Google's stance was strong in primarily being a true search engine and having infinite information for their users to find. Later on, they realized that many users were not only interested in searches, but also in having contacts within on site for the convenience. Yahoo!'s interests were different in the sense that they marketed towards clientele that wanted to have contacts and networks. Only afterwards, they were interested in searches to compete with Google's popularity.

It is obvious from the table and figures that the majority of the participants primarily used Google, yet they enjoyed Yahoo!'s features much more than Google's. From some of the recommendations and background information on the companies, it was quiet interesting to read that the complaints about Yahoo! had to do with having better search results in comparison to

Google and that Google was too simplistic with their interface in contrast to Yahoo!'s homepage.

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## A Longitudinal Statistical Analysis of the U.S. Health Care System and Associated Costs

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### Abstract

The current environment of health care in the United States is quite complex and dynamic. Over recent years, the spending in health care has increased significantly. Several variables including death and aging, nationalized healthcare, insurance policies, insurance company fraud, and the pharmaceutical industry, etc., all contribute to the rising costs that face each and every one of us today. Given the economic turmoil over the past few years, along with federal proposals for improved care for all, this issue is at the forefront of the public eye. As inflation occurs consistently, the costs associated with healthcare do as well, yet the reasons for such are vast. In this paper, we examine the major drivers of healthcare cost via both qualitative and quantitative analyses. The data analysis was conducted between the years of 1960 and 2007. A statistical evaluation of trends may lend themselves to better planning and reforming in the future.

### 1. Introduction and Literature Review

A country's health care system is the foundation of its standard of living. It is designed to meet a country's population health care needs. Ultimately, it involves a country's resources, organizations, and institutions whose purpose is to improve the

health of its people. Even though health care systems around the world have the same function, all of the factors involved in them can vary tremendously from one country to another. In some countries, the health care systems are heavily supported by government funding, whereas others countries put the financial burden on the public. Reasons for the differences are whether a country has the capability and resources to maintain an efficient health care system.

Moreover, a country's health care system is a mirror of its history, economic development, and political structure [12][1]. The design of any country's health-care system involves political, medical, and economic decisions [17][18]. But the primary issue for any health-care system is a moral question: Should a rich society provide health care to everyone who needs it? If a nation answers yes to that question, it will build a health-care system like the ones in Britain, Germany, Canada, France, and Japan, where everybody is covered. If a nation decides not to provide universal coverage, then the nation is likely to end up with a system where some people get the finest medical care on Earth in the finest hospitals, and tens of thousands of others are left to die for lack of care. Without the moral commitment, in other words, you end up with a flawed system.

According to Vasishtha [24], access to health care and health-care costs top the list of the most urgent health-care problems facing the country. Each year, in its annual Health and Healthcare Poll, Gallup asks respondents to name the "most urgent health problem facing this country at the present time." For the last seven years, and eight of the last nine years, either health-care costs or health-care access has topped the list. These two issues have been first or second on the list for the last six years. It is these systematic factors, rather than specific medical conditions that require immediate attention.

Although the nation's health care problem is extremely complex, most of the reform plans presented to Congress attack it on only one or two fronts [15]. Enduring reform must cover the uninsured, reduce inefficiency in funding and delivery of care, improve quality, and tame but not destroy the development of new medical technologies. In the long run, major reform is inevitable [8]. Also, public confidence in a major reform proposal must be won, and congressional support must be garnered, even if the election is a landslide. Insisting on universal coverage as a precondition may undercut the ability to enact other policies needed to improve the health system. Excessive regulation and price controls are likely to exacerbate underlying problems [2].

In line with Zonies [26], primary care doctors can save health care in the United States, but only if the United States saves primary care. Three serious problems confront the country at this time: Lack of accessibility for all people; uncontrollably rising costs; widely variable quality of care. At the same time, primary care practices are declining in number, suffering financial strangulation and sliding into irrelevancy.

Barr [3] provided an overview of the history of health-related public-private

partnerships during the past 20 years and described a research protocol commissioned by the World Health Organization to evaluate the effectiveness of public-private partnerships in a research context. However, other scholars [10] [25] emphasized that insight into the concerns and attitudes of health care consumers is invaluable information for developing a new plan design, launching communication strategies, planning incentive programs, and recognizing disparities in employer/employee perceptions.

The purpose of our paper is to explore the major drivers of healthcare cost via both qualitative and quantitative analyses. A statistical evaluation of trends may lead us to better planning and reforming in the future.

## 2. Qualitative Analysis

In addition to running many regression analyses in order to identify the potential factors that have more influences over the health care expenditures in the U.S., we applied qualitative analysis to pinpoint the same relevant factors.

### 2.1. Aging & Death

Certainly, aging and death are a big piece in today's health care world. And these factors cannot be ignored or overlooked.

#### Aging

Aging in America has increased over the years. More Americans are living longer than usual. Reasons for the increase in aging are because of today's medical technology, more advanced medications, and higher education levels. Also people are more aware of health risks and are taking better care of themselves. More people are eating healthier and are staying active during their every day routine.

Huang [11] observed that as the baby boomers reach their retirement, the number of Americans over 65 will be more than doubled, from 34.8 million in 2000 to 70.3 million in 2030. According to the Fact Sheet on Aging in America [7], Americans reaching the age of 65 today have an average life expectancy of an extra 17.9 years. The additional years for females are 19.2 and 16.3 for males. The Fact Sheet also states that chances of an American reaching the age of 90 has doubled over the last 40 years. As time goes on, more than likely the United States will continue to improve our health care system. With that said, life expectancy should continue to grow year after year.

### **Death**

One major issue in dealing with death is infant mortality. There are five main reasons of infant mortality: congenital defects, preterm birth and low birth weight, sudden infant death syndrome, maternal complications of pregnancy, and complications of the umbilical cord, placenta, and membranes. The infant mortality rate has continued to increase over recent years. "In 1990 the United States was ranked 23<sup>rd</sup> in infant mortality, 29<sup>th</sup> in 2004 and 30<sup>th</sup> in 2005. Almost seven infants die for every 1,000 born in America. Singapore, Sweden, Hong Kong, and Japan rate 2.1 and 2.8 infant deaths per 1,000" [9].

Premature birth is a very big factor in America's infant mortality. One in eight babies in the United States is born too soon [16]. It also states that premature birth is the main reason our nation's infant mortality rate is higher than that of most other major industrialized nations around the globe. There are numerous reasons for preterm birth. Some possible reasons are pregnancy with multiple babies, smoking, drinking or using drugs during pregnancy, poor nutrition, stress, and maternal obesity [21].

## **2.2. Insurance Practices**

### **Medicare and Medicaid**

Medicare and Medicaid are two programs that are designed to make the lives of people easier. Those who cannot afford health insurance and those who are older and lack the income that is required for Americans to get adequate healthcare. There are many advantages to Medicare and Medicaid. They make the lives of so many people so much better and allow people to live normal lives without the worry of one day getting hurt or sick. Just the ability to not worry about these things makes living a lot easier for most people. It is a fact that most people would be able to sleep better with the knowledge that they can get help from doctors if help was ever needed. This extra sleep may be responsible for keeping these people healthy.

With all the benefits that Medicare creates for people it also makes available a great playground for criminals. These are people who love to break the law and steal countless amounts of money that is extremely important in supporting the elderly and allowing them to continue to maintain healthy lifestyles in the United States. The criminals are becoming more and more able to steal large amounts of money from these paid Medicare benefits each year. It is estimated that Medicare fraud totals about \$23.2 billion in 2008 [6] or up to \$60 billion in 2009 [19].

It is considered one of the most profitable crimes in America. The biggest problem with Medicare fraud is that it is a quiet crime which allows it to continually fly under the radar with the American people. The only ones who are being affected by this crime are the American tax payers who for the most part do not even know it is happening in the first place. In southern Florida Medicare crime is said to be the worst crime of all. In recent years it

has even overcome the amount of crime that has surrounded cocaine problems in this area.

A disadvantage in the Medicare package is the amount of people living up to the age of 65 and older. This takes a toll on the amount of benefit available for each individual person. With the numbers of people using this plan increasing while the working world of people who are paying for the benefit package continues to stay the same, it causes a problem for the benefit availability. But as the baby boomer generation retires, it is anticipated that Medicare spending will continue to grow an average of 7.4 percent annually from 2011 to 2019 [23]. This causes a great frustration with those who are available to use the plan and those who are working and paying for it. It is predicted that with the problem that the increased number of people living to the age of 65 or older, there will be not enough money produced to sustain this plan for years to come. Therefore those who are paying for the Medicare Benefit package now may not reap the benefits of it when they get to their age of retirement in the future. This is a major concern for most people, understandably so.

In part as a result of rising life expectancy, but mainly as a result of the aging of the baby boom, the number of Medicare beneficiaries is expected to rise from around 39 million (14 percent of the U.S. population) today to around 77 million (22 percent) by. For all of these reasons, Medicare spending is expected to increase substantially in the absence of reform, by some estimates rising to around 5 or 6 percent of GDP and one-third of the federal budget by 2030 [13].

### **2.3. Health Insurance Fraud**

Insurance fraud is a widespread costly problem to the United States health-care programs. Health insurance fraud is

defined by intentionally misrepresenting, deceiving, or concealing information to the insurance group to seek extra revenues. Insurance fraud can be committed by any individual, such as the insurance subscriber, the physician, or a fake insurance provider by simple moves that can go undetected if not closely looked at or reviewed. Insurance fraud should be reported to help America decrease the loss of dollar amounts, and be more aware of the situation. Fraudulent activities affect everyone in the health-care programs, because the amount of money lost can help America offer more insurance to families unable to receive any for their families.

Health insurance fraud can be committed by anyone that has the proper information. A research indicates that card members and physicians are most likely to commit this crime [6]. Insurance subscribers contribute to insurance fraud by providing their information to family members to receive medical attention. A family member will pretend to be the subscriber, and receive the care they need at the cost of the health-care program. Physicians have a greater range in committing fraud, because they state all the procedures and tests that were completed and bill the insurance company. Doctors commit health insurance fraud by billing insurance companies for medical procedures that were never done, adding on different medicines that were never used, performing unnecessary medical procedures for financial gain, or stating tests or procedures that were never performed.

Corresponding to Serota [20], health care fraud is a dangerous and expensive crime. The national cost tops \$85 billion a year and is a burden borne by all - employers, workers and tax payers - in the form of higher health insurance premiums, out-of-pocket costs and tax dollars. Moreover, every dollar stolen by a con artist

is a dollar not available for emergency services, life-saving treatments, drugs, medical research and other vital health care services. Fraud is not only a crime, but also a major danger to the health and safety of consumers. It undermines the public trust in the medical community.

Over the years, insurance scams have been committed, not only by card members and unreliable physicians, but also by fake insurance companies. The cons go after small size businesses, elderly people, lower income families, and minority groups ("Phony Health Coverage"). The con artists behind the fraudulent companies pose as reliable trustworthy individuals that will help and serve a person to receive health insurance. However, the promises made never go through and the end results are always bad [22].

#### **2.4. Pharmaceuticals**

The pharmaceutical industry is one which must be examined in respect to the ever rising costs of health care in the United States. One needs not look far to see the effects these large multinational companies have on individuals' lives every day. Often the approach that is taken by these companies, many of which are multinational, is that consumers must absorb many of the costs pertaining to the long and grueling process from product development through the final phase of clinical trials. With more and more stringent controls by the FDA, as lawsuits are on the rise (for instance, Vioxx), the costs associated with product development are on the rise. Additionally, with new technologies, which have great potential to ward off symptoms of many diseases and even cure many, there is a premium incurred by those in need. An important factor to remember is that those who have debilitating conditions, are often unable to work and in turn have a reduced income (dictated by social security, and

Medicare or Medicaid) and are usually the ones for whom the most expensive pharmaceuticals are intended. According to studies performed, as the cost of medicines increases by a little as a dollar, many users who struggle financially may decide to no longer fill the prescription, regardless of the impact it may have [5]. Other drugs, such as those used to treat more virulent strains of cancer are often so expensive and become reserved for those with the best insurance coverage or deep pockets. One such company is GlaxoSmithKline which has an anticancer drug called Arzerra, which it \$98,000 for only a six month supply [14].

While it would be foolish for the large pharmaceutical companies to disclose precisely how much each drug development cost is, the trend in general can lead us to infer that they are rising. While generics are much more cost effective, it is not until after a patent runs its course, usually ten years. At that point it may be too late for those who had the need long ago to recover.

### **3. Quantitative Analysis**

In order to understand what influences health care expenditures in the US, we have conducted a series of regression analysis. The reason for us to choose a mature methodology is due to the complexity of the confronted problem.

First of all, we observed national health care expenditure per capita amount and discovered a huge jump from \$148 in 1960 to \$7,421 in 2007 [Appendix]. However, absolute number has less meaning compared with relative number due to the differences in nation, economic structure, policy changes, etc. Nonetheless, this model considered an obvious fact since the population in US has increased dramatically during the same time period.

In order to find a reasonable and meaningful comparison with other industrialized countries, we focused on the

healthcare spending related in percentage of GDP. The U.S. has committed a higher share of GDP to health care over the last half-century. In the United States, which has had both a high level of health spending per capita and a relatively high rate of real growth in that spending, the share of GDP devoted to health grew from 5.2% of GDP in 1960 to 17.3% of GDP in 2009 [23].

Then, we switched our attention to inflation-adjusted overall health care expenditures in order to draw an overall picture. The result is really alarming since the increase in health care expenditure in the US is beyond anyone's imagination: Starting at \$27.50 billion in 1960 and hitting \$2,241.20 billion in 2007.

For instance, a multiple regression was conducted to examine the potential main health care expenditure drivers. Certainly, health care spending is our main target. The independent variables are private spending, structures and equipment, durable medical equipment, research, number of beds available, Growth in 65+ Population. Appendix provides coefficient estimates for and other relevant parameters. The high t-values and low p-values indicate a convincing relationship.

Furthermore, Multicollinearity is a common barrier for running a complicated regression analysis. The regression coefficients can lose their meaning since it is not possible to "hold the other variables constant." We screened potential collinear set of independent variables and removed a few predictor variables from the regression equation in the follow-up marginal t analysis in order to decrease *Variance Inflationary Factor*, a standard test, down to  $VIF_j \leq 5$ .

We have conducted regular *Inflation-adjusted Time Series*, *Difference Time Series*, and *Moving-Average Time Series* with two-period, three-period, five-period, seven-period, ten-period respectively. Only *Difference Time Series* are not statistically

significant due a low t-Stat (0.6242) and a high p-value (0.5357).

Our results show that medical advances are the most important independent variable affecting healthcare spending. A domino effect is obvious, where new equipment and technology is needed to arrive at the next level in research with new breakthroughs that will require even more funds. Increased spending on medical advances (product of research and medical equipment) will also result in improved health. Though a counter argument states as follows, at times the marginal cost of newer equipment might not always be justifiable when there are cheaper alternatives available.

Better health care provided by technological and medical advances will increase life expectancy. An increase in life expectancy combined with the enormous size of the "baby boom" generation will also strongly affect spending since there are now more people to take care of, who also need more care due to their age.

The chart labeled "Population age 65+" clearly shows the increase of our senior population. This specific independent variable has showed a remarkable growth of 137% in the time period from 1960-2009. Naturally such large growth will require more spending. We found that the independent variable of the specific age group of 65+ is statistically significant in the way that if all other variables were held at a constant, this variable will affect spending. This interesting target was run in a regression model. Separate models were run to fully analyze and to avoid co-linearity.

We felt that more seniors now are choosing to receive their care in a hospital vs. having in home treatment. This will impact spending on Structures & Equipment due to the fact that more beds and more of everything will be needed to accommodate the increase in patients. The number of

hospital beds available would influence the relationship between the quality of health received versus expenditure across countries. However, to our surprise, the number of hospital beds available shows a decrease from 1,658,000 (1960) to 945,000 (2007). The number of admissions at the same period was increased from 25,027,000 to 37,120,000. Taking this into consideration along with the population growth, it seems that the healthcare industry has become more efficient at healing more people. The cause of the efficiency is advances of medical technology and shorter stays for routine operations.

The baby boom generation has lived a longer and enjoyed a higher standard of living than ever. It has been known to this generation that the results of increased spending in medical technology are apparent and therefore it is in their best interest to contribute more funds to adding years to their life. As GDP has increased similarly has the percentage of spending of GDP. Healthcare spending has been a cornerstone for policymakers.

#### **4. Conclusion**

The current healthcare system in the United States is not sustainable. There are currently about 46.3 million Americans without any health coverage whatsoever along with millions of others who are inadequately covered. As one of the leading nations and the super power in the world, clearly this is unacceptable. There is much we can conclude from the research and regression analysis from all of the various parts of health care. An obvious conclusion is that the United States is drastically increasing the annual change of health care in our nation's GDP, increasing from 5.2% in 1960 to much more than tripling to 17.3% in 2009. National health care expenditures are skyrocketing and will continue to go up

and will reach record highs almost every year.

Certainly, due to these skyrocketing expenditures comes advancements in the medical world that are resulting in a longer life expectancy rate for both females and males alike. Although there is a serious problem, which could be the reason life expectancy rates are not going up even higher, it is that the number of uninsured Americans is increasing also. Not only increasing, but is also predicted to continue to increase due to poverty levels going up, costs going up, and basically the overall effect that the economy has had to the lower and middle classes of the United States. This leads to these uninsured Americans having to pay loads more out-of-pocket payments for health care, even more specifically hospital care because most uninsured people would try and stay away from medical care unless it is an emergency.

Another reached conclusion is the decreasing infant mortality rate and its factors. Infant mortality rates are higher among the poverty stricken Americans, as well as the smoking population of Americans. But overall Infant mortality rates are typically going down per year, but not fast enough and a bit behind schedule.

Also, it is concluded that Medicare and Medicaid expenditures, as well as costs are going up on an annual basis. There are many factors as to why these two are increasing such as the baby boomers aging into the Medicare coverage ages, fraudulent charges taking away billions from the system, inflation, and the charging of deductibles to patients and in some cases a monthly premium.

As with every other controversial government issues there are lingering myths that skew people's rational thinking. Healthcare reform is no exception. Both the opponents and proponents of healthcare are at odds creating distorted views, which has

been confusing the general public about the validity of the plan. However, many of the myths hold no truth at all [4].

As explained, the realm of health care and the costs associated with such are quite high and are vital to the national and in turn the world economy. With a changing workforce and population ages shifting, it is feasible to think that costs will continue to rise at an alarming rate, and statistical evaluation of trends may lend us to better planning in the future.

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# Relating White Papers using Word Frequency and Clustering

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## Abstract

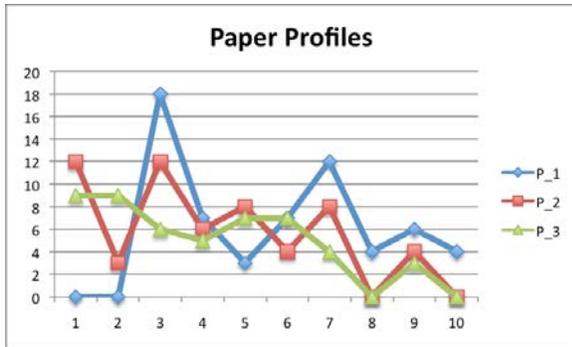
Relating information is a key, if not primary, function of many search engines. The ability to locate information may be secondary to providing results that are logically connected in some way. Locating data within the World Wide Web (WWW) can be a simple process but associating the data can be a daunting task. Metadata provides a simple approach for building these relationships using explicit keywords. In metadata, the keywords are provided by the publisher and hopefully represent the general subject of the document. Using these keywords it is easy to relate documents. In this paper we propose a technique for relating information using word frequencies not explicit keywords. Our approach uses clustering to relate papers based upon the frequency of words that occur in the body of the document. We are not proposing a new clustering algorithm or trying to determine the subject of the paper, but instead are suggesting an alternative approach to representing the information and making relationships between the documents. Our premise, given a document with a defined subject, a word or group of words will occur within the document that represent the subject of the document. Additionally, these words will likely occur with a greater frequency than other words. We shall discuss the motivation, implementation and results of our approach.

## 1. Introduction

In this paper, we discuss an approach to associating white papers using data clustering for the purpose of augmentation of search results. The intent is to cluster or classify, and thereby associate, white papers stored in a paper repository. For example, the Institute of Electrical and Electronic Engineers (IEEE) has a vast repository of white papers on many subjects that are available to members via a web portal. These papers have explicit keywords assigned by the author and are categorized based upon topic. The proposed system could be used to cluster the papers in the repository and after a user search, could then recommend other papers that are not explicitly linked. This approach would allow implicit association versus explicit keyword association.

For this implementation, a data mining tool called Weka is used to provide the clustering functions. Weka is a collection of Java based tools developed by the University of Waikato and available for download. It is open source and issued under the GNU GPL [1].

A learning algorithm called Simple K Means is provided by Weka and used to cluster the papers. In simple K means, data is clustered



**Figure 1. Word Frequency Profiles**

using an iterative process. First, “K” number of data centroids is chosen either randomly or by using random samples of the input data. These K centroids ultimately result in K clusters or groups. Then each input object, in our case papers, is assigned to the group that has the nearest centroid. After assigning all the objects, the data centroids are recalculated. This process of assignment and recalculation continues until the centroids no longer move when recalculated.

Clustering cannot be directly performed using the text inputs and therefore the documents are converted into vectors. The vectors are a series numbers representing the weighted frequency of word occurrences within the paper. Each position or index into the vector is associated with a specific word in the global dictionary. Assuming  $P$  papers are processed, the papers are then represented by a collection of  $P$  multidimensional vectors each containing  $N$  values, where  $N$  is the number of words contained in the global dictionary. The construction of the global dictionary is discussed in section 2. For simplicity, each vector can be visualized as a profile of values and Figure 1. illustrates  $P=3$ ,  $N=10$  data profiles. The final data set contains  $P=86$ ,  $N=407$ .

## 2. Preprocessing of Input Papers

The algorithm uses a global dictionary that is constructed based upon the words that occur in the input papers. This global dictionary is

required since one weighting will be applied to the word frequencies and the length of the global dictionary. The raw weight is just the occurrence frequency of the word divided by the length of the input paper (total words before any reductions are applied) while the modified weight is the raw weight divided by the length of the global dictionary.

For the algorithm we established two configurable parameters. The first is called minimum support and is defined as the minimum number of occurrences a word must have to be considered for addition to the global dictionary. The second parameter is the maximum words per paper. This parameter minimizes the dimensionality of the resultant vector ``establishes the upper limit to the number of words a paper can contribute to the global dictionary. Minimum support has the highest precedence. For instance, even if a paper has not contributed its maximum number of words the minimum support will exclude low frequency words and the paper will contribute less than the maximum words allowed.

The input documents must be preprocessed to remove spurious information not needed for the clustering algorithm. The test document repository contained Adobe portable document files (pdf). By converting to the ASCII text format, all graphics and special formatting are removed and was completed using the Linux command **pdf2txt**. Additionally, conversion from MicroSoft® Word doc format was accomplished using **antiword** both commands were executed within bash scripts. Finally, punctuation, numbers and special characters are removed using a series of string replacements and regular expression matching.

Since the algorithm clusters the papers based upon word frequency, many words are too common to be considered and should be excluded. If the most common words in the English language were considered in the clustering, all the papers would have common

attributes. For example, allowing “the” to remain in the papers would introduce erroneous clusters since all papers would contain “the” with a frequency that would rank near the top. A frequently occurring word list was created and then used to remove those words from the input papers.

Each word occurrence within an input paper is then counted and stored in an intermediate file. During the counting process, the frequencies are stored in a hash data structure where the word was the index and the frequency was the data. The intermediate file is required since the global dictionary has not been created and therefore word weights cannot be calculated.

Using the minimum support and the maximum words per paper parameters, the algorithm creates a global dictionary. Upon completion, the global dictionary contains all the unique words that are contributed by all the papers. Each paper can contribute the maximum number of words if each word has at least minimum support occurrence frequency. If a word already exists in the global dictionary, the current paper cannot add it again. In this case, number of words contributed by the current paper is incremented to avoid over representation of any specific paper.

After accumulating the occurrence frequencies for each paper, the final step is to construct a data file that can be imported into Weka. Each word becomes an attribute and each attribute has a weight. The definition is “@attribute word real” where “real” is the datatype for the attribute. After all the attributes are defined, a list of comma-delimited values is added, one per paper, representing the calculated weights for the associated word. These lists are the associated vectors for the papers. The resulting file is saved as a “.arff” file that can be used by Weka.

### 3. Results

For the test execution, eighty-four (84) papers were collected for the repository. To avoid the obligation of reading them to establish relationships, control papers were introduced. The control papers were two (2) strongly related papers with a financial subject while the remaining papers were in the construction domain.

After preprocessing the repository, a global dictionary of four hundred and seven (407) words was established. The clustering algorithm was executed using  $K = 1, 2, 6,$  and  $10$  with both weighting schemes. Obviously, given one cluster all the papers were clustered together. Using higher values of  $K$  caused a fracturing of the cluster representing the construction papers while in all cases the control papers remained clustered together. Qualitative analysis of the results was not performed other than as noted and quantitative analysis was not performed. Examining the attributes of each cluster and noting the financial papers were clustered together determined the results.

### 4. Limitations and Future Work

There are a few limitations in the current implementation. All of these limitations are easily overcome and should be considered for future work. First, word roots and plurals are considered separate words. Second, contractions are considered to be distinct words. Two possible solutions exist for this problem: expand the contractions or delete them. Third, preprocessing of the papers is a multi-step process that is not completed by a single program. This allows for user error in processing that can introduce anomalies. Fourth,  $K$  is set statically and must be *a priori* execution and is a limitation of Simple  $K$  means. Fifth, to add a new paper to a dataset that is clustered, the complete dataset must be re-clustered. Sixth, the number of words contributed by each paper must be minimized to prevent very large

dimensionality and increased computational complexity. Seventh, after all the papers are clustered, there is no way to determine which cluster holds which paper without manually looking at the attributes of the cluster and comparing to the raw paper data.

These limitations are relatively easy to overcome with the exception of the problem of high dimensionality. Alternative clustering algorithms exist to handle high dimensional data such as hypergraph partitioning or grid based clustering but implementation of the algorithms is not trivial. Simple K means clustering is sensitive to dimensions and therefore may need to be replaced in a production environment.

As stated, all of the enumerated limitations should be considered for future work. Additionally, more in-depth research into creating a dataset with documented relationships should be considered. Ideally, a data set with explicit relationships should be established that could then be used to omit the need for control papers. This addition will be time consuming since each paper in the repository will need to be read and classified.

## 5. Conclusion

In this paper an alternative view of text data has been presented. Using this alternate view, we illustrate an approach to classify the data contained in white papers in an unsupervised manner. By converting the text data to numerical vectors, we can then apply standard clustering techniques to classify the papers. Although limitations exist, most defined limitations are surmountable. Even though the approach is not perfect, it does provide a possible path to successful classification with minimal user interaction, which was one of our goals.

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## A Study on the Implementation of a Novel Entrepreneurial Training Services Program

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### Abstract

Novel approaches to university and community collaboration are increasing across the U.S. in a national push for achieving higher rates of success in launching, sustaining, and growing small businesses. One such approach, the Entrepreneurial Training Services (ETS) program, is being studied by a university as a means of promoting regional economic development and job creation [1]. The ETS program, piloted in 2009, emphasizes an intensive training approach implemented in a short time frame. Clients are fully entrenched in aspects of business development with the objective of completing a business plan. Clients voluntarily utilize mentoring resources for personalized assistance in completing their business plans. This paper focuses on the relationship between measurable outcomes, in the form of number of training seminar and mentoring hours, and the number of business plan presentations and completions. The paper concludes with lessons learned for future ETS programs.

### 1. Introduction

*Individuals, whether they are working in an existing organization or unemployed at the time of their discovery, are the entities that discover opportunities [2].*

The United States views small businesses as the backbone of America and integral in the recovery of any economic downturn. According to Minniti and Bygrave[3], the U.S. has achieved its highest economic performance during the last 10 years by fostering and

promoting entrepreneurial activity. In 2005, the small business population in the U.S. consists of some 6 million employer firms and 20 million nonemployer firms<sup>i</sup> [4].

Table 1 summarizes the importance of small businesses on the U.S. economy [5]. It is seen that small businesses have a significant impact on local job creation, economic growth, product and service development, and much more.

**Table 1: Impact of Small Businesses**

Represent 99.7% of all employer firms.
Employ just over half of private sector employees.
Pay 44% of total U.S. private payroll.
Generated 64% of net new jobs over past 15 years.
Create more than half of the nonfarm private gross domestic product (GDP).
Hire 40% of high tech workers.
Comprise 52% home-based and 2% franchise businesses.
Made up 97.3% of all identified exporters and produced 30.2% of known export value in FY 2007.
Produced 13 times more patents per employee than large patenting firms.

Entrepreneurship is a driving force in the U.S. economy particularly in terms of technology innovation and creation. According to CHI Research, Inc. [6], small firms on average produce more highly-cited patents than large firms and small firm innovation is twice as closely linked to scientific research as large firm

innovation. Reynolds, Hay, and Camp [7] state that about two-thirds of all new inventions are created by smaller companies.

Entrepreneurial companies enable women, minorities, those with disabilities, veterans, and immigrants the opportunity for economic success. Kuratko [8] quotes from the US Small Business Administration [9], "Entrepreneurship plays the crucial and indispensable role of providing the "social glue" that binds together both high-tech and "Main Street" activities".

Kuratko and Hodgetts [10] further explain that entrepreneurship is the essential mechanism by which millions enter the economic and social mainstream of our global society. Entrepreneurial ventures enable millions of people to access the "entrepreneurial dream." The greatest source of economic strength remains the entrepreneurial pursuit of economic growth, equal opportunity, and upward mobility.

## 2. Background

*"Higher education is the means by which a skilled workforce is produced and the source of new knowledge capital and, thus, economic growth and advances in society, for the benefit of both the individual and the collective" [11].*

Today, there is major push in the U.S. for research collaboration between universities and entrepreneurs to innovate and bring to market new products and technologies. Increasingly, universities are developing programs that take advantage of community and government resources for fostering such partnerships. State and federal funding initiatives, such as the American Recovery and Reinvestment Act (ARRA) 2009, offer unprecedented opportunities for universities to connect with entrepreneurs for research innovation, technology transfer, and new business development. Traditional funding sources, such as provided by the U.S. Department of Commerce's University Center for Economic Development and the U.S. Small Business

Administration's Small Business Development Centers, Women's Business Centers, U.S. Export Assistance Centers, and Veteran's Business Outreach Centers; help connect academic institutions and local constituencies in support of nascent entrepreneurs and small businesses. Currently in the U.S., there are 54 funded University Centers for Economic Development. There are 63 Small Business Development Centers (SBDCs), as posted on the SBA.gov locator web site. Almost 90% of the listed SBDC's are affiliated with universities or communities colleges.

Coduras et al. [12] point out that education and training are considered to be some of the main factors in fostering entrepreneurship given that knowledge is an instrument to graduated entrepreneurs in creating initiatives with more possibilities to survive and grow. Furthermore, they state that universities, as facilitators of contemporary knowledge, are fundamental catalysts for regional economic and social development. As a result, the role of universities as organisms delivering potential entrepreneurs to society is becoming very relevant.

Entrepreneurs have started seeking out university resources such as offered through educational programs, new venture laboratories, and business development centers. The Kauffman Foundation, in its study of the anatomy of an entrepreneur, found that entrepreneurs considered a lack of business skills as a risk factor in new business development. Of those surveyed, "89% said business management skills, 84% said knowledge of how to start a business, and 83% said knowledge about the industry and markets were important issues [13, p.6]." University programs on entrepreneurship are demonstrating that business development skills can be taught and small businesses supported through resource offerings, collaboration, and networking ([14]; [15]).

Our ETS program is focused on reducing perceived risks associated with a lack of business development knowledge by offering nascent entrepreneurs an intensive training program supplemented with technical assistance services. We consider the program a facilitator of knowledge, acting as a catalyst for new business development. Long-term measurable outcomes, associated with the ETS program, include both business creation and job creation.

This paper presents data findings from the initial offering of the ETS program. Our objective is to identify areas for improvement for the next launching of the ETS program. A secondary objective is to identify areas for future study in advancing the field of entrepreneurship.

**3. Initial Offering of the ETS Program**

The ETS framework, shown in Figure 1, has entrepreneurial workshops, training seminars, and mentoring services all of which guide a client through the business planning process. Networking events bring together entrepreneurs, business experts, mentors, and small businesses for collaboration and information sharing. External partnerships, with both profit and nonprofit organizations, minimize the duplication of technical assistance services offered to nascent entrepreneurs. Tools and technologies support clients in building business networks and promoting lifelong learning.

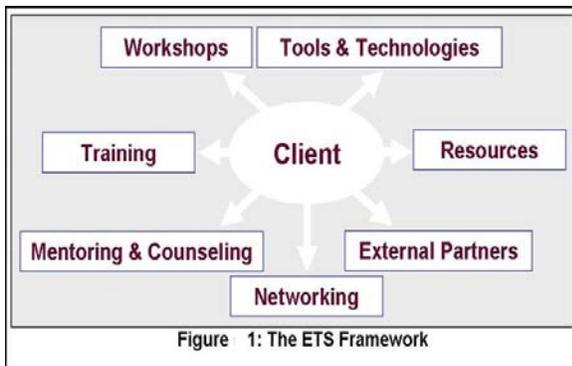


Table 2 briefly summarizes each element in the ETS program. Though not covered in this

paper, important research identifies personality traits, talents, and interests as playing a role in whether an individual pursues a career path in entrepreneurship. As such, the ETS workshops offer a client the opportunity to assess his or her talents before further participation in training and mentoring activities. The training seminars focus on the exploration of a business opportunity via the business planning process. Each client receives intensive training on business plan components inclusive of market planning, customer service and sales, financials, company formation, and human resources and operations. Throughout, each client has available mentoring services to further explore a business opportunity in the completion of a business plan.

**Table 2: ETS Program Elements**

<i>Workshops</i> - Client explores a career roadmap to entrepreneurship.
<i>Training</i> - Client learns basics of business development; completes a business plan; and has it reviewed by a panel of experts.
<i>Mentoring</i> - Client meets with mentor for business development guidance. Client may also receive expert guidance in related areas (e.g., legal, intellectual property).
<i>Networking</i> - Client participates in networking events for support and lifelong learning.

Throughout the ETS program, a client is exposed to successful entrepreneurs, small business resources, networking events, and educational offerings. The overall objective is for the entrepreneur to have the knowledge, resources, and tools necessary for launching a small business and further sustaining and growing it.

A concluding activity in the ETS program is the client’s presentation of his or her business plan to a review panel of successful entrepreneurs, business area experts, and business faculty. This step provides feedback to the client in support of making a “go” or “no go” decision to launch a business. It also prepares a client for effective business plan presentations to

various funding sources including financial institutions, venture capital, and angel investors.

**4. Data Analysis**

The initial program took place over a four month time period in the fall of 2009. Seventy-five clients participated in training and mentoring services. There were a total of seven training seminars offered as a series in support of the business planning process. The series started with an overview of the business planning process and concluded with preparation for presenting a business plan to a review panel.

Each training seminar was offered on a weekday from 5 pm to 8 pm, and in a facility located near the targeted population. The seminar series, offered as a cohort, was followed by a two week break in preparation for business plan presentations. Each client was encouraged to submit a completed business plan for review as a final activity in the business planning process.

**Table 3: Training Seminar Attendance**

Number of Seminars Attended	Number of Clients	Percent of Total Attendance
7/7	16	21.3%
6/7	24	32.0%
5/7	10	13.3%
4/7	11	14.7%
3/7	8	10.7%
2/7	4	5.3%
1/7	2	2.7%
Total:	75	100.0%

Table 3 shows attendance data associated with the training seminar series. The table shows that though less than 25% of clients attending all of the training seminars, over half attended most or all of the training seminars. About two-thirds attended five or more. Only a small percentage (8%) attended less than one-third of the training seminars.

Attendance at times was impacted by client work schedules. Clients typically worked full

time with work days ending before 5 pm. Over the course of the ETS program, several clients reported missing a seminar due to mandatory overtime. Several other clients reported missing a seminar due to an unpredicted work event that overlapped the seminar meeting time.

**Table 4: Attendance Percentages**

Training Seminar	Topic Area	Number of Attendees	Percent
1	Business Plan Overview	70	18%
2	Marketing, Sales, Customer Service	58	15%
3	Marketing Plan	62	16%
4	Financials	57	15%
5	Business Operations	55	14%
6	Business Administration	54	14%
7	Business Plan Completion	28	7%
Total:		384	100%

Table 4 shows the number and percentage of clients attending each seminar in the series. The data shows close to an 18% drop in attendance after the first training seminar. This data includes clients dropping out due to entrepreneurship not being a viable career path and clients failing to identify a business idea to be pursued as a business opportunity. Thereafter, seminar attendance had a relatively consistent, significantly smaller drop-off rate. The average after the third seminar was an attrition rate of 4%. Much of the attrition is attributed to clients making a “no go” decision for business startup. Several clients reported that after doing some market research, their business opportunity no longer appeared to be a viable one.

A significant drop is shown for the final seminar in the series (almost 50% reduction in attendance). This seminar covered presenting and completing a business plan. Some of the low attendance is attributed to clients reporting they were not far enough along in completing their

business plans; anxious about presenting to a review panel; and uncertain about or had made a “no-go” decision about business startup.

Each client was afforded up to four mentoring hours during the course of the program, though this was later revised to allow for additional hours on an “as needed” basis. Table 5 shows a total of 163 mentor hours utilized by the 75 clients in the ETS program. In general, the average number of mentor hours declined as the attendance rate declined. This seems to reflect fewer clients utilized mentoring services when a “no-go” decision was made for business startup.

**Table 5: Mentor Hours By Attendance Category**

Number of Seminars Attended	Total & Percent of Mentor Hours (Rounded)	
	Total	Percent
7/7	49	30%
6/7	49	29%
5/7	25	15%
4/7	20	13%
3/7	14	9%
2/7	0	0%
1/7	6	4%
<b>TOTAL:</b>	<b>163</b>	<b>100%</b>

Table 5 shows that most of the mentoring services were utilized by clients with high rates of training seminar attendance. Close to 60% of the mentor hours were used by approximately half of the clients all of whom attended six or seven of the training seminars.

Those attending less than half of the training seminars utilized only 13% of mentor services. This percentage would be much lower; however, if the two clients attending a single training seminar (bottom category) were not included as data points. One of these clients partnered with two other clients, each having a high training seminar attendance rate.

Table 6 shows the average, maximum, and standard deviation data for client use of mentor services. The table shows that the average

number of mentor hours for all categories was less than the four hour allocation per client. A significant number of clients averaged between two and three mentoring hours over the course of the program. However, there was variability in mentor hours used; as reflected in the standard deviation and maximum hours per client. For the categories of four to six seminars attended, the variability was most pronounced. This reflected clients in preparation for business plan presentation utilizing a higher percentage of mentor hours than those not presenting a business plan.

**Table 6: Statistics for Mentor Hours per Training Seminars Attended**

No. of Seminars Attended	Avg Mentor Hrs/Client	Maximum Mentor Hrs/Client	Standard Deviation
7/7	3.0	5.7	1.40
6/7	2.0	7.3	1.74
5/7	2.5	8.0	2.26
4/7	1.9	6.3	1.66
3/7	1.8	3.2	1.04
2/7	0.0	0.0	0.00
1/7	3.0	3.0	0.00

**Table 7: Business Plan Data by Attendance Category**

No. of Seminars Attended	% of Business Plans Presented	% of Business Plans Completed
7/7	30%	22%
6/7	37%	45%
5/7	15%	33%
4/7	7%	0%
3/7	7%	0%
2/7	0%	0%
1/7	4%	0%

Overall, 36% of the clients presented business plans; and twelve percent of the clients submitted completed business plans. Table 7 presents further information about business plan presentations and completions by clients in the ETS program. The table shows over 80% of business plans presented were by clients attending five or more training seminars. Those

attending less than half of the training seminars comprised only 18% of total presentations. (This percentage would be lower by discounting the client reported as attending only one training seminar while partnering with others.) Table 7 also shows the percentage distribution of business plan completions, as submitted for review by a panel of experts. All business plan submissions were by clients attending five or more training seminars.

**Table 8: Business Plan Presentations, Completions, & Percent of Mentor Services**

No. of Seminars Attended	% of Business Plans Presented	% of Business Plans Completed	Mentor Hours
7/7	30%	22%	30%
6/7	37%	45%	29%
5/7	15%	33%	16%
4/7	7%	0%	13%
3/7	7%	0%	9%
2/7	0%	0%	0%
1/7	4%	0%	4%

Table 8 shows the percentages of business plan presentations, completions, and mentor services utilized for each attendance category. Those attending six or seven training seminars accounted for two-thirds of business plans presented and completed. They also used close to 60% of mentoring services provided. Those attending five or fewer training seminars had a significantly lower percentage of business plan presentations, completions, and mentoring services used.

**Table 9: Percent Change in Business Plan Presentations, Completions, Mentor Services by Training Seminar Attendance Category<sup>ii</sup>**

No. of Seminars Attended	% of Business Plans Presented	% of Business Plans Completed	Mentor Hours
7 to 6	+23%	+100%	-3%
6 to 5	- 60%	-27%	-45%
5 to 4	-53%	-33%	-19%
4 to 3	0%	0%	-31%
3 to 2	7%	0%	9%

Table 9 shows a reduction in business plan presentations and completions in terms of percentage change from one category to another. The likelihood of presenting a business plan, shown in the table, drops significantly for each additional seminar missed.

Several clients, though training seminar attendance was low, took advantage of training and mentor resources in pursuit of new business development. One data point is a client attending four training seminars, used 6.25 mentoring hours, and presented a business plan to a review panel. A second data point is a client attending three training seminars, used 1.67 mentoring hours, and also presented a business plan.

**5. Data Findings and Future Research**

The data presented in this paper are being used to identify areas for improvement for the next ETS program and for further study. We discuss in this section the focal areas of client engagement and program components in pursuit of higher attendance rates, greater utilization of mentoring services, increases in the number of business plan presentations, and higher submission of completed business plans.

**5.1.1 Client engagement.**

We define client engagement in terms of training attendance rate, mentoring services utilized, and the presentation and completion of a business plan. The data in this study shows that those attending a higher number of training seminars also have a higher rate of business plan presentations and completions. As such, it would be important to identify ways of increasing attendance. In particular, we propose to study environmental factors, such as geographic location, work hours, and program schedule (e.g., start and end times, length of time between seminars, weekday versus weekend), and their impact on the successful completion of the ETS program.

The training program was preceded by workshops that focused on the requirements of the programs and expected outcomes. Yet, there was an 18% drop in attendance after the first training seminar. We propose to study client engagement by identifying at the onset of the program the number of clients having a “firm” business idea that can be further pursued as a viable business opportunity. Several clients dropped out of the program because they either couldn’t think on an idea or didn’t think their idea posed a business opportunity. Further study is needed to identify mechanisms for fostering innovation and creativity as a first step in the business development process.

We propose to study personality types, level of education, and work experience and their impact on client engagement. Past research, not cited, has studied personality types associated with entrepreneurship. We intend to study personality types in relation to the successful completion of the ETS program; and longer term, in relation to business creation and growth. Studies point to education as having an influence on the startup of innovative versus imitative businesses (cited in [16]). As such, we would like to track by level of education type of business startups and intellectual property contributions.

### **5.1.2 Program Components**

The training seminar series was structured similarly to an educational program with lecture, small group interaction, and in class exercises. Further study is needed to determine optimal approaches to presenting components of a business plan particularly when accounting for a client’s business background and education. For those clients with little or no exposure, the training approach taken may deter or discourage clients from further pursuit of new business development.

The training seminar series was intended to provide an intensive overview of the business

planning process. Though there was significant attendance drop-off after the first training seminar, the attrition rate leveled off to a lower percentage. We view this favorably as client commitment to pursuing knowledge in new business development. We propose to implement mechanisms, such as small group mentoring and networking events, to further engage clients in the successful completion of the ETS program.

The interactive support system was primarily a mentoring component that provided one-on-one guidance by an expert in the field or by a successful entrepreneur. Though each client was provided four hours of mentoring, and later the limit was lifted, a significant number did not fully take advantage of these services. In fact, less than 54% of potential mentoring service hours were used to support clients.

We are in the process of surveying clients and mentors to uncover factors that may have impeded the use of mentoring services. One such factor may be the mode (phone, email, direct) of providing mentoring services. Initial feedback on the use of email for client and mentor interaction appeared to impede the process of communication for some clients. Further study is needed to identify effective communication in providing mentoring support throughout the business planning activities.

### **5.1.3 Long-term Impact**

The data presented in this paper focuses on factors that provided immediate insights on the success of the program. These include seminar attendance, business plan presentations and completions, and the utilization of mentoring services. For this initial program, we view as a success factor the percentage of business plans that were presented. Close to one-third of the clients participating in the ETS program showed the potential for future new business development through their business plan presentations.

From an economic development perspective, program success would be further measured by the number of business startups and jobs created. At the time this paper was written, it was too early to report data on economic metrics. However, long-term, we propose to utilize these metrics as a means of assessing the effectiveness of the ETS program in new business development.

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<sup>ii</sup> The data point for attendance at one seminar is not included in the table.

## **A Benchmarking Study to Identify Best Practices in Curriculum Vitae Construction**

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### **Abstract**

A well written Curriculum Vitae is essential for professionals in the university setting to acquire a faculty or other significant position within higher education. Establishing best practices in academic resume writing will assist both future and current faculty members in potential job searches. One major problem in the field is that there is limited literature that provides expected standards and formats practices. The purpose of this benchmarking study is to discover best practices in Curriculum Vitae construction. As there are extensive sources for resume construction but not vitae design, this study will provide recommendations for best practices in field. There have also been instances in which the intellectual property contained in Curriculum Vitae has been compromised, and this issue will also be reviewed.

### **1. Introduction**

Every individual who is looking for a career in higher education, professional schools, research, and teaching and even in some management positions needs an impressive Curriculum Vita that describes their educational and professional history. A well-prepared and individually tailored Curriculum Vitae is invaluable and can greatly improve a candidate's chances of being offered the job they want. (6)

There is not much literature available that helps guide a prospective college professor in preparing the perfect Curriculum Vitae. This paper will begin to examine best practices in Curriculum Vitae construction based on a review of the current literature written by experts in the field as well as through the compilation of a survey conducted with professionals in higher education who are in the hiring capacity. The goal of this study is to provide a best practices outline in order to assist in "Preparing the Perfect Curriculum Vitae." Personal privacy protection of Curriculum Vitae and other personal information will also be examined.

With respect to applying for and obtaining a position within a University, strange as it may seem, people can also be viewed as products. When they apply for a job or sell their services, they sell their skills, experience, qualities and potential. No matter how good a "product" the person is, their future success will depend to a great extent on how well they market themselves. (12)

One of the most important marketing tools an individual can have when seeking to promote themselves is a Curriculum Vitae (CV for short) which is the Latin for "the course of your life". (10) A benchmarking study with provide sufficient information to guide an individual in creation of their Curriculum Vitae.

### **2. Benchmarking and Best Practice**

What is benchmarking? Benchmarking is an improvement process used to discover and incorporate best practices into your operation.

(7) The origins of benchmarking and strategies for its use are found in many sectors of the economy such as utilities, education, financial services, health care application as well as in many organizational functional areas such as human resources, marketing, research and development. Most agree that Xerox Corporation is the pioneer of benchmarking. (3) Bob Camp of Xerox Corporation wrote, "Benchmarking - The Search for Industry Best Practices That Lead to Superior Performance" which became a world best seller. (3)

The benchmarking process has been divided into four stages: planning, analysis, action and review. (5) Within these four stages are three distinct types: internal, external and best practice. Internal – defined as benchmarking with partners from within the same company or dept. External is comparison of partners from different units or companies. Best Practice is defined as identifying and comparing performance against the owners of processes regarded as best in best in class. (5)

The thesis will look at the Best Practice type of benchmarking with respect to the formulation of a Curriculum Vita. DT Kerns, the former CEO of Xerox Corporation, defined benchmarking as "the search for industry best practices that lead to superior Performance". (3) Ideally the results of this study will find best practices in Curriculum Vitae construction which will lead to superior performance of those professionals. Two facets of Best Practice implementation have been identified: the first involves developing plans related to the tasks and activities to be performed by the employees; the second deals with the culture of the organization encouraging acceptance and understanding of the plans. (3) With respect to Curriculum Vitae construction these two facets apply. This first involves writing the Curriculum Vitae related to the past education and experience of the individual and the second addresses the culture of the organization where

the Curriculum Vitae is to be submitted to ensure acceptance and a match to the targeted position.

### 3. Curriculum Vitae or Resume

There are a few distinct differences between a Curriculum Vitae and a resume. The most notable difference between a Curriculum Vitae and a resume is length. Resumes are always never longer than two pages. Curriculum Vitae s however can range in length between six pages and over 40 pages.

A more subtle but equally important distinction is where the goal of a resume is to construct a professional identity; the goal of a Curriculum Vita is quite specifically to construct a scholarly identity. (1) The Curriculum Vitae is also gaining acceptance among undergraduates applying for graduate programs and professional schools as well as selected areas of employment. Resumes are so short – often times employers are requesting Curriculum Vitae be included with applications. For this reason, a Curriculum Vitae often is referred to as an academic resume. (10)

With respect to formatting differences between a Curriculum Vitae and a resume – a resume typically use bullets, this formatting is used less frequently in Curriculum Vitaes. Whether or not bullets are used to separate lines in a CV should depend on how the bullets will affect the appearance of the CV. If a number of descriptive statements about work that all run to about a line in length are used, bullets can be a good way of separating them. If, however, there are many very short phrases, breaking them up into bulleted lists can leave a lot of white space that could be used more efficiently. Remember that the principles guiding any decision you make should be conciseness and ease of readability. (10) Also, with a Curriculum Vita, educational background within the best practice model always comes first. With a resume,

professional work experience is always suggested to be listed first. References should never be listed on a Curriculum Vitae or a Resume. (8)

#### 4. Components of a Curriculum Vita

A Curriculum Vitae is your sales document that highlights your skills, achievements and experience in such a way that the reader is motivated to meet you. (6)

One of the most important things to remember when working on your curriculum vitae is that there is not one standard format. There are different emphases in each discipline, and a good Curriculum Vitae is one that highlights the points that are considered to be most important in your discipline and conforms to standard conventions within your discipline. (12) Because the curriculum vitae is a living document it should be updated frequently. The Curriculum Vitae ought to be tailored to the specific positions that you are applying to and made relevant to the reader. A Curriculum Vita can also be looked at as a personal sales brochure, which advertises what we have done and can do for the reader. (6)

In general a Curriculum Vitae should be relevant, promote achievements, easy to read, detailed, accurate, and truthful. It should never include irrelevant information, personal information such as age, marital status, nationality, health status, and it should never be dishonest. In order to grasp the reader's attention initially, the first item on a Curriculum Vitae is the profile summary. This can be one sentence or one paragraph, which defines an individual's basic areas of expertise and objectives which match the direction or field that the applicant is applying.

Next, educational experience is listed. All education should be included! It is important with a Curriculum Vitae is to include everything related to academia candidate's education listed

in reverse chronological order. Include achievements and honors. List the degree, the specialization and the outcome for all degrees - Professional, Post Graduate, Doctoral, Masters and Undergraduate. (13) There is no need to list High School experience. Include GPA and special honors or academic achievements – especially if they are related to the area in which the applicant is applying.

Third, work and professional experience is added to a Curriculum Vita. Career history is defined as what the individual has done, for how long, what was achieved and what skills were developed. Do not simply list and label a position or function. Maintain congruence between the professional or career goals and the profile summary. This is where focus should be concentrated on skills and knowledge. Teaching experience that can be documented should also be detailed.

Next list all Theses or Dissertation abstracts. Include research that has been done, research interest as well as research which is in process should be included. If you are applying at a research university, research projects, conference presentations, and especially publications become very important. (10) This area needs to strike a delicate balance between your specific objectives as related to your research experience and your employment opportunity, but also must be broad and general enough to illustrate that you may be flexible in your research interests. It is also suggested that credit be given to supervising professors in a research environment. (15)

Publications and work in progress is covered next on the Curriculum Vitae. Include dates, locations of presentations, and whether the publications are peer viewed. This is all relevant information for the Curriculum Vitae.

Next if applicable, cover any instrumentation experience, special skills such as leadership,

language, computer, etc. as well as professional associations.

Finally, travel experience should only be included on a Curriculum Vita if it is extensive and pertains to the overall objective.

Best Practices Curriculum Vitae construction it is not suggested to include outside hobbies or interests, references, or community service activities.

## 5. Curriculum Vitae Construction

First and foremost – all professionals interviewed agree that the number one most important factor of a Curriculum Vitae is that Grammar and spelling MUST be perfect! The writing style should be confident, authoritative and crisp. It should be concise and consistent. Always avoid first person, and use tenses that are always in agreement with actions.

Parallelism is also very important to a strong Curriculum Vita. The structure of phrases and/or sentences should keep consistent throughout the document. Thus, if you use verb phrases in one portion of your Curriculum Vitae to describe your duties, try to use them throughout your Curriculum Vitae Particularly within entries, make sure that the structure of your phrases is exactly parallel so that your reader can understand what you are communicating easily. (15) The format of a Curriculum Vita commonly is publication style APA, however best practice suggests that the format match the format used within the organization that is being applied to.

In general, a strong Curriculum Vita must look good visually and be easy to follow.

The outcome of the literature review for this paper resulted in the opinion of the expert that a Curriculum Vita should be no longer than 8 pages in length. However, the interviews conducted with the professionals in higher education resulted in overwhelming vote that there should be no limit to page number and the

longer the Curriculum Vitae the better. This is a question which can be posed for future research in this area.

## 6. Privacy Protection

In the literature review for this paper – it was learned that Curriculum Vitae is not considered intellectual property, but personal privacy protection comes into play with respect to information on a Curriculum Vitae. If the Curriculum Vitae are copy written it falls under the guise of intellectual property. The Privacy Act of 1974 is a Federal Act which protects against personal information of employees and students being released.

Rapidly changing technology makes it challenging to keep abreast of the privacy, security, and management of information and identities. Policy and leadership will be the key during this time of change. (16)

There have also been amendments made to the federal Freedom of Information Act which impacts on governments' collection, maintenance and dissemination of personally identifiable information. (18)

There is an extensive amount of research to be conducted in this area and work to be done to protect individual's personal information from unlawful distribution. This topic could prove to be an investigation all on its own. The answers to these questions would also benefit individuals' use of the Curriculum Vitae and privacy protection of their rights.

## 7. Conclusion

The term Curriculum Vitae is of Latin origin and it means "the course of one's life or career". (10) It has been established that creation of an effective Curriculum Vitae is highly important and an essential part of a career search, especially in the world of academia. This paper outlined Best Practice concepts for Curriculum

Vitae construction and development with the hopes of making future Curriculum Vitae development more easily understandable and effective for those in the highly competitive job market today. It has also been determined that protection of personal information and privacy has a long way to go with respect to Curriculum Vitae as well as electronic information regulations.

## 8. Appendix Sample Curriculum Vitae

Sample Curriculum Vitae  
Mary Smith  
313-333-5200 Cell Phone  
msmith@aol.com

### OBJECTIVE

A position as a senior research scientist for a biotechnology company specializing in the development of vaccines for infectious diseases.

### SKILLS AND TECHNIQUES

- lymphoproliferation assays
- cytotoxicity assays
- ELISA, PCR, and southern blotting
- SDS-PAGE protein separation and immunoblotting

### EDUCATION

Ph.D., Immunology and Infectious Diseases  
The Johns Hopkins University, Baltimore, MD  
1998.

Dissertation: [Title of dissertation]

M.P.H., Epidemiology  
The Johns Hopkins University, Baltimore, MD  
1984

Thesis: [Name of thesis]

B.S., Biology  
Haverford College, Haverford, PA, 1981

### HONORS AND AWARDS

[List honors and awards]

### RESEARCH EXPERIENCE

Assistant Professor, Department of [Name department], The Johns Hopkins University Bloomberg School of Public Health, 1990 to Present.

Independently designed and carried out in vitro tests of ... [Describe responsibilities using action verbs.]

- [Key Accomplishment #1, e.g., “Discovered that...”]
- [Key Accomplishment #2, e.g., “Published results of study in...”]
- [Key Accomplishment #3, e.g., “Completed experiment using only 60% of allotted funding.”]

[Additional research experience, by position title, in reverse chronological order]

### TEACHING EXPERIENCE

Assistant Professor, Department of [Name department], The Johns Hopkins University Bloomberg School of Public Health. 1990 to Present.

Taught Epidemiology and Immunology courses to graduate students. [Describe additional responsibilities using action verbs.]

- [Key accomplishment #1, e.g., “Consistently received outstanding student evaluations for teaching effectiveness.”]

- [Any other accomplishments listed in bullet form.]

[Additional Teaching Experience, by position title, in reverse chronological order]

### ADMINISTRATIVE EXPERIENCE

Director, American Type Culture Collection, Rockville, MD, 1998 to 1990

Oversaw day-to-day operations of the Institute. Supervised and trained technical staff. Managed a research budget of \$7.5 million. [Describe additional responsibilities using action verbs.]

- [Key accomplishments in bullet form]

[Additional Administrative Experience, by,  
position title, in reverse chronological order]

## PROFESSIONAL MEMBERSHIPS

## PUBLICATIONS

## PRESENTATIONS [1]

## 8. Reference List:

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# A Study of Healthcare Quality in the US and Saudi Healthcare Systems

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## Abstract

Healthcare is the treatment and management of illness, and the preservation of health through services offered by the medical, dental, complementary and alternative medicine, pharmaceutical, clinical sciences (in vitro diagnostics), nursing, and allied health professions. Healthcare embraces all the goods and services designed to promote health, including “preventive, curative and palliative interventions, whether directed to individuals or to populations.” (World Health Organization Report, 2000)

In this paper we discuss the different factors that affect patients’ satisfactions with healthcare services provided by public and private hospitals in Saudi Arabia and the United States. The study compares the two countries in healthcare services, patients’ requirements, and the impact of culture on patients’ requirements as well as their healthcare services satisfaction. Also this paper provides demographic information and the correlation between some of variables such as age, gender; income, citizenship and the type of healthcare facility that patients prefer to use based on survey implemented during five month period of time in 2005 at four government hospitals and seven private hospitals in Jeddah, Saudi Arabia. Statistical analysis of patients’ requirements show that there is correlation between the times spent with healthcare providers and the patient satisfaction with respect to the patient’ waiting time to see them.

## 1. Introduction

In patient satisfaction is important to measure the quality of care provided by physicians.

Different patients have different criteria to measure their satisfactions. Some patients care about the clinic location, while others care about waiting time to schedule an appointment or the technical skills of the office staff. A study was conducted in 2002 at University of Kentucky Internal Medicine Clinic on the amount of time patients spend waiting to see the physician and the amount of time physician spent with the patient to rate customer satisfaction. The study was implemented during two month period of time in summer 2002. The patients at the clinic vary in age from 16 years old to 100 years old and have diverse population in terms of gender, insurance status, and school. A survey was distributed to the patient before seeing the physicians. The survey results shows that 25% of the 220 patients who responded to the survey were waiting for long time either more than 15 minutes in the waiting room or more than 10 minutes in the exam room. The study shows that 29% of those patients were dissatisfied with the waiting time. In addition, 48% of all patients who spent long time in the waiting area and less than 15 minutes with their physician were dissatisfied with their waiting time, while only 18% were dissatisfied if the physician spent more than 15 minutes. Therefore, the study shows that the time spent with the physician has a strong effect on the patient satisfaction and is correlated the waiting time (Feddock, 2005).

Another factor that impact patient’s satisfaction is language barriers. The Emergency department serves many patients who may not have access to primary healthcare providers. The study shows that non-English speaking patients

are less likely to be satisfied with the care they receive in the Emergency department (Carrasquitlo, 1999).

## 2. Comparative statistics of healthcare systems in US and Saudi Arabia

Table 1 shows some statistics, for both United States and Saudi Arabia, in term of specific indicators such as population, life expectancy, hospital staff, and number of health centers with their capacity.

## 3. Study of Patient Satisfaction in Saudi Arabia

### 3.1. Patients According to Citizenship Status

This section describes the study performed on private and government hospitals to identify if there was a difference among patients in the following categories:

1. Nationality (citizen or non-citizen)
2. Gender
3. Age
4. Education level
5. Social status
6. The time spent in the hospital

The reason of doing this study was to analyze the relation between the stated variables and the data collected from patients. The patients are classified according to their citizenship status (Saudi Citizen / Non-Saudi Citizen). Table 2 shows the result of this classification.

From the results, 57.7% of the patients are citizens and 42.3% are not. We can also observe that the percentage of Saudi patients in private hospitals is higher than patients in Government hospitals. For Non-Saudi patients is the opposite. The reason behind these percentages is that Saudi Patients believe that private hospitals offer better healthcare services and has better doctors and personnel, and they are equipped with the latest technology offering better hospitality services.

**Table 1. Health status indicators for US and Saudi Arabia**

Indicator	United States <sup>1</sup>	Saudi Arabia <sup>2</sup>
Estimated population	304,059,724	24,807,273
Crude birth rate / 1000 pop	13.82	24.1
Population growth rate (%)	.915%	2.23 %
Population < 65 yrs	267.7 M	97.21
Population > 65 yrs	39.5 M	32.26
Total fertility rate	2.1	3.04
Life expectancy at birth for male	75.29	72.4
Life expectancy at birth for female	81.13	74.5
Physicians	2.3 per 1000 population	21.5 per 10,000 population
Nurses	8.1 per 1000 population	93,735 40.8 per 10,000 population
Hospitals beds	2.7 per 1000 population	53,519 21.72 per 10,000 population
Health centers	4897	387

<sup>1</sup> America Hospital Association, 2009  
<sup>2</sup> Health Statistics Book of MOH, 2007

**Table 2. Classification of patients according to citizenship**

Citizenship	Private hospital		Government hospital	
	#	Percentage %	#	Percentage %
<b>Citizen</b>	103	62.8 %	96	53.04 %
<b>Non Citizen</b>	61	37.2 %	85	47 %
<b>Total</b>	164	100 %	181	100 %

### 3.2. Patients According to Gender

Patients are also classified according to their gender (Male / Female). Table 3 shows that the higher percentage of male patients is found in private hospitals. On the other hand, female patients' result shows higher value for government hospitals. The reason of having more male patients in private hospitals is the manpower in Saudi Arabia depends on male

more than female. This means that male usually worker, and this leads to the fact that healthcare of male patients are covered by their work insurance. Furthermore, another reason we found for female patient to prefer having their pregnancy follow up and their delivery in government hospitals is that it is cheaper in government hospital and these types of cases do not need high healthcare services.

**Table 3. Classification of patients according to gender**

Gender	Private hospital		Government hospital	
	#	Percentage	#	Percentage
Male	91	58.3 %	86	48 %
Female	65	41.7 %	93	52 %
Total	156	100 %	179	100 %

**3.3. Patients According to Age**

Patients are also classified according to their age. Table 4 shows that patients in between 18-29 years old are more likely to go to hospitals among the three age groups. The reason is that the population average is most around this age. Also at this age, they prefer to go to a hospital for regular check-up.

**Table 4. Classification of patients according to Age**

Age (years)	Private hospital		Government hospital	
	#	Percentage	#	Percentage
18-29	103	62.4 %	132	68.2 %
30-44	48	29.1 %	37	20.7 %
More than 45	14	8.6 %	20	11.1 %
Total	165	100 %	179	100 %

**3.4. Patients According to Education Level**

Patients are classified according to their education level. Table 5 shows that patients with higher level of education are more likely to attend to hospitals and that is due to their financial status. These patients are usually in a better economical situation than uneducated patients. Moreover, as the education level gets higher, patients attempt to go to private hospitals more than government hospitals since they are able to cover higher expenses and they care for higher healthcare quality services.

**Table 5. Classification of patients according to Education Level**

Age (years)	Private hospital		Government hospital	
	#	Percentage	#	Percentage
Doesn't have degree	32	18.8 %	62	35.03%
Has intermediate school	55	32.4%	39	22.03%
Diploma or higher	83	48.8%	76	42.93%
Total	170	100%	177	100%

**3.5. Patients According to Social Status**

Patients are also classified according to their social status. Table 6 shows that married patients are more likely to go to private hospitals. We also verified the correlation between the social status of the patients and the type of hospital (private or government) using the Chi-Square test conducted at  $\alpha = .1$  and 1 degree of freedom. The Chi-square result was equal to 0.383 indicating that the social status and type of hospital were not significant correlated.

**Table 6. Classification of patients according to Social status**

Social Status	Private hospital		Government hospital	
	#	Percentage	#	Percentage
Married	95	76.6 %	133	73.5 %
Single	29	23.4 %	48	26.5 %
Total	124	100 %	181	100 %

**3.6. Patients According to Time Spent in the Hospital**

Patients were also classified according to their time spent in the hospital. Results show that patients who are staying less than a week preferred private hospitals over government hospitals, and that is due to the healthcare services expenses (Table 7)

**Table 7. Classification of patients according to the time spent in hospital**

Time Spent in Hospital (Weeks)	Private hospital		Government hospital	
	#	Percentage	#	Percentage
Less than week	91	76.5 %	99	55.3 %
More than week	28	23.5 %	80	44.7 %
Total	119	100 %	179	100 %

**3.7. Patients' Direction in Private and Government Hospitals in Saudi Arabia**

From the data above and by conducting a Chi-Square test for all the six patient classifications we conclude the following:

There is a significant correlation among patients who prefer private hospitals and patients who prefer government hospitals according to:

1. Education level
2. Time spent in the hospital
3. Citizenship status

We can say that patients who prefer private hospitals are:

- Patients with higher education level.
- Patients who do not spent more than a week in the hospital
- Patients who have Saudi Citizenship

Patients who prefer government hospitals are:

- Patients with low education level
- Patients who spent more than week in the hospital
- Patients without Saudi citizenship

We can also conclude that there is not significant correlation among patients who prefer private or government hospital according to:

1. Gender
2. Age
3. Social status

**Table 8. Reasons for going to hospitals**

Category	Private hospital		Government hospital	
	#	Percentage	#	Percentage
Performing surgery	70	26.8 %	87	46.5 %
Chronic health problem	48	25.3 %	58	21 %
Emergency	41	21.6 %	26	13.9 %
Diagnostic & check up	26	13.7 %	26	13.9 %

**3.8. Reasons for Going to Hospitals**

There are several reasons and medical situations that cause visiting hospitals. The major reasons are:

- Chronic health problem (i.e.: Diabetes, blood pressure).

- Performing surgery.
- Emergency (i.e.: Car Accident).
- Diagnostic and check-up.

Table 8 shows that performing surgery is the most frequent category among other reasons for going to the hospital.

### 3.9. Major factors for choosing a hospital

In this section we describe the criteria of choosing a specific hospital. Patients have different factors in choosing the preferred hospital such as cost, cleanness, qualified Doctors, availability of private rooms and suites, etc. Table 9 shows the different between the government and private hospitals and the criteria for choosing the hospital. Patients who go to government hospitals ranked Medical Expense as the primary reason for choosing the hospital and that is due to limited income. Job benefits do not include medical insurance, and some private hospitals request minimum payment before processing your file.

On the other hand, patients who choose private hospitals placed cleaning as the major factor for choosing a hospital because they are able to afford medical expense, caring more about the hospitality and the doctors.

When studying the medical expense, we considered the following criteria: Limited income, job doesn't include medical coverage, and some private hospitals request minimum payment. Tables 10, 11, and 12 show the patients' responses. Results show that 43% of the patients have been asked to pay minimum payment and by asking those patients to evaluate the medical expense 62% of the patients evaluated as high rate and most of the patients carry their expense by themselves where only 43.7% of the patients have their medical expense covered by their jobs.

**Table 9. Major factors for patients to choose a hospital**

Factor	Private Hospitals		Government Hospitals	
	Patients rating	Rank	Patients rating	Rank
Better cleaning	182	1	66	6
Better Doctor	155	2	206	3
Availability of private rooms and suites	134	3	7	10
Medical equipments	121	4	217	2
First time registration procedure	127	5	92	4
Allowing dependent to stay with patient	96	6	16	9
Allowing visitors	74	7	19	8
Hospitalization	45	8	88	5
Knowing employee or doctor work in the hospital	41	9	43	7
Medical expense	15	10	289	1

**Table 10. Requesting minimum payment before entering the hospital**

Status	Private hospital		Total	
	#	Percentage	#	Percentage
Yes	77	43.3 %	77	43.3 %
No	101	56.7 %	101	56.7 %
Total	178	100 %	178	100 %

**Table 11. Evaluate the medical expense (High, average, and Low)**

Status	Private hospital		Total	
	#	Percentage	#	Percentage
<b>High</b>	96	62.8 %	96	62.8 %
<b>Average</b>	32	20.9 %	32	20.9 %
<b>Low</b>	25	16.3%	25	16.3 %
<b>Total</b>	153	100%	153	100 %

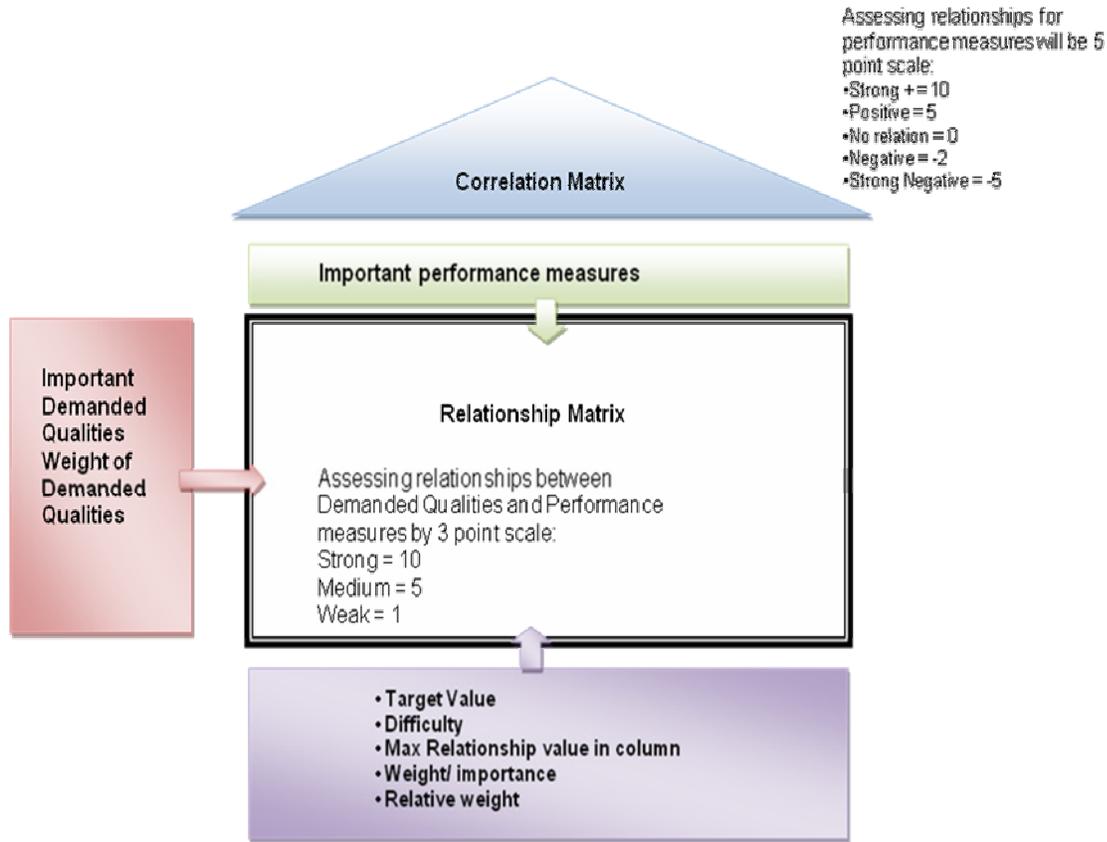
rating for each category in the demanded qualities column. The bottom of the model provides the performance of the hospital according to the relationship matrix as well as it allows the hospital to benchmark their performance with other hospitals.

**Table 12. Who carries medical expense?**

Status	Private hospital		Total	
	#	Percentage	#	Percentage
<b>Patient</b>	102	56.3 %	102	56.3 %
<b>Patient's work</b>	79	43.7 %	79	43.7 %
<b>Total</b>	181	100 %	181	100 %

#### **4. Proposed Model for Measuring Patient Satisfaction**

Figure 1 shows the proposed model for measuring patient's satisfaction. This model is a combination of the House of Quality and other quality factors. The quality function deployment (QFD) can be used to measure patient needs in hospitals in order to increase patients' satisfaction (Büyüközkan, 2004). QFD uses the house of quality which is a matrix providing a conceptual map for the design process, as a construct for understanding patient needs. The roof of the House of Quality represents the voice of the hospital. The left column of House of Quality represents important demand qualities weight of Demanded Qualities that will be driven from the major factors for patients to choose at the hospital (Table 9). Also the relationship matrix will be driven from patients



**Figure 1. Proposed Model**

Below is a summary of the data needed to implement the House of Quality:

- Factors affecting Patients Satisfaction (factors)
- Relationship matrix (patients rating)
- The weight and correlation values of performance measures
- Key performance measures
- Target level for each key performance measure
- Benchmark (SA healthcare systems to US )

## 5. Conclusion

From the data collected we can conclude that there is a significant correlation between patients' preference of place of treatment

(government versus private hospitals) and the following factors: educational level, time spent in the hospital, and citizenship status.

In addition, patients have other factors in choosing the preferred hospital such as cost, availability of private rooms, suites, etc.

Our next step is to continue validating the proposed model with other hospitals. The validation will be implemented by collecting the needed data to construct the House of Quality for selected US healthcare systems in order to build a comparative study of the two healthcare systems and draw a base line for benchmarking.

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## Appendix A

### In Patient Questionnaire

- 1) **The reasons for coming to the hospital**
  - Get special medication (i.e. for high pressure)
  - Emergency
  - Regular Examination
- 2) **Did you spend the night in the hospital?**  
( ) Yes ( ) No
- 3) **Where did you spend your night in the hospital?**
  - ( ) Private room
  - ( ) Sharing room
  - ( ) Emergency room
- 4) **Did the hospital allow your family member or friend to stay with you in the room?**  
( ) Yes ( ) No
- 5) **Do you think it was necessary to have someone with you in the room over night (friend, family?)**  
( ) yes ( ) No
- 6) **The process of opening your file was**
  - Easy
  - Complicated
- 7) **Do you think the time you spent in the hospital was enough?**
  - Yes
  - No
  - Too long
  - Too short
- 8) **The reason of choosing this hospital was? If there is more than one reasons rank them in order of importance (1 being the highest)**
  - Recommendation or transfer from another Doctor in a different hospital
  - Better medical equipments
  - The location of the hospital
  - Knowing someone who works in this hospital
  - The hospital name is well known
  - Job contract with this hospital
  - The medical expense is reasonable
  - Good feedback from friend or family
  - Allowing visitor in the patient' room
  - Option of having company in the patient room
- 9) **How was the hospitality from the hospital staff?**  
( )Great ( )Good ( )OK  
( )Fair ( )Poor
- 10) **Did the hospital request a minimum payment before being admitted?**
  - Yes
  - No
  - Don't know

**If yes, Was the amount high?**

  - Yes
  - No
  - Don't care
- 11) **Do you prefer having your physician gender same as yours?**
  - Yes
  - No
  - Don't care
- 12) **Would you recommend this hospital to someone else?**
  - Yes
  - No

**13) Is this medical cost on you or on your insurance?**

- My own expense
- My insurance
- Both, because I have to pay a co-payment/deductible

**14) How do you rate this medical expense?**

- High
- Average
- Low

**15) Do you think some of the medical exams that were done to you were not necessary?**

- Yes
- No
- Don't know

**16) Gender:**

- Male

- Female

**17) Education level:**

- Less than high school
- High school diploma
- Some College classes
- College degree
- Master degree
- Doctorate degree

**18) Age:**

- 18 – 29
- 30 – 44
- Older than 45

**19) Duration of time you spend in the hospital:**

- Less than 3 days
- 3 days – 7 days
- 1 week – 2 weeks
- More the 2 weeks

**Appendix B**  
**Out Patient Questionnaire**

Questions	Great	Good	OK	Fair	Poor
<b>EASE OF GETTING CARE</b>					
Ability to get admitted to be seen					
Hours of the Center being Open					
Convenience of the Center's location					
<b>WAITING</b>					
Time in the Waiting Room					
Time in the Exam Room					
Waiting for tests to be performed					
Waiting for test results					
<b>STAFF - PROVIDER</b>					
Listened to you					
Take enough time with you					
Explained to you what you wanted to know					
Gave you good advice and treatment					
Answered your questions					
<b>STAFF - NURSES AND MEDICAL ASSISTANTS</b>					
Friendly and helpful to you					
Answered your questions					
<b>STAFF - ALL OTHERS</b>					
Friendly and helpful to you					
Answered your questions					
<b>PAYMENT</b>					
What you paid was reasonable					
You got an explanation of charges					
<b>FACILITY</b>					
Neat and clean					
Ease of finding where to go					
Comfort and safety while waiting					
Privacy					
<b>CONFIDENTIALITY</b>					
Keeping my personal information private					
The likelihood of referring your friends and relatives to us					
Do you consider this center your regular source of care?					
( ) Yes ( ) No					

## **Is the Telecommunications Department an Organization Within an Organization?**

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### **Abstract**

This paper discusses how telecommunications department is managed in terms of strategic planning, designing, directing, training, and controlling. It also discusses the importance of managing both data and voice within the same department, the role of different technical support levels, and the importance of telecommunications manager being proactive rather than reactive.

### **Long-Term Plan**

As a result of fast changing in telecommunications technology and the marketplace, a long-term plan is about 5 years. Such plan should be written with flexibility to allow changes. It should have the cost, reasons, benefits to the organization, starting and finishing dates, and people charged with specific responsibility to accomplish the plan.

Today, telecommunications department is viewed as organization within organization, due to many functions that exist, and the strategic importance to many organizations.

Telecommunication department is on the front seat to lead the organization to success, and by so doing, planning is critical.

Telecommunications department planning should be tied to the overall organization

strategic plan, and should have long-term plan as well as short-term plan.

### **Short-Term Plan**

Telecommunications department short-term plan should be about 3 years. The plan should be specific and with a very limited room for changes. Immediate budget should be in place, and decision on whether the actual work will be handled internally or externally, cost, reasons, benefits, and starting/finishing dates should be made as soon as possible.

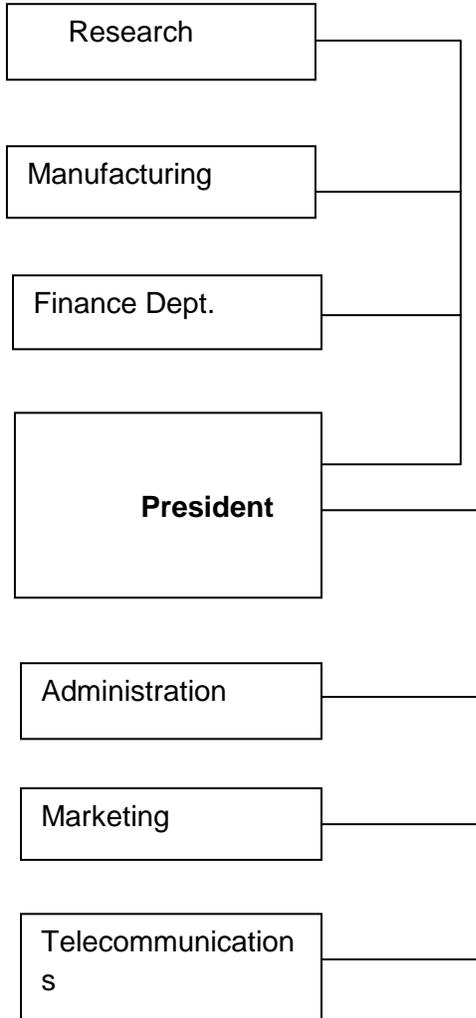
### **Designing**

Most of today's telecommunications design is more or less an extension or improvement of an existing network. A network analyst determines users need through a survey, or any other methodology. The result is used to predict users demand and technology needed for implementation.

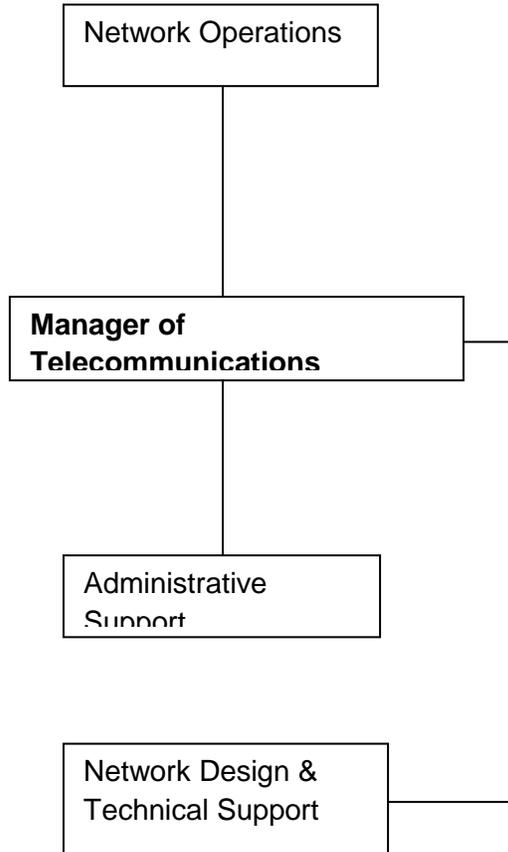
The growth of voice, data and video makes it very difficult to predict the future bandwidth needed for the telecommunications network.

Most telecommunications equipment life expectancy of today is about 5 years, and this is not because of less equipment quality, but rather the fast changes in capability makes it obsolete after few years.

### Typical Organization Chart Showing Telecommunications Department



### Telecommunications Dept. Operation

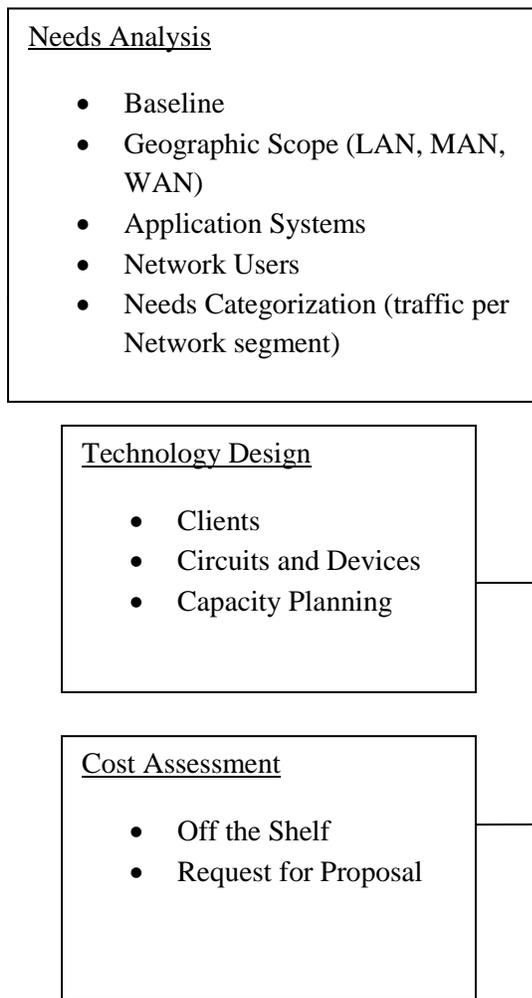


**Life expectancy for selected network equipment**

<u>Equipment (years)</u>	<u>Life Expectancy</u>
Rack Mounted Switch.....	4.5
Chassis Switch .....	4.5

Backbone Router .....	5
Branch Office Router .....	4
WI-FI Access Point .....	3
Desktop PC .....	3.5
Laptop PC .....	2.5

**(Source: “When to upgrade,” Network World, November 28, 2005, pp.49-50)**



Designer makes an effort to understand and evaluate the current and future network needs, evaluate current technologies for user requirements.

Designer also looks at the cost of technologies and the budget which might lead to design modifications.

**Telecommunications Department Staffing**

One of the most difficult functions for telecommunications manager, due to less trained people, data and voice experience requirements, and the competition for such professionals in the marketplace. Skills needed include: Designers and implementers, network operations, technical support, administrative support, and section managers or supervisors.

**Questions that need to be considered by Telecommunications manager during staffing process**

1. What type of expertise are needed to achieve the goals of the department?
2. Should you hire people from outside with telecommunications experience?
3. Should you train some technical people within the organization in telecommunications?
4. Should you hire new graduates with degrees in telecommunications and provide initial training?
5. Should you outsource some of the telecommunications work to outside firms?

**Things that need to be considered by telecommunications manager for the staff to stay longer:**

Career path should be clearly defined

1. There should be an ongoing training opportunities
2. Their efforts must be recognized
3. Salary should be competitive with similar organizations
4. They should be made to feel a sense of community within the organization

**Directing the Telecommunications Department**

The direction of the telecommunications department is critical and must be stated and shared with all subgroups of the department. Each group should have written objectives that are tied to the overall goals of the department. Standards or protocols should be made clear, and individuals should be motivated and included in all communications to ensure the success of the departmental goals.

**Telecommunications Control**

This may include budgeting, quality, and auditing. Below shows a typical budget for telecommunications department:

1. Salaries
2. Employee Benefits
3. Equipment Rental/Lease (if applicable)
4. Maintenance (equipment/facility)
5. Depreciation (for purchased equipment)
6. Office Supplies
7. Educational Training
8. Travel
9. Utilities
10. Building/Corporate Overhead

**Quality Control**

It ensures an agreement between the user and the telecommunications department in terms of network availability and response time. It also compares the performance of equipment to the established vendor standards.

**Telecommunications Department Audit**

The periodic auditing is to review and examine the activities of the department. This process evaluates the adequacy and effectiveness of control procedures. It is conducted by internal or external auditors, and the result can be used to improve the telecommunications department.

### **Managing both Data and Voice within the same Organization**

Data and Voice communications had been managed separately for years. The two networks have had two separate managers with two separate budgets, and sometimes purchasing similar products from different vendors. This practice also created politics in the workplace among the data and voice staff, which led to high cost, low efficiency and productivity.

Today, some organizations have combined voice and data into one department. The technology is

available to allow a common network to carry voice, data, and video. This means that telecommunications department can save money on technology, buy from a common source, and have a better maintenance. However, more training is needed to keep up with the rapid changes in technology. It also means less staff, and people losing jobs.

### **Technical Support in Telecommunications Department**

In most organizations, the technical support team is divided into three levels:

- (1) Help Desk Technician –Level (I)
- (2) Network Technician – Level (II)
- (3) Technical Specialist – Level III (level (III) technicians have experience in software, hardware, network design, and general problem solving).
- (4) Networks problem solving normally starts with technician level (I), and

passed on to level (II) if the problem is not resolved within about 15 minutes. It is passed on to level (III) if the problem is not resolved within 4 hours by level (II) technician. However, level (II) technician retains ownership, and must monitor and communicate with the user and supervisors. If problem is not resolve after 8 hours, upper level managers must be notified to determine the next level of action.

### **Telecommunications Manager Being Proactive**

Telecommunications department has become a leading force to many organizations, and constantly looking for an opportunity to use telecommunications to position themselves ahead of competitors in the marketplace. The emphasis is making money with telecommunications rather than saving money.

Telecommunication managers are under constant pressure to be proactive and keep up with the rapid changes in technology, and to be a forward looking person. Companies such as Banks, Airline, American Express, and Federal Express could not succeed without telecommunications.

### **Conclusion**

As a result of the leading role, and coupled with many sub-divisions and functions within the telecommunications department (Strategic Planning, Designing, Directing, Training and Controlling), It is indeed sometimes viewed as organization within organization or business within a business.

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## Why Modulations in Telecommunications Technology?

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### Abstract

Modulation is the process of combining two signals into a form that is appropriate for transmission. Modulation is very critical in telecommunications and there are various forms of modulations in telecommunications technology. As a result, this paper will discuss the importance of modulations in telecommunications technology, different types of modulations, and focus on the differences, advantages and disadvantages between Amplitude Modulation (AM), and Frequency Modulation (FM).

### Introduction

Telecommunications Technology Modulation – Is a process in telecommunications technology where the intelligent signal is combined with the high carrier signal. The combination of two signals help the low frequency intelligent signal with enough power to cover longer distance, and to distinguish one signal frequency from another, and to produce a result that is suitable for the medium being used for transmission

#### Different types of modulation:

- \* Amplitude Modulation (AM)
- \* Frequency Modulation (FM)
- \* Pulse Modulation (PM)
- \* Frequency Shift Keying (FSK)
- \* Phase Shift Keying (PSK)
- \* Amplitude Shift Keying (ASK)
- \* Quadrature Amplitude Modulation (QAM)
- \* Trellis Coded Modulation (TCM)

**Frequency Shift Keying (FSK)** This is a process in digital communications where the frequency of the carrier is varied proportional to the intelligent signal.

### Phase Shift Keying (PSK)

This is a process in digital communications where the phase of the carrier is varied proportional to the intelligent signal.

### Amplitude Shift Keying (ASK)

Is a process in digital communications where the amplitude of the carrier is varied proportional to the intelligent signal.

### Quadrature Amplitude Modulation (QAM)

This is another form of modulation process where both amplitude and phase of the carrier are varied proportional to the information or intelligent signal.

### Trellis Coded Modulation (TCM)

This is a type of digital modulation that combines both Phase Modulation and Amplitude Modulation.

### Pulse Modulation

This is a series of regular pulses that are made to vary in shape, amplitude, or period. Examples of pulse modulation are –Pulse Position Modulation (PPM), Pulse Width Modulation (PWM), Delta Modulation (DM), Pulse Code Modulation, and Pulse Amplitude Modulation (PAM). Among all the pulse modulations, PCM is the most widely used within the Public Switched Telephone Network (PSTN).

#### Advantages of pulse modulation:

- \* Noise immunity
- \* Inexpensive digital circuitry
- \* Increased transmission distance by using Repeaters
- \* Storage capability
- \* Easily implemented error detection and correction

**Disadvantages of pulse modulation:**

- \* It requires much greater bandwidth than analog.
- \* Pulse streams are difficult to recover.
- \* Precise synchronization of clock signal between the transmitter and receiver is needed.

The industry standard method for converting analog voice signal into digital signal is called Pulse Code Modulation (PCM).

**The five basic steps in PCM process are:**

- \* Sampling
- \* Quantization
- \* Encoding
- \* Companding
- \* Framing

**Sampling**

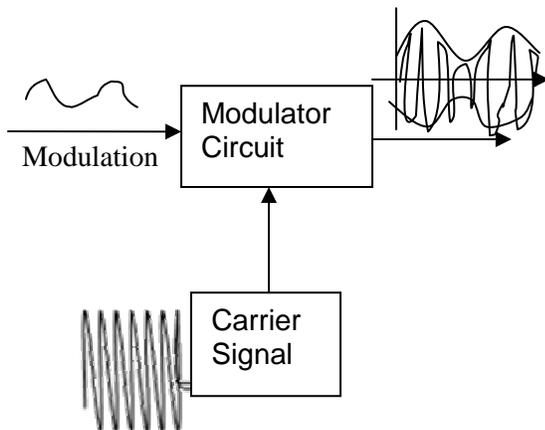
A process based on Nyquist theorem where 8000Hz of analog signal is sampled at 8000 times/sec.

**Quantization**

This is an adjustment that needs to be done at the input signal level of the PCM since the voltage is converted to 8-bit code at two stages (1 or 0).

There are 256 possible codes and the process of adjusting the input signal to within one of the 256 codes is called Quantization

**Basic Amplitude Modulation Technique**



Three frequencies are created after modulation (Carrier, Upper Sideband, and Lower Sideband)

**The instantaneous voltage for the modulated signal:**

$$e_{AM} = \underbrace{V_c \sin 2\pi f_c t}_{\text{Carrier}} + \underbrace{mV_c / 2 \cos 2\pi (f_c - f_m)t}_{\text{Lower Side Band}} - \underbrace{mV_c / 2 \cos 2\pi (f_c + f_m)t}_{\text{Upper Side Band}}$$

**Companding**

This is a process of assigning and expanding of a signal to prevent quantization noise.

**Encoding**

This is a process of assigning an 8-bit code to represent the signal level after quantization and compression.

**Framing**

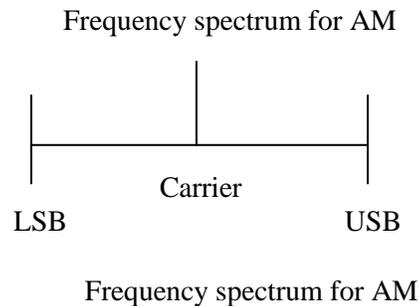
Is the procedure use to identify the beginning and end of a group of data bits.

**Comparison between Amplitude Modulation (AM) and Frequency Modulation (FM)**

**Amplitude Modulation**

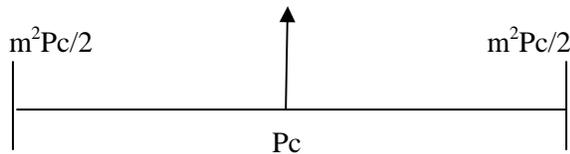
This is where two signals (carrier and information) are combined, the amplitude of the modulated signal changes continuously, while the frequency of the carrier remains constant. The bandwidth (BW) for AM is 530 KHz to 1710 KHz.

In AM frequency remains constant and the amplitude changes



**Power in Amplitude Modulation**

After modulation, the power is located in three places as shown in the spectrum below.



Modulation index or coefficient ( $m$ ) =  $V_m/V_c$

Total power ( $P_t$ ) =  $P_c + P_{LSB} + P_{USB}$

$P_t = P_c ( 1 + \{m^2\} / 2)$

When modulation index or modulation factor or coefficient exceeds (1), it is called over-modulation, and that creates distortion in voice transmission. Given  $V_{min}$  and  $V_{max}$  of the modulated waveform, and the index ( $m$ ), the carrier voltage ( $V_c$ ), and modulating voltage ( $V_m$ ) can be determined.

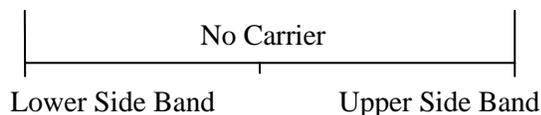
$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

$$V_m = \frac{V_{max} - V_{min}}{2}$$

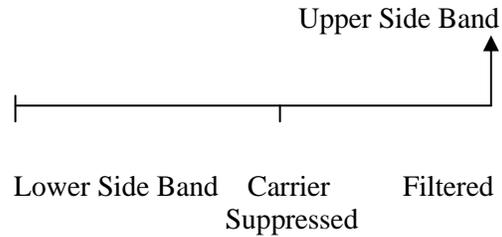
$$V_c = \frac{V_{max} + V_{min}}{2}$$

In amplitude modulation, the carrier contains no intelligent information after modulation, but it tends to consume over 30% of the total power. Balanced modulators are used to suppress the carrier after modulation, so the carrier power can be put on the sidebands to improve power for transmission. This is called Double Side Band (DSB) transmission.

Frequency Domain of DSB with Carrier Suppressed



Since the double sidebands (DSB) contain the same information, filters can be used to eliminate one of the sidebands, and when that happens we have what is called Single-Sideband (SSB) transmission.



**Some advantages of the single-sideband transmission (SSB):**

- Greater power for transmission
- Signal to noise ratio is improved due to narrower bandwidth

The main disadvantage of the DSB and SSB is the difficulty in demodulation at the receiving end due to the suppressed carrier. This brings about higher cost for the receiving equipment.

To overcome some of the difficulties, a small carrier signal (pilot carrier) is transmitted with the modulated signal.

**Applications of SSB and DSB**

- SSB is used in the telephone systems, two-way radio, military applications, marine applications, and amateur radio operators.
- DSB is used in FM radio and TV broadcasting to transmit stereo signals as well as picture information.

**Frequency Modulation (FM)**

The process of combining the intelligent or modulating signal with the carrier signal, where the amplitude remains constant and the frequency continuous to change. FM transmitters are generally designed for short distance communications. This process allows many similar stations to be established within a reasonable distance apart, and using the same frequency for transmission without interference problems.

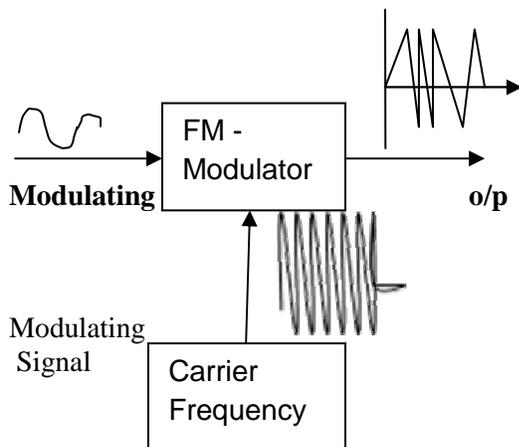
**Some applications of FM are as follows:**

- Commercial (FM) Broadcast
- Amateur Radio
- Communications
- Television

- Paging System
- Cellular and Cordless Telephony.

FM Bandwidth (BW) in the United States is 88 MHz to 108 MHz

### Frequency Modulation (FM) Technique



Federal Communications Commission sets the maximum deviation frequency to 75KHz. The maximum frequency deviation for the sound section of the television broadcast is 25KHz.

The maximum frequency established by FCC for modulating frequency is 15KHz.

### Conclusion

Modulation is the process in tele-communications to combine the intelligent signal with the high carrier signal. This improves signal to noise ratio, it allows different signals to be distinguished from one another, and enables FCC to have better control in frequency allocations. Some of the different types of modulations discussed in this paper were Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Quadrature Amplitude Modulation (QAM), and Trellis Coded Mod (TCM). Advantages of FM: Noise Immunity, Capture Effects, and Transmitter Efficiency. Disadvantages of FM: Excessive Spectrum Use, and Circuit Complexity.

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$$fc - 2fm \quad fc - fm \quad fc + fm \quad fc + 2fm$$

$$\text{Modulation Index (mf)} = Fd/Fm$$

$$\text{Carrier Swing (Cs)} = 2Fd$$

$$\text{Frequency Deviation (Fd)} = Cs/2$$

# BEMD-Based Image Processing: A novel Approach to Color Image Edge Detection and Analysis Using Cubic Spline Interpolation

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## Abstract

The area of edge detection has been quite intriguing, which explains why it continuously draws interest not just from computer scientists but also from different fields of science. Despite this reality, however, designing an image edge detection operator that satisfies the necessary properties like low probability of error (i.e., failure of marking true edges or incorrectly marking non-edges), accuracy, and consistence response to a single edge has been elusive. It should be further noted that most of the work in the area has been geared toward detecting edges of grayscale images. Colored images have to be converted to their grayscale equivalent for analysis, feature extraction and edge detection – losing necessary information in the process. Little, if any work has been done toward edge detection of color images. In this digital world where grayscale images – also known as black and white become less prevalence, while their color counterparts are taking over our lives, it become obvious that a methodology is needed to address this shortcoming. In this paper, the authors propose an efficient, yet simple methodology to address the problem. It involves the use of bidimensional empirical mode decomposition (BEMD), a variance of empirical mode decomposition (EMD), which is a sifting process that decomposes a signal into its one-dimensional (1D) intrinsic mode functions (IMFs) and a one-dimensional (1D) residue based on the local frequency or oscillation information. Essentially, the BEMD is an extension of EMD for the purpose of images and 2-dimensional data processing and analysis and will be supplemented by the cubic spline interpolation algorithm.

## 1. Introduction

The idea of detecting an edge or feature of an object is not computer scientists' attempt to be different or aloof. In fact, this process is significant in almost every aspect of our daily lives and is a part and parcel of a bigger picture of our existence and interaction with science and nature. In that sense, it is increasingly becoming popular in many fields of study [1, 2, 3]. Through history, humans have always looked to science for the purpose of trying to understand certain natural phenomena. The reverse is also true, for they also look to nature when they are trying to understand scientific phenomena. Whether it is Charles Darwin's 'natural selection,' which he described as 'preservation of favored races in the struggle for life' in his book entitled *On the Origin of Species* and later described as 'survival of the fittest' by Herbert Spencer, or John Holland's Genetic Algorithm which emulates biological evolution in the computer, nature and science have proven to be complementary pair. Backed by scientific evidences, it is believed that the human species are the smartest of all species on earth. Psychologists, Sociologists, physiologists, Biologists and Computer Scientists alike have all announced their verdicts. The human brain is of particular significant in this distinction. Equipped with thousands of neurons, making a decision is a trivial matter. Though computers make decisions faster than the human, they first go through a rigorous, explicit and detailed process to make even the simplest decision, a process that would take little to no effort for human. Our recognition system is particularly powerful because we can recognize an enormous range of objects, involving unrehearsed detection of edges and other features, with little difficulties [1]. As such, Physiological theorists believe that human vision system (HVS) go

through some sort of edge and feature detection prior to recognizing a color or image intensity [4, 5]. In essence, Computer Scientists believe that some edge and feature detection is required prior to image interpretation for an automatic computer system. As a result, finding edges and other features in an image is considered an important process in many artificial vision systems and the source of motivation for researchers in this area. The area of edge detection and its subsets have been around for quite sometimes. Nonetheless and because images have no real edges as we know them in the real world, the term edge, in reference to image, is somewhat misplaced. What we describe as edges are actually abrupt changes of intensity in image. Because the overall goal is to locate edges in the real world through the image however, the term edge detection has gained general acceptance in the research community [6, 7]. Indeed, edges characterize boundaries and, as such, are problem of fundamental importance in image processing [8]. The main reason for detecting sharp changes in image brightness is to capture important events and changes in properties of the world. In fact, it can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond to discontinuity in depth and surface orientation, changes in material properties, and variations in scene illumination [9, 10]. In the ideal case, the result of applying an edge detector to an image may lead to a set of connected curves that indicate the boundaries of objects, the boundaries of surface markings as well as curves that correspond to discontinuities in surface orientation. For this reason, applying an edge detector to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image [7, 11]. If the edge detection step is successful, the subsequent task of interpreting the information contents in the original image may therefore be substantially simplified [9, 10, 7, 11, and 12]. Having introduced the edge detection concept, the rest of the paper is organized as followed. Section 2 summarizes other image operations, some of which are generally applied as a

preprocessing step in classical edge detection, and gives a technical definition of edge detection. In section 3, we introduced the method that we use to analyze and produces edge map of color image in the RGB domain. Section 4 discusses our proposed method. We provide preliminary results and comment on our future plan in section 5 while providing references in section 6.

## 2. Other Image Operations

Edge detection is a fundamental problem in the broader area of image processing. Nonetheless, successfully detecting edges involves one or more image processing operations. For this reason, a brief summary of the available operations, namely denoising, restoration, registration, and deblurring, is presented in this section.

*Denoising:* Digital images are prone to a various types of noise. Noise is, by and large, the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created [13]. For example, if the image is scanned from a photograph made on film, the film grain is a source of noise. Also, noise can be the result of damage to the film, or be introduced by the scanner itself. Furthermore, if the image is acquired directly in a digital format, the mechanism for gathering the data, such as a charge-coupled device (CCD) detector, can introduce noise. Electronic transmission of image data can also introduce noise [15].

*Restoration:* Restoration is a very broad image operation that actually includes various operations, such as denoising and deblurring. As defined previously, it is the removal or reduction of degradations that are incurred during the image attainment process. Through restoration, low quality images can be restored to their original forms [14]. As a result, various techniques and methodologies that stretch the boundary of the overall image improvement exist. For example, a shape-based landmark matching to optimize conformal parameterization of cortical surfaces was introduced by Lui et al. [14]. In this work, a

meaningful parameterization of the cortical surface utilizing prior anatomical information in the form of anatomical landmarks, such as curve, is proposed. The basic merit is that the computed maps are guaranteed to give a shape-based diffeomorphism, or invertible function, between the landmark curves. Furthermore, distorted documents, resulting from geometric distortion and non-uniform illumination, require restoration but no particular technique provides a silver bullet solution to this type of degradation. In the literature, various techniques are suggested.

*Registration:* Registration is an image operation whose aim is to align two or more images of the same scene. In this process, the base or reference image is compared to the input image with the objective of bringing the input image into the alignment with the base image. The process involves application of spatial transformation to the input image. Generally speaking, the differences between the input image and the output image may occur as a result of terrain relief and other changes in perspective when shooting the same scene from different locations or viewpoints. In addition, lens, other internal sensor distortions, or differences between sensors and sensor types, can also cause distortion that necessitates the registration routine [15]. Registration is one of the most important image analysis tasks there is in the area of image processing and computer vision, for it allows us to gain useful information from various data source [14]. In general, registration is required in remote sensing where multispectral classification, environment monitoring, change detection, image mosaicing, weather forecasting, creation of super-resolution images, and integration of information into geographic information system (GIS), are desired [14].

*Blurring:* According to Dangeti [15], blurring is a form of bandwidth reduction of the image caused by the imperfect image formation process such as relative motion between the camera and the original scene or by an optical system that is out of focus. For instance, when aerial photographs are produced for remote sensing purposes, blurs are introduced by atmospheric turbulence, aberrations in the

optical system and relative motion between camera and ground.

## 2.1 Edge Definition

It was also claimed earlier that edges are abrupt changes in an image. To understand what was meant, we must first understand the origin of edges and the factors that cause them [50]. Fig. 2.1 illustrates the conversion of a two-dimensional image into a set of curves where extraction of salient features of the scene can be carried out [50]. It is to be noted, however, that the curves in this figure are more compact than the typical edges, but the idea of extracting the important features of a scene is clearly illustrated therein. Nonetheless, the question remains as to what caused edges in the first place? Remember it was also mentioned earlier that various discontinuities are the main causes of edges. To further understand this reality, Fig. 2.2 illustrates several of these discontinuities [1, 2]. From the above illustrations, in addition to factors which cause them, we can see that edges are the places in the object corresponding to the object boundaries, and are, as a result, technically defined as pixels where image brightness changes abruptly [1, 4, and 5].

This can be seen by examining Fig. 2.3, which compares and contrasts brightness and spatial coordinates. As such, an edge can also be described as a property attached to an individual pixel and is calculated from the image function behavior in its neighborhood. It is, therefore, considered a vector variable consisting of magnitude of the gradient and the direction of an edge [8, 9, 1]. In particular, edge information in a given image is found by looking at the relationship a pixel has with its neighbors. If a pixel's gray-level value is similar to those around it, then there is a good chance that there is no edge presence at that point. By contrast, if a pixel has neighbors with widely varying gray-levels, there is high likelihood of an edge point at that location [5, 7, and 8]. An edge point could be any of the available edge types as illustrated by Fig. 2.4.

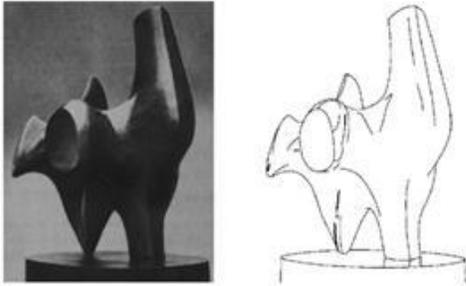


Figure 2.1. Converting a two-D image into a set of curves

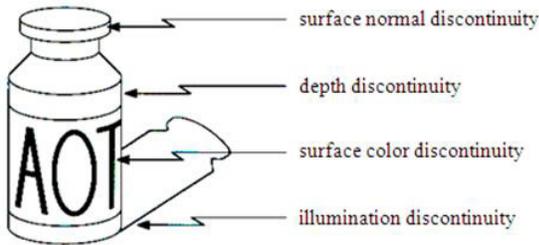


Figure 2.2. Various factors responsible for the occurrence of edges

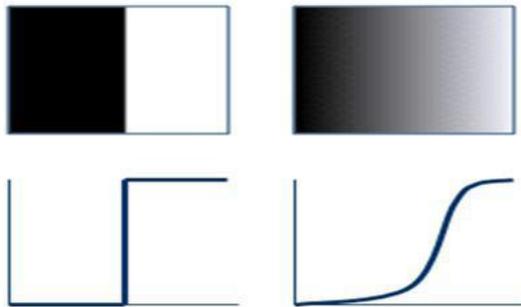


Figure 2.3. Brightness versus spatial coordinates

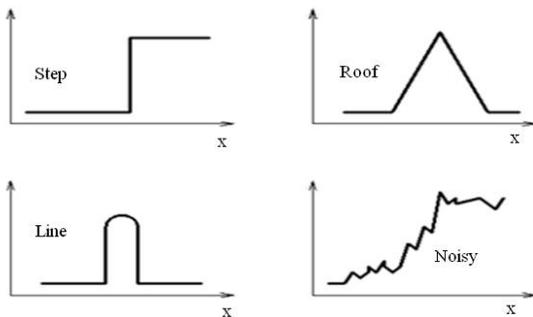


Figure 2.4: Classic edge profiles

## 2.2 Edge direction and magnitude

Note that the gradient magnitude and the gradient direction are continuous image functions consisting of the angle in radians from the x-axis to the point (x,y). Remember it was established earlier that edge is where change occurred, and this change is measured by a derivative in one-dimensional space. Anytime we encountered the biggest change during this measure, one of two things will be realized: The derivative will have a maximum magnitude or the second derivative will be zero [5, 9, 7]. The former case describes the gradient family of edge detectors while the latter is a typical behavior of the Laplacian edge detection methods [7, 6]. The gradient of an image is given by

$$\nabla f = \left[ \frac{\delta f}{\delta x}, \frac{\delta f}{\delta y} \right] \tag{2.1}$$

The image points in the direction of the most rapid change.

Finally, the gradient direction and gradient magnitude are respectively given by

$$\theta = \tan^{-1} \left( \frac{\delta f / \delta y}{\delta f / \delta x} \right) \tag{2.2}$$

$$\|\nabla f\| = \sqrt{\left( \frac{\delta f}{\delta x} \right)^2 + \left( \frac{\delta f}{\delta y} \right)^2} \tag{2.3}$$

## 3. Empirical Mode Decomposition (EMD)

One Empirical mode decomposition (EMD), developed by Norden E. Huang et al. [17] in 1998 is a method of breaking down a signal without leaving a time domain and, in some sense, serves the same purpose as the Fourier Transforms and wavelet decomposition image analysis techniques. It is, however useful for analyzing natural signals, which are, by and large, non-stationary, time-varying and non-linear [17]. The Fourier Transform and wavelet decomposition methods deal strictly with stationary, periodic and linear data and signals. Because EMD decomposes a complex signal into finite and oscillatory modes known as intrinsic mode functions (IMFs), it is self-

adaptive and efficient and, as a result, gained major impetus in various fields of study outside of computer science [18]. This popularity stemmed from the fact that the basic functions used to decompose a signal are not predefined but adaptively derived from the signal itself [17]. Huang and others were motivated by the inability of the existing data analysis techniques to effectively handle nonlinear and non-stationary data and signals. Because data analysis is important in research and practical applications, it is necessary to have a reliable and efficient mechanism of examining the data so that we can make sense of them so they argued [17]. Since one of the main goals of data analysis is to determine the parameters needed to construct the necessary model and to confirm the model that is constructed to represent a phenomenon, it is imperative that some of the inherent problems are addressed. Data, whether from physical measurement or numerical modeling will exhibit one or more of the following problems: The data span will be too short; the data are non-stationary; the data represent a nonlinear process [17]. Because the existing methods, such as the spectrogram, the wavelet analysis, the Wigner-Ville Distribution, evolutionary spectrum, the empirical orthogonal function expansion (EOF), etc., do not address some of the above problems, at least in the pragmatic standpoint, EMD attempts to empirically bridge the gap [17].

An intrinsic mode function (IMF) is a function that satisfies two conditions: (1) in the whole data set, the number of extrema and the number of zero crossings must either equal or differ at most by one; and (2) at any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima is zero [17]. The specifics of these conditions, typically described as a “sifting process,” are summarized below.

- (i) Make the initialization
- (ii) Compute the kth IMF (by initializing, identifying all local extrema, interpolate the local minima or maxima to get the envelope, compute the means of the envelopes until the stopping criteria is fulfill)
- (iii) Check if the last IMF is monotonic, in which case the decomposition is

complete (otherwise start over from ii).

#### 4. Bidimensional EMD (BEMD)

Bidimensional empirical mode decomposition (BEMD) describes the empirical mode decomposition (EMD) technique for image or two dimensional data processing. Based on the properties of the empirical mode decomposition (EMD) and characteristics of images, the EMD technique has been extended to analyze images or two dimensional data. For this reason, the bidimensional empirical mode decomposition (BEMD) is also known as image EMD (IEMD), 2D EMD, and directional (DEMD), among other designations [19]. The BEMD decomposes an image or two-dimensional (2D) data into its 2D or bidimensional IMFs (BIMFs) and a 2D or bidimensional residue (BR), which represents the characteristic of local spatial scales at various levels of the image or 2D data, defined by the BIMFs or the BR. Because of the inherent nonlinearity and non-stationarity in images, BEMD presents a legitimate promise for image processing tool [19, 1]. In regard to the sifting algorithm for bidimensional signals, a similar algorithm as that described above can be applied while the fundamental question to answer is what interpolation technique to use in the sifting process (SP) and how much iteration to consider in the SP to build the IMFs [19]? For the purpose of this work, an efficient and robust interpolation method, known as the cubic spline interpolation, is applied. Details of the BEMD algorithm or the sifting process are given below:

- (i) Set  $i = 1$ , and  $S_{i(x,y)} = I_{(x,y)}$ . If  $S_{i(x,y)}$  (i.e., the given image  $I_{(x,y)}$ ) is not the only component, with  $S_{i(x,y)}$  having the BR properties, then go to step two.
- (ii) Set  $j = 1$ , and  $F_{i,j(x,y)} = S_{i(x,y)}$ .
- (iii) Obtain the local maxima points of  $F_{i,j(x,y)}$ , which is known as the 2D maxima map and denoted by  $P_{i,j(x,y)}$ . Similarly, obtain the local minima points of  $F_{i,j(x,y)}$ , which is known as the 2D minima map and denoted by  $Q_{i,j(x,y)}$ .
- (iv) Generate the upper envelope (UE),  $U_{i,j(x,y)}$ , and the lower envelope (LE),  $L_{i,j(x,y)}$ , of ISBIMF,  $F_{i,j(x,y)}$ , from the

- maxima points in  $P_{i, j(x,y)}$  and minima points in  $Q_{i, j(x,y)}$ , respectively.
- (v) Find the mean envelope (ME) as  $M_{i, j(x,y)} = U_{i, j(x,y)} + L_{i, j(x,y)} / 2$
  - (vi) Calculate  $F_{i, j(x,y)}$  as  $F_{i, j+1(x,y)} = F_{i, j(x,y)} - M_{i, j(x,y)}$ .
  - (vii) Check to see whether  $F_{i, j(x,y)}$  follows the properties of a BIMF.
  - (viii) If  $F_{i, j+1(x,y)}$  meets the BIMF properties as per step (vii), then take  $F_{i(x,y)} = F_{i, j+1(x,y)}$ ; set  $S_{i+1(x,y)} = S_{i(x,y)} - F_{i(x,y)}$ , and  $i=i+1$ ; go to step (ix). Otherwise, set  $j = j+1$ , go to step (iii) and continue up to step (viii).
  - (ix) Find out the number of extrema points (maxima and minima together) (NEP), denoted as  $e_i^2$ , in  $S_{i(x,y)}$ . If  $e_i^2$  is less than the extrema threshold (ET),  $e^{2T}$ , the BR,  $R_{(x,y)} = S_{i(x,y)}$ ; and the decomposition is complete. Otherwise, go to step (ii) and continue up to step (ix).

In our method, we extended the BEMD to deal with color by adding an additional variable to the BEMD process. As such we have a color image denoted by  $I(x, y, p)$ , where  $p$  is the color index of the color index components (CICs) (e.g.,  $p=1, 2,$  and  $3$ ), and  $(x, y)$  is the 2D coordinate of the corresponding CIC. For an  $m \times n$ -pixel image,  $x \in 1: m$  and  $y \in 1: n$ , where  $m$  and  $n$  are the total number of pixels in the horizontal and vertical directions, respectively. Hence, the three CICs of the original color image can be denoted as  $I^p(x, y)$ , where  $p=1, 2$  and  $3$ .

Applying the algorithm to an image using the matlab software produces some useful results, some preliminary of which are provided below.

### 5. Preliminary Results and future work

As can be seen from the below figures, the application of the extended EMD, called the bidimensional EMD coupled with its combination with a useful interpolation algorithm make for a good edge detection technique. Because of its adaptability, extending it in a unique way to analyze and produce edge map of a color image in their

RGB domain prove useful. It is to be noted that this idea is part of an ongoing work, and although the results do not currently seem to be greatly superior to the existing methods, the future of the idea looks very good. Two original images, one is a gray image and the other is a color image, are use in this experiment to produce edge maps in both gray and color domain respectively.

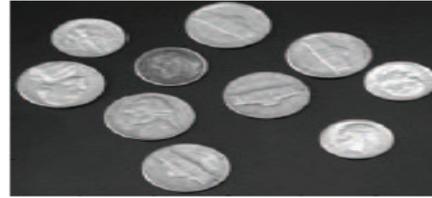


Figure 5.1: Original 246 x 298 coin image

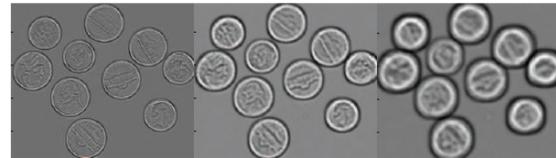


Figure 5.2: Edge map produced by the BEMD-based method with three iterations



Figure 5.3: Original 256 x 256 Lena image

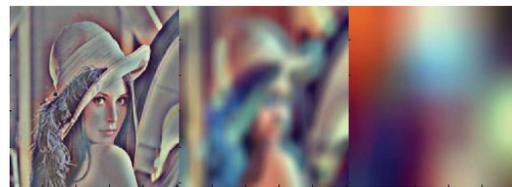


Figure 5.4: Edge map produced after three iteration of the BEMD-based method

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## Assessing an Organization's Transition to Lean

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### Abstract

Ever since the book 'The Machine that Changed the World' by Womack, Jones and Roos was published, many organizations have invested in the lean philosophy for their continuous improvement initiatives. Unfortunately, the level of reported success in implementing lean has been highly variable. This has led some organizations to limit or abandoning improvement initiatives even after significant resources have been committed to the efforts. To address this, lean researchers and practitioners have worked to develop better tools to aid in training, implementing and assessing lean. One focus area has been the development and testing of specific tools that focus on the assessment of an organization's lean implementation efforts. While the development of these assessment tools has helped continue the use of lean philosophy they have also raised additional questions related to increase in resources invested in making these assessments effective. The purpose of this research is to review lean principles and lean implementation assessment tools, and then assess the similarities and differences of these tools in order to make recommendations on how to improve the assessment process. Opportunities to build on these tools to support future implementations of the lean philosophy are also identified in this work.

### 1. Introduction

Ever since the early 90's when Lean came into prominence with publishing of the book "Machine that Changed the World", manufacturing has seen massive leaps in improvement in both quality and efficiency. The book had laid out studies that had been compiled of 5 years of industry research and ways and

approaches that could be used to eliminate waste and improve processes. Many studies have followed since, but there has been very less research done in the field of studying how one can measure Leanness. This has led to few researchers studying and presenting certain ideas by which this could be done but none have been simple to use and easy to implement. This brings us to the problem statement of my topic which we hope enables answer this question in an effective manner.

### 2. Theory Base for research

Lean methodology or Lean Thinking is not a new concept. It has been utilized in industry for almost a century and is an intrinsic part of our daily lives. The concept is very simple: remove 'waste' from a system. In this context, 'waste' is any 'non-value added activity' in a system. Value is defined as something the customer is ready to pay for. Therefore, if the customer is not willing to pay for something, it is waste and a drain on the resources of the organization. Today, Lean is utilized in a wide range of industries, nonprofit organizations, government agencies, healthcare, and organizations in other areas as a means for producing goods and delivering services that create value for the customer with a minimum amount of waste and a maximum degree of quality [8]. The main difference between the way manufacturing was undertaken in yester years and the way lean was implemented was the perception of the customer. The customer was treated as an entity at the bottom of the chain. A customer would have nothing to do with the product until it actually was on the shelf of a store or showroom from where he selected or picked it out for us. But with the introduction of Lean into the workplace, the customer is treated a very significant part of the product life cycle. The customer views and customer needs are studied

upfront so that the product to could be made and define with respect to him/ her.

The basic principles of Lean though have been around for more than 100 years now, starting with Henry Ford's concept of the 'Assembly Line' which was considered to be the first advent of Lean principles. Thereafter the Toyota Production System laid the foundation for the current form of LEAN. Toyota's development of ideas that later became Lean may have started at the turn of the 20th century with Sakichi Toyoda, in a textile factory with looms that stopped themselves when a thread broke, this became the seed of automation and *Jidoka*. Toyota's journey with JIT may have started back in 1934 when it moved from textiles to produce its first car. Kiichiro Toyoda, founder of Toyota, directed the engine casting work and discovered many problems in their manufacture. He decided he must stop the repairing of poor quality by intense study of each stage of the process. In 1936, when Toyota won its first truck contract with the Japanese government, his processes hit new problems and he developed the "Kaizen" improvement teams.

Levels of demand in the Post War economy of Japan were low and the focus of mass production on lowest cost per item via economies of scale therefore had little application. Having visited and seen supermarkets in the USA, Taiichi Ohno recognized that scheduling of work should not be driven by sales or production targets but by actual sales. Given the financial situation during this period over-production had to be avoided and thus the notion of Pull (build to order rather than target driven Push) came to underpin production scheduling. It was with Taiichi Ohno at Toyota that put these themes together. He built on the already existing internal schools of thought and spread their breadth and use into what has now become the Toyota Production System (TPS). It is principally from the TPS, but now including many other sources, that Lean production is developing. Norman Bodek wrote the following in his foreword to a reprint of Ford's *Today and Tomorrow*: "I was first introduced to the concepts of Just-In-Time (JIT) and the Toyota production system in 1980.

Subsequently I had the opportunity to witness its actual application at Toyota on one of our numerous Japanese study missions. There I met Mr. Taiichi Ohno, the system's creator. When bombarded with questions from our group on what inspired his thinking, he just laughed and said he learned it all from Henry Ford's book [7]". It is the scale, rigor and continuous learning aspects of the TPS which have made it a core of Lean.

The research will be based on earlier research on Lean which states cornerstones of the Lean Philosophy and using those cornerstones as attributes in survey to help assess the current state of the Lean process and also give is insight into what areas could be focused on in the future. The cornerstones will have under it a list of questions which, by a self assessment, would help in the measure of Current State of Lean Implementation in the organization. These attributes will be based on theories from various authors of Lean compiled from different articles, books and other technical literature. The methodology adopted thereafter, added with all the various inputs from dissertations, books and journal articles, will result in a complete solution to organization's need for a measurement of Leanness.

### 3. Significant Prior Research

The prior literature has led me to ask the research question and hopefully will lead to a solution that could be an addition to the body of knowledge and serve Lean organizations effectively. Few of the significant prior literature with their salient features and their respective positives and shortfalls of their studies are as follows;

The Shingo Prize Model is based on the lean management approach by Dr. Shigeo Shingo, a lean management consultant and considered to be one of the first proponents and contributors to the Toyota Production System. He has written many books on process, product and business improvement over the past years. His proposed model describes three levels of business improvement, which he calls levels of

transformation, namely, Principles, Systems and Tools and Techniques. This model emphasizes that true innovation is not accomplished when Tools and Techniques and Systems ('know how') are used but its true effect is only seen when the underlying Principles ('know whys') are understood.

Usually most organizations begin their journey in lean transformations by implementing tools and techniques. Once this is done they primarily try to sustain it by pushing their people on a daily or regular basis. This usually cannot be sustained over a long time as people tend to forget or get lazy or tend to take the easier way out when encountered with the grind of daily work life. Shingo proposed that the Tools and Techniques are the foundation on which all Lean transformation must be built, but further suggests that Systems level followed by an understanding of the basic Principles would further help cement this philosophy and the lean ideology forever in a person's mind thereby enabling deeper and a more permanent lean transformation.

The Shingo Prize was established in 1988 to promote awareness of lean concepts and to educate, assess and recognize companies that achieve world-class operational excellence status around the globe. The Shingo Prize philosophy is that world-class business performance is achieved through a deep understanding and integration of lean principles, lean systems of management, and the wise application of lean tools and techniques to create a sustainable culture of continuous improvement.

According to the model, Lean transformation is a journey that is composed of 4 dimensions: Cultural Enablers, Continuous Process Improvement, and Consistent Lean Enterprise Culture and Business results. These dimensions overlay five business processes, namely, Product / Service development, Customer Relations, Operations, Supply and Management. These

categories were so designed so that they encompass all activities within an organization, regardless of industry. There are weights given to each dimension in terms of points. The basis for awarding of these points is unknown.

As per this model, a self assessment report must be first submitted to the examiners, based on which the company is given the 'green signal' for an on-site inspection. There are finally 2 assessment scales; one for the Principles, Systems and Tools and the other for the Results. The score will finally put the assessed company at a particular level and further depending on the individual descriptors a qualitative assessment would be made to get finalized a high, medium or low standing within that level[9].

***Positives***

1. Based on the underlying principles that guided the Lean Movement, the Toyota Production System.
2. Weights in terms of points given for each dimension, which helps in quantifiable means of assessing Lean.
3. Uses a systemic view of Lean assessment.
4. Considers organization culture as a key driver for Lean improvement, which is seldom done in lean assessments.
5. Considers the right metrics to be the key driver for Lean improvement and assessment.

***Shortfalls***

1. There is a qualitative element in the tool which determines the high, medium or low within a dimension. This is highly variable.
2. The tool has to be assessed by examiners who are trained in the field of Lean.
3. The self assessment report could be inflated or misrepresented as it is a

self assessment made by management done in order to win recognition.

4. Basis for weights is unknown, which makes it difficult to understand the importance or priority of each dimension.
5. Not a real assessment of the situation as the visit is time constrained.
6. It has a flavor which suggests that it is conducted from a company perspective, a perspective which is keen on winning a prize rather than improvement of its people.

The importance of Lean in today's form in the western world is based on the 90's book of Womack, Jones and Roos, "Machine that Changed the World". This book laid the foundation for Lean philosophy. They proposed the tenets of lean thinking: Specify Value, Eliminate Waste, Make value flow, Pull value and Pursue perfection. This proved to be the basis for most Lean research in the years to come. They were the first to talk about value to the customer and make it the goal around which everything else was developed. This concept got more interest in the early 21 century when competition started to heat up between organizations. Their philosophy builds a case for the origin of lean from the non-productive days of mass production as early as 1955- differences between the Japanese and American approach to manufacturing especially auto- manufacturing. Further, their research talks about the key differences between mass and lean production: Leadership, teamwork, communication and continuous development. This provided a basis for which further comparison and studies could be made between the two. It was a qualitative study was a result of the 5 years of observation. It was not backed by much data analysis. It was the first detailed book or literature about lean and its principles in the western world [1].

### ***Positives***

1. Set the foundation on which lean is being practiced to this date in the western world.

### ***Shortfalls***

1. Not a quantitative study
2. Literature did not state any method of lean assessment.

Karlsson and Ahlstrom in 1996 developed a model for Lean which formed a basis for the attributes of Lean Teachings. Their research was conducted over 2 ½ year period with 3-4 days a week observation done to collect data- clinical field study. They developed 7 attributes to assess lean production and also the determinants that define these attributes. These determinants were only studied as increase or decrease in it rather than a quantity. They also proposed that quantitative measures for each determinant could be established to help put numbers behind each of the attributes. Further, they also made a significant point, that lean is not a state but a journey, a journey of change [2].

### ***Positives***

1. Was one of the first researches that tried to break up 'LEAN' into its elements
2. Defined lean in terms of which it could be quantified at a later time

### ***Shortfalls***

1. Uses only the book, "Machine that changed the world", to develop its set of attributes. This is a very small literature background to draw conclusions.
2. Tested in only one organization.
3. Qualitative study, nothing quantifiable.

A study done by Massachusetts Institute of Technology (MIT) based LAI's (Lean Aerospace Initiative) developed LESAT (Lean Self-Assessment Tool) which could be used to assess the extent of Lean implementation within the organization and the areas of improvement. It is very detailed and has a lot of pre-understanding of the tool before the assessment is done. 54 lean enterprise practices are assessed.

A CMM scale is used to assess each practice with respect to maturity. The tool was divided into 3 sections; Transformation/ Leadership, Lifecycle processes and Enabling Infrastructure. Each section is defined and certain enterprise characteristics are laid out in order to measure the construct or factor [10].

**Positives**

1. Current state of Leanness can be obtained
2. Used over the complete organization
3. Very extensive in-depth assessment

**Shortfalls**

1. Cannot be used over a particular department or workstation
2. Patience required in completing a 68-page document is very important, because if impulsive it could lead to answering tool in a very relaxed manner.
3. Extensive knowledge of the company required in completing the assessment successfully which may be difficult to get
4. Does not benchmark a company against an ideal industry standard and does not provide direction for improvement under cost constraints
5. Need in-depth training to make evaluation and come to conclusion and thus usually consultants are used to make these assessments.

Eugene Goodson in 2002 wrote an article in the Harvard Business review about how an organization could be assessed based on some key observations. He developed a Rapid Plant Assessment Tool which places key visual information over numbers as they provide more information to the assessor. This was further divided into 2 assessment tools: RPA rating sheet (11 categories) and the RPA questionnaire (20 questions). His research talks about how to select a team and give the required necessary to build a team to make this assessment [3].

**Positives**

1. Could be used for Benchmarking, Competitor analysis and Strategic Acquisitions

2. Simple to understand as the questions asked are very simple and straightforward, making it easy to implement
3. Has extensive numerical data to back up its claim as they have been student from universities who have used the tool for their studies and report back their findings on a common website.
4. Helps in estimating a plant's Cost of Sales which requires more experience

**Shortfalls**

1. The questionnaire has only 2 options in questionnaire: yes and no- This would not help is preciseness of answers as it does not register what the true feeling of the answer is. This creates a bias in the solution.
2. Need to be extremely well trained to make the assessment because it is only well trained team that can make these assessments.
3. There is no basis for the 11 categories chosen - has not been validated for content

Hung-da Wan's dissertation on measuring Leanness using the DEA (Data Envelopment Analysis) technique, wherein he uses this Operations Research method to help develop a leanness frontier against which one can plot the current state of Leanness of the organization. A Slacks Based Model was used to develop a method to measure the current Lean state and the direction of potential improvement [5].

**Positives**

1. Measured leanness and Identified the directions for improvement for manufacturing systems
2. Highly quantitative
3. Shows that the SBM model is more effective than the CCR model for leanness measure using the DEA technique.

**Shortfalls**

1. Hypothetical cases of different scenarios were created to verify effectiveness of methodology

2. Discrete rather than continuous events were used in this analysis
3. Updating the model is of utmost importance whenever any changes are made which could pose a problem in a production environment, especially since any of the decision making units (DMU) can change on any given day.

A study of Lean measurement by using the Mahalanobis metric by Allada and Srinivasaraghavan in 2006 concluded that Lean implementation could be measured by finding the distance of the various variables in the model and comparing the standard data to the abnormal data from the information collected. This method benchmarks against an industry standard. It facilitates direction for continuous improvement of a particular workstation or department with the positive and negative signs. It uses only 5 tangible attributes in the model chosen from the LESAT instrument. Further, it takes into consideration interrelationship of variables in the model by using the MTGS (Mahalanobis Taguchi Gram-Schmidt) system in the model [4].

***Positives***

1. New quantitative techniques that can prove to be successful if all variables can be made tangible and quantifiable
2. Can be used at various levels: organization, department and even specific areas

***Shortfalls***

1. Uses a limited number of variables to be applied in the model.
2. Uses a real sample of 7 and further extrapolates for normal data and further, uses only 4 data points and creates fictitious data for the 8 samples for abnormal data

Next, the critical success factors as described by Achanga et al. in 2006, could help the research gain focus towards achieving its objective. The study involved data that was collected from 10 SMEs and 3 large scale organizations in the form of observations and semi- structured interviews. They spent approx.

30-min at each particular point of observation [6].

***Positives***

1. Arrived at 4 key success factors for lean implementation, leadership and management, finance, skills and expertise and finally culture of the recipient organization
2. Study determined that Leadership and Management commitment was the most critical
3. The study also maintained that lacking of funding denies hiring a good management team and therefore lack of astute leadership which in turn prevents SMEs from implementing improved strategies

***Shortfalls***

1. Skepticism within SMEs about the benefits of Lean to their business, therefore lack of willingness to provide data was observed
2. Also noted was the fact that the sample was small and that further analysis regarding interrelationship of variables would be interesting to investigate
3. Quantitative analysis was minimal to none
4. 30-Minute observation is not good enough for an observation type of data collection.

There have been many other research articles and dissertations that have helped me narrow down my research, but at this point in time the above mentioned papers played a vital role in creating a focused topic. I now feel the need to further narrow down my topic which will make it a focused solution rather than a generalized one.

**4. Possible Methodology**

The possible methods by which this can be resolved as given below;

1. The first, by using a current invalidated survey and help answer the questions that my research poses regarding the

degree of leanness of an organization and also the direction of improvement that management want to take in future improvement efforts, thereby in the process creating a validated document which can be used for further research.

2. The second, by creating some kind of a mathematical formula that would help ascertain the same. By possibly giving weights to the attributes one can arrive at the final answer for the measurement of Leanness.
3. The third possibility is by creating a survey which would not only help in the measurement of Lean but also inform us of the lack of it with respect to certain attributes. This method would entail, to first developing attributes which would best measure lean and its philosophy and then validating it for content and construct. Content validity can be accomplished by using subject matter expert to validate the instrument. Once that is complete, as a part of a pilot study, the survey would then be given to a set of about 25-50 people who have used Lean for a certain period of time professionally. Once that is complete, the survey would then be subject to a larger sample which could help is complete validation of the methodology and solution.

## 5. Possible Outcomes

This study has the following potential outcomes if successful;

1. The Literature study would lead to a set of attributes would be key indicators which when measured would give us and understanding of the Lean philosophy and the extent of its implementation in the organization.
2. This further gives us a measure of the Lean implementation which would help us to easily benchmark itself with the best of the industry.
3. This would also help us to easily assess the previous improvement efforts and analyze the direction of improvement.

4. The measure would help the organization decide whether their financial investments have paid for it and also opportunities for future investments.
5. The survey would be easy to complete unlike the LESAT which is a 68-page document and requires some amount of prior knowledge and understanding of the tool.
6. As a result of this research, there would also be a consensus on the improvement efforts rather than just the manager's view, which is the norm at the moment in most organizations.

## 6. Conclusion

In conclusion this research strives to find and dig deep into the solutions available to make a lean assessment. It further expands the key features of each tool as well as the positives and shortfalls of each tool thereof. The positives and shortfalls are way to realize that lean principles can be so complex that finding a best method to assess it is indeed going to be a challenge in itself. The study goes on to further suggest a possible methodology to deal with this problem and also a list of plausible and possible outcomes that can be derived from this method. This would enable for a tool which would not only have an effective way to assess Lean but also do it success using lesser resources and a better perspective of the whole implementation from an employee's perspective. In conclusion, if one has to really experience the complete benefits of Lean it is of utmost importance to be able to assess it in an effective and efficient manner with complete endorsement from all levels of the organization. This would further endorse the positive effect that Lean has made and will continue to make, to all organizations in the years to come.

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## **An Industry-Academia Partnership for the Design of a Robotics Technology Curriculum**

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### **Abstract**

It is well recognized that the United States must invest in Science, Technology, Engineering, and Mathematics (STEM) training and education to prepare a workforce to globally compete in the 21<sup>st</sup> century. To accomplish this, more academic and industrial partnerships and collaborations must be created and supported to address K-12 challenges and post-secondary curricula to develop the technical skills and knowledge for product and process innovation. The National Science Foundation has long encouraged the need for these partnerships, and has supported numerous collaborations focused on curriculum design for workforce development. This project discusses the relationship between a community college, several four-year institutions, a small business, and a major corporation to develop critical thinking and technical skills through robotics for high school and college students of multiple universities. A NSF sponsored partnership of Baltimore City Community College (BCCC), Morgan State University, Pace University, Carnegie Mellon University, Juxtopia, LLC, Lockheed Martin Corporation, and the NSF Advanced Technology Education TIME Center, will describe their configuration and their efforts to increase the number of underrepresented and qualified technicians for autonomous robotics and with a designed curricula to develop a Robotics Technology Program at BCCC. This

paper will describe the Robotics Technology Program Model (2+2+3), and an academic career pathway from the Baltimore City Public High School System (BCPSS) to the Robotics Technology program at BCCC. The program also supports the transfer to four-year institutions, and internships with local industry that helped design the curricula.

### **1. Introduction**

According to business and technology analysts, the robotics industry will rise from \$4.4 billion in 2003 to \$5.9 billion in 2010 and fuel electronics growth [1]. Industry analyst expected the total robot OEM sales revenue, initially dominated by heavy industrial robots, to rise from US \$5.7 billion from 2004 to US \$32.6 billion in 2009, a CAGR of 415 percent [2]. The worldwide robotics market surpasses \$8 billion where Japan and the United States lead the market, respectively. Additionally, the sales volume for a class of professional service robots, medical robots, is expected to reach \$2.08 billion by 2010. Furthermore, the international Federation of Robotics has estimated that there are currently 6,400 medical robots in use around the globe [3].

To supply the workforce needs in areas related to robotics, The Technology Collaborative (TTC) conducted a study in 2004 involving regional and national robotics companies, university researchers, military and civilian contractors. The study identified robotics technician and technologist work-force

needs that may be filled through an articulated robotics technology education program [4]. The study indicates that robotics technician will be in high demand throughout various industries including: medical technology, military, homeland security, automotive, aircraft, and etc.

NSF data revealed that in 2000 only 7.5% of engineering/science technicians were African American [5]. This percentage is considerably lower than the 12.2% national population of African Americans [6]. To increase the number of African American technicians, more African American technicians must be trained in emerging technologies such as robotics and the undergraduate engineering enrollment/retention /success rate for African American students at community colleges and four-year institutions must be significantly increased.

## 2. BCCC Robotics Technology Program

The National Science Foundation (NSF) has awarded a grant of \$870,521 to Baltimore City Community College to develop a robotics technology program with the support from Morgan State University, Pace University, Carnegie Mellon University, Community College at Baltimore County, Juxtopia LLC, and Lockheed Martin Corporation. BCCC Robotics Technology Program trains students to be SUPER TECHNICIANS who can be hired as robotics/automation/ manufacturing/electronics technicians. The BCCC Robotics Technology graduates can also earn enough credits to transfer to Morgan State University to pursue BS degree in Engineering with the concentration in Robotics.

The program is the only robotics associate degree in the State of Maryland and the neighboring states. The course sequence for this two-year program is listed below.

### SEMESTER 1 (15 credits)

PRE100 Preparation for Academic Achievement  
 ELC101 Mathematics in Electronics  
 ELC 120 DC Circuit Analysis  
 MAT 128 College Algebra  
 RBT 101 Introductions to Robotics  
 HLF Health and Life Fitness Elective

### SEMESTER 2 (16 credits)

ELC 121 AC Circuit Analysis  
 ELC 151 Digital Fundamentals  
 EGN 101 Engineering Graphics  
 RBT 102 Fluid Power and Components  
 CSC 108 Programming in C  
 HLF Health and Life Fitness Elective

### SEMESTER 3 (16 credits)

ELC 131 Semiconductor Devices  
 PHY 101 College Physics I \*\*  
 RBT 201 Computer Assisted Manufacturing  
 ELC 251 Digital Systems/ PLCs  
 CADD208 CADD Mechanical Applications

### SEMESTER 4 (16 credits)

ECO 201 Macroeconomics  
 RBT 203 Robotics Applications  
 ENG 101 English Composition  
 SP 101 Fundamentals of Speech  
 Social and Behavior Sciences Elective

TOTAL - 63 credits [Note: If students want to transfer to Morgan State University to pursue BS degree, they will be advised slightly differently in Math and Physics courses]

## 3. Industrial partnerships

In order for the BCCC robotics technology program to be successful, industrial partnerships are essential.

### 3.1 Partnership between Juxtopia, LLC and BCCC Robotics Technology Program

Juxtopia is a human performance company that improves human learning and health performance with innovative product/services. Juxtopia's human performance products and services range from wearable biomedical devices to prevent disease, illness and injury to wearable devices that assist humans learn and make decision in the face of complex scenarios. Juxtopia® Learning division develop custom interactive and mixed-reality learning simulation composed of both virtual reality and augmented reality technology. The partnership between Juxtopia and BCCC robotics technology program includes:

- (a) Internship opportunities for BCCC robotics technology students at Juxtopia;
- (b) Technical assistance to BCCC Robotics Technology Program;
- (c) Provide Juxtopia's augmented reality based instructional system to facilitate this mixed reality robotics instructional intervention to assist BCCC Robotics Technology Program;
- (d) Commercial Readiness Evaluation for BCCC Robotics Technology Program graduates; and
- (e) Job opportunities for BCCC robotics technology graduates at Juxtopia.
- (f) Provide work study/scholarships (Up to \$10,000) to qualified BCCC robotics students

### 3.2 Partnership between Lockheed Martin Corporation and BCCC Robotics Technology Program

Headquartered in Bethesda, MD, Lockheed Martin is a global security company that employs about 140,000 people worldwide and is principally engaged in the research, design, development, manufacture, integration and sustainment of advanced technology systems, products and services. The corporation reported 2008 sales of \$42.7 billion. The partnership

between Lockheed Martin Corporation and BCCC Robotics Technology program is including the following:

- (a) Provide assistance and/or suggestions to make the BCCC robotics technology program commercial ready or industrial ready.
- (b) Introduce some internship/job opportunities to BCCC robotics technology graduates.
- (c) Help develop recruiting materials for BCPSS high school students
- (d) Provide detailed guidelines for the equipment selection of the BCCC Robotics Lab.

### 3.3 New Industrial Partnerships Under Development

BCCC Robotics Technology program is currently developing partnerships with Northrop Grumman, Black & Decker, and other local industries. The partnerships will focus on the internships and job opportunities for BCCC robotics students and graduates.

### 3.4 General Commitment of Industrial Partners

For all industrial partners, the general commitment to BCCC robotics technology program is listed below.

- a. Advise the process of curriculum design.
  - Provide the industrial insights for the skill sets of a qualified robotics technician.
  - Serve as the advisory committee member for BCCC Robotics Technology Program.
- b. Participate in the instructional design for curriculum courses.
  - RBT 101 Introduction to Robotics
  - RBT 102 Fluid Power and Components
  - RBT 201 Computer Assisted Manufacturing
  - RBT 202 Robotics Applications
- c. Serve on the Advisory Committee of the BCCC robotics technology program.
  - Provide change trends of the changing

- industries.
- Attend regular meetings with BCCC Robotics Technology program twice a year.
- d. Provide guest speakers to BCCC robotics technology students
  - Encourage students to pursue technology or engineering as their professions.
  - Explain the importance of the mathematics in robotics fields.
- e. Recruitment and Transfer Assistance
  - Work with BCCC Robotics Technology program to recruit BCPSS high school students into BCCC robotics technology program
  - Work with both BCCC robotics technology program and Morgan State University to help BCCC robotics transfer students to complete their BS degree in engineering in three (3) years after graduating from BCCC robotics technology program.

#### 4. Current Status of BCCC Robotics Technology Program

The Robotics Technology Program at BCCC was approved by the Maryland Higher Education Commissions (MHEC) on 9/2009. The program officially started on 9/2009.

Currently, BCCC Robotics Technology enrolls 30 students, who are coming from BCPSS high schools, veterans, and surrounding communities.

As of May 2010, two (2) students will transfer to Morgan State University for bachelor's degrees in Engineering with the concentration in robotics.

During the first year of the program operation, the retention rate of robotics students is around 90% which is better than the college average. The average GPA of all robotics students is around 2.67 which is also significantly better than the college average. [7, 8]

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# Healthy, Efficient, and Affordable Lunch System (HEALS) a Decision Support Tool for School Cafeteria

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## Abstract

One of main concerns from parents regarding their kids' school other than quality of education is the quality of food served in the school cafeteria. Due to limited budget and manpower schools often serve preprocessed foods with low nutritional value. We propose a Healthy, Efficient, and Affordable Lunch System (HEALS) to aid schools in designing the menu for their cafeteria. HEALS considers nutritional value, available inventory, preparation and cooking time while providing a variety of food type. HEALS also further emphasizes proper food preparation and serving of food along with possible recommendations for the school inventory in cooperation with local producers. We believe that this tool will aid school officials in providing healthy, affordable and delicious foods to students of all ages.

## 1. Introduction

Food service is a challenging environment with many factors that influence the menu provided. These factors include: demand and supply of food, cost, nutritional and dietary guidelines, regulations on service and nutritional requirements. Additionally, to maintain healthy environment training for safe handling, storing and cooking food items are required.

Most decisions are made on only a sub-set of the overall information due to the complexity of the problem. These decisions tend to be predominately based on the cost of providing the

service with nutritional value rated a distant second. Menu and supplier choices are reduced to make the supply and preparation decisions easier on the administrator and kitchen staff. In addition, food handling and cooking standards are also neglected, which increases the risk.

Current solutions rely on federal regulations and oversight that set and maintain the minimum requirements for compliance in exchange for federal subsidies. While this solution does alter the price, provide a mechanism to raise the nutritional value and control the food provided, the effect is artificial as it merely shifts the cost to the agency mandating the change and shifts the burden of adhering to the change on the school administration. A key shortcoming of this approach is when funding for the subsidies is no longer available or insufficient, the program fails.

In addition to the long term consequences the short term effect of the mandated subsidies is the increase on overhead to manage the bureaucracy and uphold the standards as the effects and the requirements change. Due to poor oversight, the additional overhead increases the direct and indirect costs of the service and the regulations become outdated and fail to adhere to current issues. In various news reports we see examples of the failure of the regulations to keep with the advances of time are observed. USA Today reports that ground beef that was recalled for salmonella from retailers was not recalled from school lunch programs even though it was packaged at the same plant during the recalled

dates [1]. A separate report found the meat bound for schools is tested only one time for a 100,000 pound run of ground beef while the commercial beef was tested 10 times for the same amount [2].

In addition to the health concerns, prices for school lunches have outpaced subsidies causing additional strain on the educational system. The basics staples that compose the program, milk, cheese and bread have increased as much as 17%. The increase in expense outpaced the government subsidies increase of 3% [3] and the shortcoming has caused additional expense on the schools, which have to look for new ways to reduce cost or ways to fund the shortfalls. One of the fundamental properties of food contributing to the expense is the short product life cycle in production and storage. As quoted from [5], "Shorter product life cycles and greater product variety increase supply-chain cost". This is precisely the environment the school cafeteria is in as the life cycle revolves around the expiration of the food and seasonal pricing. The typical solution is to reduce the variety of the food, which tends to be bad for nutrition and makes the supply more susceptible to larger price volatility when the resource comes into short supply.

Example: Latest tomato shortage in Florida caused by an extended cold weather pattern shows the effects caused by unpredictable events and the regional nature of production. Destruction of 70% of the tomato crop was destroyed in Florida which supplies the largest amount of fresh tomatoes in Feb.-Mar. The effect is a short term increase in price from \$6.45 in 2009 to \$30 in 2010 for 25 pounds of tomatoes [13]. It is anticipated that the price will return to the seasonal norm in April 2010 as the production shifts to new regions.

In addition to the minimization of the food types available in the menu, the limited amount of supplier choices have a detrimental effect on price by reducing competition vital for fair and

competitive pricing. In addition to the power competition brings, the free market has the ability to adjust to changing conditions better than the contractile based food service model. For example, fuel prices were primarily blamed for the increase in food prices, however, the price of fuel has reduced considerably from its peak while the cost of the lunch program and the subsidies remain the same. The excess is simply absorbed into the system and the price for the end items is constant or ever increasing. If competition for the funding was present, the competitors would have a lower price more commensurate with the conditions and bring the food service cost down after the spike in prices subsidized.

Cooking and sanitary inspections are also a requirement although USA Today found 26,500 school cafeterias lack required inspections as part of the school lunch program [4]. The Federal Government's answer to the problem is more regulation scheduled for July 2010. This is in part to lack of literature, training, adequate supervision and reporting.

HEALS proposes the use of a decision support system (DSS) that integrates several predominate factors including cost, nutrition and meal planning. HEALS is designed around the usage of currently available technologies and the vertical consolidation and horizontal sharing of information to reduce the cost and complexity of the current system. HEALS facilitates more efficient decisions based on free-market prices and the ability to allow input and analysis at multiple levels within the educational and governmental systems. Cooking instructions are available through HEALS, as well as food handling procedures to address safety concerns. HEALS is designed to work on a distributed environment to take advantage of the knowledge and experience of other cafeterias.

## 2. Related work

Pricing has been shown to have a drastic effect on the purchase habits in schools and in daily life. Price reduction of 50% on fruit and salad items resulted in 3 times the nominal number of sales of the same items at standard prices [5]. Price reductions in vending machines of 10%, 25% and 50% on lower-fat snacks resulted in an increase in sales of 9%, 39% and 93%, respectively, as compared to usual-price conditions [6]. The results indicate the power of pricing on the consumption of items.

The impact on diet based on the availability of items has been studied. School policies which decrease access to high fat and sugary food are effective at decreasing purchases of these items [7]. A key component of price and availability is the efficiency to manage and interact with the supply train. Both of these studies show that price is effective at affecting demand of an item and it is the hope of this work to leverage this ability with the use of a DSS and several technologies.

An area that drastically affects the end cost of the product is inventory control. Current methods of using UPC labels and barcodes are the standard for tracking items. The problem with UPC is the Line-of-Sight (LOS) requirement making the system labor intensive and providing limited information in the process. Radio-Frequency IDentification (RFID) is an evolving replacement for UPCs, which offer non-LOS ability. In addition, the ability to store additional information, such as temperatures, bacteria levels, production and expiration dates are important to control perishable items [8]. Use of these technologies can drastically reduce the management required for a dynamic environment while providing more information to reduce inefficiency.

## 3. Healthy

The premier function of the HEALS DSS is to provide healthy food to the consumer. In order to accomplish this task, HEALS must first quantify and acquire a list healthy foods. HEALS accomplishes this task in a two step process. The first step defines the metrics for nutrition for the populous being catered and the second step is acquiring the list of foods which meets the requirements.

Step one uses the guidelines setup by the Federal Government to acquire the minimum metrics defining nutrition for HEALS. The food pyramid is one of the most influential guidelines recommending the ratio of food groups per day. The recommendation for boys and girls ages 4-18: 3 oz. of grains, 1 ½ -3 cups of vegetables, 1 - 2 cups of fruit, 2-3 cups of milk, 3-6 oz of meat and beans, sparsely use oils [9]. The range given in the amount of fruits and vegetables depends on age 4-18 and sex.

In addition to the food pyramid the lunch system must adhere to the requirements of the national school lunch program provided by the USDA in order to obtain subsidies currently in place. The national school lunch program is loosely based on the food pyramid with the Type A program roughly adhering to the 1/2 to 1/3 the portions described in the food pyramid [10]. Those schools adhering to the requirements receive subsidies and meals are distributed to the students based on need.

The pyramid and the national school lunch program provided the minimum requirements for nutrition and HEALS adheres to these requirements by only selecting the foods adhering to these regulations for the possible food list. Additional regulations and changes to existing regulations can be accomplished dynamically, which ensures scalability of HEALS to meet future demands. The consolidation of the guidelines and regulations provides a simple check sheet to acquire the possible food list, however, food services

require additional information to insure the meal served has the appropriate nutritional value.

The second step for HEALS is to retrieve the required additional information for each food item in the food list provided in step one. HEALS uses resources currently available as the information base and enhances this knowledge with a shared information system.

The USDA will be the primary resource for HEALS in regards to nutrition as it publishes the "Composition of Foods Raw, Processed, and Prepared USDA National Nutrient Database for Standard Reference" [11]. This reference is a relational database of nutritional information from a multitude of published and unpublished sources and is accessible online and via download. The ability to download and use this information makes it available for augmentation using other sources as the database is extensive and for practical reasons cannot be entirely complete. Products are constantly changing and most of the USDA information is for general consumption. For those items not in USDA or insufficiently referenced the use of web-services, RSS feeds, web-crawlers or mobile agents are utilized to retrieve the information from the product website or product distribution sites.

The retrieval of nutrition information must be easy and efficient due to the potential amount of items in the food list. HEALS accomplishes this with the use of distributed database techniques which links the members of HEALS and provides efficient indexing and search of already gathered and utilized information from members within the HEALS network.

Figure 1 illustrates the concept for gathering and consolidating the information available. The Food Pyramid and the school lunch program requirements are utilized as the bases to establish a possible food list. The connection to the National Nutrient Database, other HEALS members and product websites provide a comprehensive list of food to be sorted by

nutrient value. The distributed nature of HEALS using the internet as a WAN to connect the DDB and the USDA, product websites and product distribution sites is displayed in Fig. 2.

#### **4. Efficient and affordable**

In Sec. 2 it was noted how price can be used as a measure to substantially influence the purchase of healthier food. One way to influence price is through the implementation of subsidies by governmental and other agencies, however, the problems with this approach is that it neglects the free market's ability to maintain prices. A better solution to acquire affordability is to increase the diversity of the food sources thus increasing competition. Additionally, the efficiency of the supply, storage and consumption of the food should be analyzed and improved in real-time as these tasks have drastic effects on the cost of the system.

HEALS partly accomplishes the diversity of food resources in Sec. 3 by expanding the possible food list to the maximum and not relying on a simple method that minimizes the menu to a short list of the overall resources available. In order to expand the diversity even further HEALS increases the number of suppliers of the food items.

Current methodology with the reduced menu allows for a single supplier to bid on facilitating the service for a set period via contract. This partially works as several bids would have free market effects. However, in some cases only one supplier bids. In addition, just because the one supplier can produce the overall requirements for the least cost does not mean that a combined subset of the requirements issued to several suppliers could not reduce the cost to the lunch program. For example, suppliers that specialize in a specific area like fish will have a better price than the general supplier. The general supplier is most likely using this specialist which makes the general supplier a middle man producing extra overhead.

The main reason the current methodology is in place is for ease of management as the administrator does not have to think about what is served at lunch or who delivered it. In order not to increase this burden on administration and management, HEALS incorporates the suppliers into the overall network.

In Sec. 3 we have a food list required to meet the nutritional standards specified by the Federal Government. All suppliers integrated into HEALS can supply their price for that item updated in real time. This has two effects: diversity of the suppliers increases competition and the real-time bidding allows for dynamic decisions to adhere to the dynamic nature of food service. Both of these effects demand lower prices with little more complexity to the current system. The real time nature allows for seasonal prices to be taken into consideration as well as unforeseen events such as the tomato shortage referenced in Sec. 1. In the case of a tomato shortage HEALS suggest alternatives to tomatoes with the same nutritional value with the cost close to the nominal value. Any price less than the increased tomato price would have a net positive effect. Local farmers, co-ops and student farming can also be involved in the system preset in the systems to further reduce price and involvement in the schools by the community.

Once the food is purchased it must be efficiently stored, distributed and consumed. Efficiency in this case is defined by the least amount of waste with production adhering to lean production methodology. Analysis shows three major factors influence the amount of waste in the food service industry: spoilage, final product not dispensed, and product dispensed but not consumed.

Spoilage occurs when food is not utilized before the expiration date or not properly stored. Compounding the problem is that perishable items tend to be more expensive and the spoilage of the items has a drastic effect on

affordability of the service. Since most items in catering expire rapidly and at varying rates inventory control is a high priority.

Dairy products which are required by lunch program are one of the high spoilage items. Two of the main factors that influence the spoil time of dairy are the temperature at which it is stored and the duration in storage until consumption. The expiration date on the container and the temperature gauge on the refrigerator unit are the main source of the knowledge for milk. The current methodology is to monitor the temperature at set intervals and to rotate the stock, so that the oldest product is served first. Both of these processes are manual which may not adhere to LEAN management practices and are also prone to human failure.

HEALS incorporates the use of RFID tags to track the expiration date, the date arrived on site and the temperature throughout storage. Although RFID is expensive for one time use applications, the RFIDs used for HEALS are local to the application and can be reused to mitigate the expense over time with the reduction in man hours and spoilage by human error or mechanical fault. In addition to milk all other short life cycle perishable items like cheese and meat can be monitored on the same system.

The second cause of waste is the product not being dispensed which results in the product being trashed or at best donated to soup kitchen. Although the main cause is over production, the product not being dispensed has several possible reasons. This failure is attributed to the standard decision on how much food to create based solely on the number of students expected to participate in the program. This does not take into consideration any trends or product demand and may cause considerable waste. HEALS uses data mining to analyze trends based on observation. Neural networks and Bayesian inference are ideal to use observational data of the amount of a food item produced, the number

of student viewing the item and the number of food items dispensed. This information is collated to reveal the future demand of the food item and make a better decision on the amount of production.

The last cause is the food items not being consumed after they are dispensed. This results in wasted food as well and adds additional possibilities to the reasons why the food item is wasted. Major reasons including the student is full or did not like the taste. The student being full is not addressable by HEALS nor should it be as the students could not predict this event. The most important result is the student not enjoying the taste. This implicates that the student will not partake in the food item the next time it is offered and thus effect the data mining accomplished on food not dispensed. By surveying this event before the next production of the meal plan HEALS avoids the over production on the next iteration.

Note: although the ideal is to produce just as much as needed any error should be in over production. Not feeding the students is not an option, thus some degree of tolerance must always be incorporated.

## 5. Lunch and Meal Planning

The final task in the decisions support system is to centralize all the required information: menu options, literature and certifications required for the menu items and provide vertical reporting of the entire system to all required agencies to achieve appropriate oversight and provide decision making capabilities.

HEALS uses a bottom-up approach for this display as the regulations and decisions are top-down. Information will also be shared horizontally to equivalent agency to allow for information sharing and collaboration on what works. At the bottom of the hierarchy is the lunch staff serving and preparing the food. The first major item for HEALS is to provide the list of possible menu items proportioned according

to the food pyramid. This information is available to the lunch planner in real-time with a simple selection of the major food groups to complete the menu. Once the menu is completed the food preparation and cooking instructions for the menu of the day are provided to the cooking staff. This allows the food service personnel to handle the menu items provided by HEALS in a safe and efficient manner. Checks and balances can also be applied and recorded in HEALS to maintain accountability. The food service workers at the end of the service will provide HEALS food not dispensed information for analysis by HEALS as explained in Sec. 4. In order to track the portion dispensed and uneaten, a combination of the lunch personnel observation entered into HEALS and students surveys are used in order to solicit the required input. This information is collated to determine the usage effect on spoilage as described in Sec. 4.

This information is collated into reports to the food service director and staff in charge to help them to make the appropriate adjustments to the system. For example, if lima beans are not adequately consumed, but an equivalent vegetable source is better, using the trend analysis engine the administration can minimize or eliminate the vegetable from the list.

As stated, a key inefficiency to subsidies is the added oversight required to make sure the entities adhere to the regulations. HEALS reduces the inefficiency by providing information to both the school administration and the regulatory systems. The reports generated by HEALS show the nutritional value actually being served by the school, the amount consumed by the student, and the cost of the meals. This information allows not only for more efficient management within the school district, but it also allows for quick inspection by the USDA on compliance. The survey of the students provides the checks and balances demonstrating that what is stated in the record is

actually severed and that the nutritional and proportion data collected in Sec. 3 fulfills the requirements.

In addition, to the vertical component of HEALS described, a horizontal component is also available by sharing the information with other schools within the network. The horizontal component allows for menu plan sharing, cost analysis, supplier information and product information pricing. The vertical and horizontal components also provided a mechanism for distributed intelligence and facilities communication between all the organizations involved in the food service. The mechanisms reduce overhead and subsequently cost of service.

### 6. Conclusion

The food service which provides school lunches is a complex environment involving decisions that affect our children’s daily lives. As such, special attention is needed to facilitate these decisions and provide the student with a healthy and affordable lunch. HEALS simplifies this process by using several technologies to gather and collated information in a centralized location. This information includes nutritional and regulator guidelines applicable to school lunches as well as the food list with applicable nutritional values.

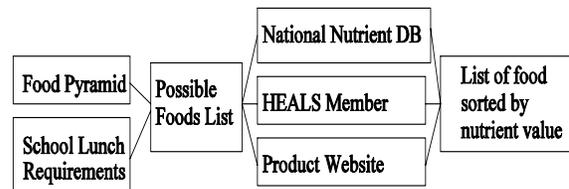
Suppliers are integrated into the system to allow real-time pricing and to diversify the supply sources to reduce the cost of the food items. Inventory control and lean protocols are integrated in order to minimize waste and better sever the students.

Once the information is gathered it is vertically and horizontally distributed in order to enhance the decisions and insure proper adherence to safety and regulatory guideline.

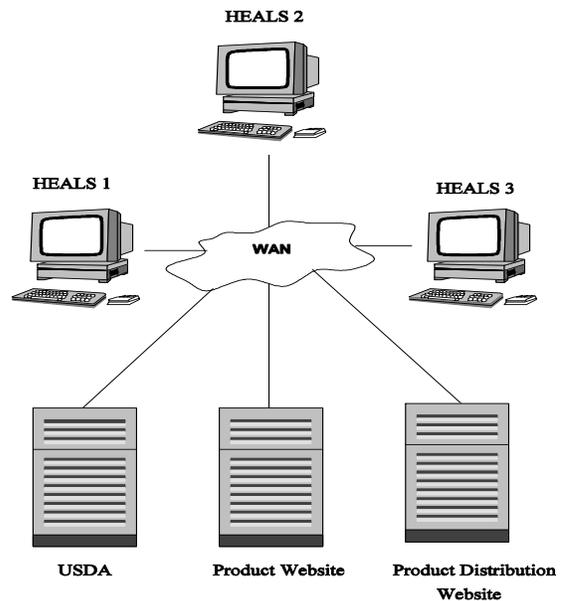
It is the hope of the authors that this system will be put in place to reduce the complexity of the situation regarding the lunch menu and allow

the administration to focus their effort back to the primary task at hand: educating the children.

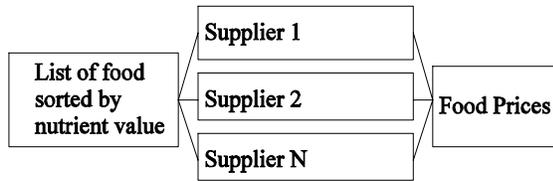
It is noted that several of the information sources and technologies can be enhanced once the original system is in place and operational. The purpose of this work is to make the initial proposal and lay the groundwork for the overall system.



**Figure 1. Health: Retrieving best nutrient food list meeting the USDA requirements from the NNDB, HEALS member of product website.**



**Figure 2. Distributed connectivity for the retrieval of nutritional information.**



**Figure 3. Connection diagram of Suppliers to HEALS generated food list allowing them to bid in real time on supplying the resource.**

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## Statistical Analysis on C-5 Aircraft Pod Panel Damage

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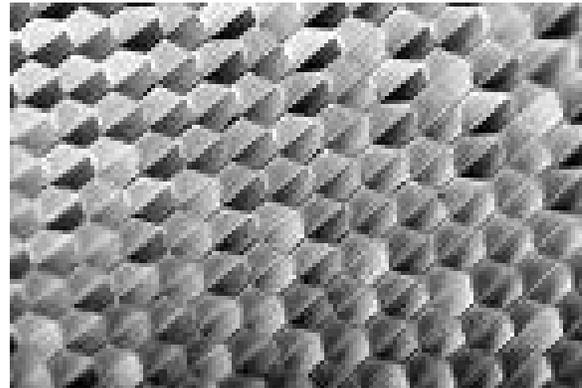
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### Abstract

The C-5 aircraft program office engineers at Warner Robins Air Force Base, Macon, Georgia are having repeated problems repairing landing gear pod panels. These landing gear pod panels are honeycomb panels, each having a distinctive curvature. The ideal repair is to remove the damaged panel from the aircraft and replace it with a new panel; however there are no molds available from which to make new panels. Therefore, engineers are continually attempting to repair the damaged panels on the aircraft, which is many times unsuccessful. The statistical analysis on the aircraft's pod panel damage explores the effects of three different factors on the size (area) of the delaminations that occur: the age of the aircraft, the location of the panel, and the distance between the damage and an existing repair. Two different statistical tools are used to analyze the data, which allows for more accurate conclusions: single, one-way Analysis of Variance (ANOVA) tables are used to find the individual significance of each factor on the area of damage and a multiple linear regression is applied to the data to find the significance of the aircraft age and distance from damage to an existing repair on the area of damage. Using the knowledge of where these panels are susceptible to damage, measures can be taken to prevent delaminations from occurring in these "damage-prone" areas resulting in savings in the materials and man hours.

### 1. Introduction

There are three panels around the main landing gear on the C-5 aircraft [1-3]. For the purposes of this analysis, they have been referred to as the "left", "right", and "center" pod panels. These panels are made of aluminum sheets sandwiched around a honeycomb core. The honeycomb core is made up of hexagonal cells of aluminum, as shown in Figure 1.



**Figure 1. Aluminum honeycomb structure [4]**

This structure provides exceptional strength with very little weight, which makes it ideal for use on the aircraft. On the pod panels, the aluminum sheets are bonded onto the honeycomb core using a high strength adhesive. These particular panels take abuse every time the landing gear is lowered or raised, and are therefore highly susceptible to damage [5]. The most common damage that occurs is delamination of the aluminum face sheets from the honeycomb core, which can be due to frequent use of the panels [5]. Due to the high

number of delaminations that occur on these panels, the most preferred method of repair is to remove and replace the panels. However, these panels take up to a year to receive when purchased and there are no molds available to use in making new ones. These panels have precise curvature and a mold is needed to manufacture a new panel. Therefore, engineers attempt to repair the panels on the aircraft. These repairs are many times unsuccessful, leaving the engineer to design a temporary repair for use until a new panel can be received.

## 2. Statistical analysis

This statistical analysis [6-10] is designed to provide the engineer with information that can be used to prevent damage from occurring. Three factors are evaluated in order to determine their effect on the area of damage that occurs. The first factor is the location of the pod panel. This is referring to whether the damage is on the right, left or center pod panel of the main landing gear. The second factor is the year that the aircraft was manufactured. For the single ANOVA table [6-8], the year the aircraft was manufactured is used. The three years of manufacture used are 1968, 1969, and 1970. For the multiple linear regression analysis [9-10], the age (in years) of the aircraft was found by taking the tail number of the aircraft (which indicates the year of manufacture) and subtracting it from the year the damage occurred. The third factor is the distance from the damage to an existing repair. For the single ANOVA table, this factor is categorized into 0 inches (which means damage occurred on an existing repair), less than 4 inches, and greater than four inches from an existing repair. For the multiple linear regressions, the actual distance from the damage to an existing repair was used. The data taken for this analysis only records damage within the past ten years, therefore an existing repair is considered to be any repair that is older than ten years. A single ANOVA table on each factor

tells whether or not that particular factor significantly affects the size of the damage that occurs. An engineer can then use this data and apply methods in particular areas to prevent damage from occurring. A multiple linear regression analysis is performed on two of the factors, age of aircraft and distance between damage and an existing repair. The multiple linear regression applies a linear regression line to the data, and then an ANOVA table reveals whether or not that regression is significant. If the regression is significant, that means that one or both of the factors significantly affect the size of damage that occurs. These results can be used to reinforce the findings of the single ANOVA tables. Additionally, error analyses were performed for the ANOVA tables and the multiple linear regressions. This shows how much error there is in the data, and can also be used to validate the normality assumption that is used in both analyses.

## 3. Results and discussions

The first one-way, ANOVA was performed on the significance of the location of the pod panel on which the damage occurred. The three locations that were evaluated were the left, right and center pod panels. The data (area of damage, in square inches) categorized by location of the panel is given in Table 1. The hypothesis that is tested in this case is whether or not the location of the pod panel has a significant effect on the area of damage that occurs.

The data has been minimized to include only the relevant categories for a one-way ANOVA table with only the location of the pod panel playing a role (Table 1). This is an unbalanced design since the left panel has far more observations than either the right or center panels. The ANOVA results are shown in Table 2. Using a significance level of  $\alpha=0.05$ , it was found that the test statistic  $F_0$  did not meet the criteria for rejection since it was less than  $F_{0.05,2,45}$ . This shows that the location of the pod

panel does not have a significant effect on the area of damage that occurs.

**Table 1. Data for location vs area of damage**

LPP	Area of Damage (in <sup>2</sup> )				
	5	64	24	200	4
Left	55	144	10	20	144
	56	60	144	32	99
	22	400	340	100	255
	6	216	6	400	18
	13	18	576	4	768
	155	144			
Right	20	144	126	100	576
	336	12	444	144	
Center	16	4	374	32	5
	2.5	320			

LPP: Location of Pod Panel

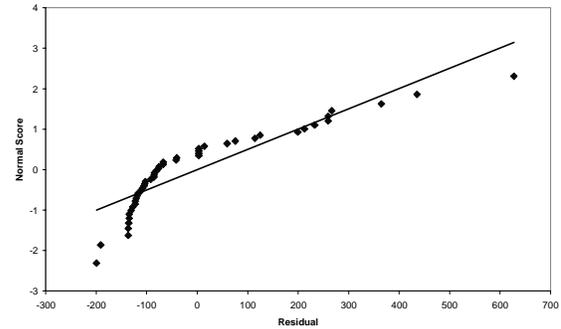
**Table 2. ANOVA - location vs area of damage**

SV	SS	DF	MS	F <sub>0</sub>	F <sub>0.05,2,45</sub>
Location	49152.39	2	24576.19	0.74	3.23
Error	1489901	45	33108.92		
Total	1539054	47			

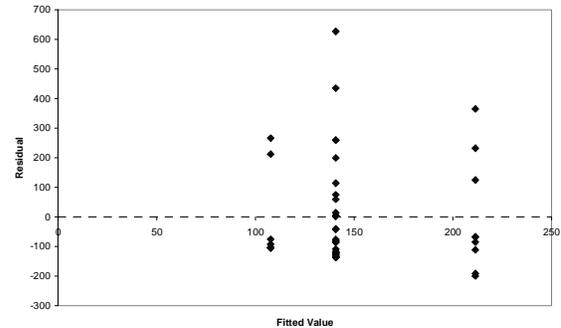
In order to further evaluate the error, the residuals of the data were found. These error values represent the difference between the observation and the mean of observations at that particular treatment. Figure 2 shows the normal probability plot of the residuals. Since the data varies significantly from the straight line, it can be concluded that there are problems with the normality assumption of the model. This could be attributed to the unbalanced nature of the observations. The excessively large error may also contribute to this, and if the error were reduced in the experiment the normality assumption may actually be valid.

Figure 3 shows the plot of the residuals versus the fitted values. The fitted values are defined as the mean of the observations for each treatment. As can be seen on the graph, the fitted value around 145 is for the observations on the left panel, as that treatment had the greatest number of observations by far. The variance in the left pod panel data is greatest, varying by

almost 850 square inches. This reinforces the conclusion that the error in this experiment is too great to produce valid results.



**Figure 2. Normal probability plot of residuals for location vs area of damage**



**Figure 3. Error residuals vs fitted values for location vs area of damage**

The second one-way ANOVA was performed on the significance of the year that the aircraft was manufactured. The three treatments of this factor evaluated were the years 1968, 1969 and 1970. The data (area of damage, in square inches) categorized by year of manufacture is given in Table 3. The hypothesis that is tested in this case is whether or not the year that the aircraft was manufactured has a significant effect on the size of damage that occurs.

The ANOVA results are shown in Table 4. Using a significance level of  $\alpha=0.05$ , it was once again found that the test statistic  $F_0$  did not meet the criteria for rejection since it was less than  $F_{0.05,2,45}$ . This shows that the year that the aircraft was manufactured does not have a significant effect on the size of the damaged area

that occurs. Just as was seen in the analysis of the first factor, the sum of squares and mean square due to error is larger than that of the year. This means that it is also impossible to tell if the results from this analysis are accurate, and further data may be needed to obtain reliable results. Once again, this is an unbalanced design, since both 1968 and 1969 have far more observations than 1970, and this may once again contribute to the significant amount of error that was found.

**Table 3. Data for year of manufacture vs area of damage**

Year of Manufacture	Area of Damage (in <sup>2</sup> )					
	5	4	400	6	18	4
1968	24	144	32	340	216	13
	768	200	20	144	100	576
	16	4	374	-	-	-
	20	144	144	56	99	100
1969	6	18	10	60	22	255
	400	126	336	12	444	32
	5	2.5	320			
1970	155	64	55	576	144	144

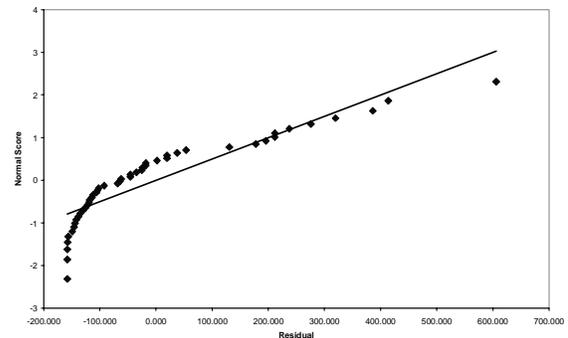
**Table 4. ANOVA - year of manufacture vs area of damage**

SV	SS	DF	MS	F <sub>0</sub>	F <sub>0.05,2,45</sub>
Year	26381.429	2	13190.715	0.3924	3.23
Error	1512672.2	45	33614.938		
Total	1539053.6	47			

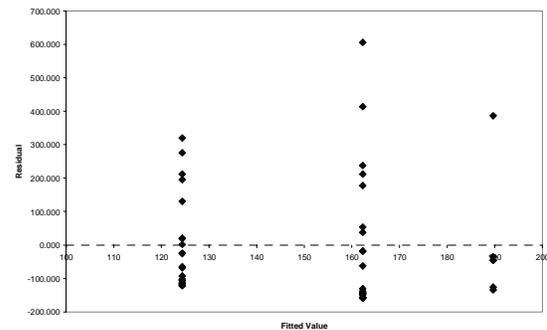
The same error analysis was performed on this factor that was performed on the previous factor. Figure 4 shows the normal probability plot of the residuals. Once again, the plot shows that there are problems with the normality assumption of the model since the data varies significantly from the straight line. Both the imbalance of the design and the large error may be a factor in the normality assumption being rendered invalid.

Figure 5 shows the plot of the residuals versus the fitted values. As can be seen on the graph, the fitted value around 190 is for the observations from aircraft manufactured in 1970, as that treatment had the least number of

observations. Another thing to notice from this graph is that once again the variance in the residuals is quite large. The variance in the data from aircraft manufactured in 1968 is the greatest since it varies by approximately 800 square inches. This graph supports the findings from the ANOVA table that the error in this experiment is too great to yield accurate results.



**Figure 4. Normal probability plot of errors: year of manufacture vs area of damage**



**Figure 5. Error residuals vs fitted values for year of manufacture vs area of damage**

The third one-way ANOVA was performed on the significance of the distance from a previous repair to the area of damage. The three treatments evaluated for this factor were 0 inches (which means the damage is underneath or on top of the existing repair), less than 4 inches and greater than 4 inches. The data (area of damage, in square inches) is given in Table 5. The hypothesis that is tested in this case is whether or not the distance from the damage to an existing repair has a significant effect on the size of the damage that occurs.

**Table 5. Data for distance from existing repair vs area of damage**

DDER	Area of Damage (in <sup>2</sup> )						
	5	4	20	144	20	144	126
0 inches	5	4	20	144	20	144	126
Less than 4 inches	400	6	18	4	24	144	56
	99	100	6	18	155	64	55
Greater than 4 inches	16	4	32	5	2.5	-	-
	144	32	340	216	13	768	200
	10	60	22	255	400	576	144
	100	576	336	12	444	144	374
	320	-	-	-	-	-	-

DDER: Distance from Damage to Existing Repair

The ANOVA results for this factor are shown in Table 6. Using a significance level of  $\alpha=0.05$ , it was found that the test statistic  $F_0$  did meet the criteria for rejection since it was greater than  $F_{0.05,2,45}$ . This shows that the distance from an existing repair does have a significant effect on the size of the damaged area that occurs. Once again the sum of squares and mean square due to error is larger than the sum of squares and mean square due to the treatments. This means that the variability within the treatments is greater than the variability between the treatments. This renders the results from this analysis inaccurate, and further data is needed to obtain reliable results. This is also an unbalanced design, since a distance of 0 inches has the fewest observations. Having a balanced design (equal number of observations for each treatment) may reduce the error to an acceptable level.

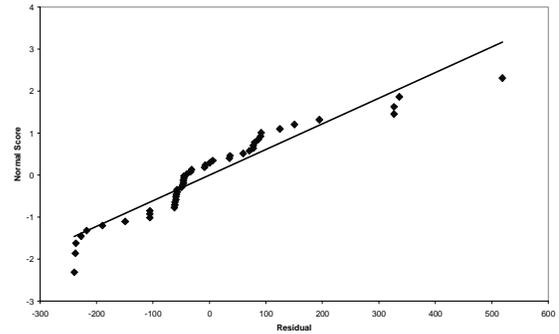
**Table 6. ANOVA for distance from existing repair vs area of damage**

SV	SS	DF	MS	$F_0$	$F_{0.05,2,45}$
DER	408212.38	2	204106.19	8.1221	3.23
Error	1130841.2	45	25129.805		
Total	1539053.6	47			

DER: Distance from Existing Repair

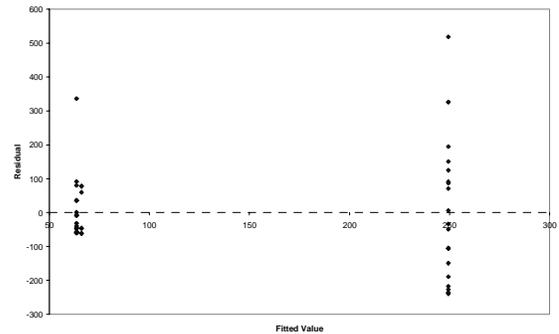
The error analysis performed on this factor supports the conclusions found from the one-way ANOVA table. The normal probability plot of the residuals is shown in Figure 6. While the data appears more normally distributed than the first two factors, there is still some deviation of the data from the straight line. Removing the

outliers would validate the normality assumption for the model.



**Figure 6. Normal probability plot of errors: distance from existing repair vs area of damage**

The plot of the residuals versus the fitted values (average of the observations in each treatment) is shown in Figure 7. The variance is the smallest in damage that occurs 0 inches from an existing repair, less than 200 square inches, but this can also be explained by the fact that this treatment has by far the fewest observations. However, the large variances in the other two treatments support the ANOVA findings that the error is so great and invalidates the conclusions.



**Figure 7. Residuals vs fitted values for distance from existing repair vs area of damage**

The next statistical tool applied to the data was a multiple linear regression analysis. A linear regression model was fitted to the data shown in Table 7. The fitted equation is given by:

**Table 7. Data for multiple linear regression**

Observation	Repair Area (in <sup>2</sup> )	Age of Plane (Years)	Distance from Previous Repair (in)
	<b>y</b>	<b>x<sub>1</sub></b>	<b>x<sub>2</sub></b>
1	10	33	8
2	60	33	5
3	22	33	9
4	255	33	7
5	336	33	6
6	12	33	5
7	400	37	1
8	144	37	8
9	4	37	0
10	144	35	7
11	374	37	10
12	4	37	2
13	16	37	1
14	32	37	6
15	400	37	8
16	20	37	6
17	144	37	1.5
18	56	37	2
19	99	37	6
20	100	37	8
21	55	36	1
22	144	36	12
23	320	37	10
24	32	37	0
25	100	38	8
26	20	38	0
27	6	39	1
28	18	39	0.5
29	216	39	10
30	13	39	8
31	200	39	6
32	144	38	0
33	5	39	1.5
34	4	39	1
35	24	39	0
36	6	38	1
37	576	39	10
38	768	39	10
39	18	38	0
40	126	38	0
41	444	38	11
42	2.5	38	1.5
43	340	37	3
44	144	37	0
45	5	36	2
46	155	36	2
47	576	36	7
48	64	36	1

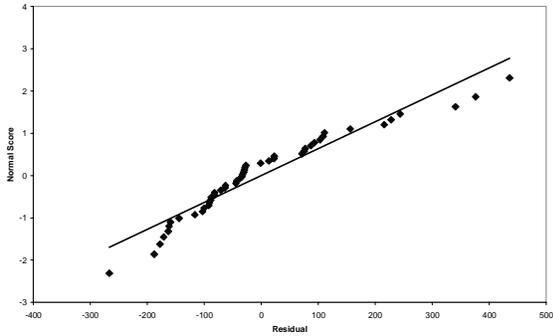
$$\hat{y} = -624.457 + 17.767x_1 + 26.392x_2 \quad (1)$$

The next step in this analysis was to test for significance of regression using an ANOVA (Table 8). The hypothesis that is being tested with the analysis of variance is whether or not at least one of the factors significantly affects the area of the damage. Using a significance of  $\alpha=0.05$ , the test statistic,  $F_0$ , was found to be greater than  $F_{0.05,2,45}$ . This meets the criteria to reject  $H_0$ , which leads to the conclusion that the area of the damage is significantly affected by the age of the plane ( $x_1$ ), the distance of the damage from an existing repair ( $x_2$ ), or by both factors. These conclusions support what was found using the single ANOVA tables that the distance of the damage from an existing repair is the factor that significantly affects the area of damage that occurs.

**Table 8. ANOVA for significance of regression**

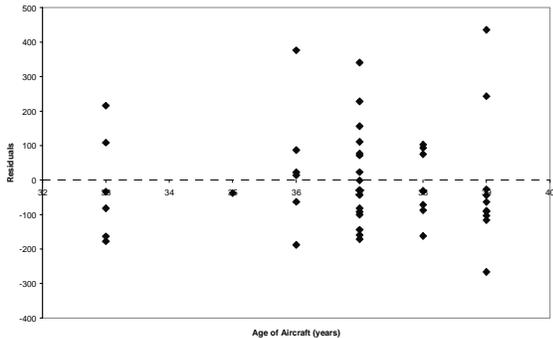
SV	SS	DF	MS	$F_0$	$F_{0.05,2,45}$
Regression	470738.8873	2	235369	9.9143	3.23
Error	1068314.733	45	23740.3		
Total	1539053.62	47			

The final step in the multiple linear regression analysis was to analyze the error in the model. Just as was seen in the single ANOVA tables, the sum of squares and mean square due to error in Table 8 are much greater than the sum of squares and mean square due to regression. This is an indication that once again the error is too great to yield accurate results. An analysis of the residuals, however, will shed more light on the behavior of the error. Figure 8 shows a normal probability plot of the residuals in the multiple linear regression model. While the data is not perfectly normally distributed, the deviations from the straight line are small and therefore the normality assumption can be considered valid. The residuals are quite large however, and this indicates errors in the out of control state.



**Figure 8. Normality plot of residuals in the multiple linear regression analysis**

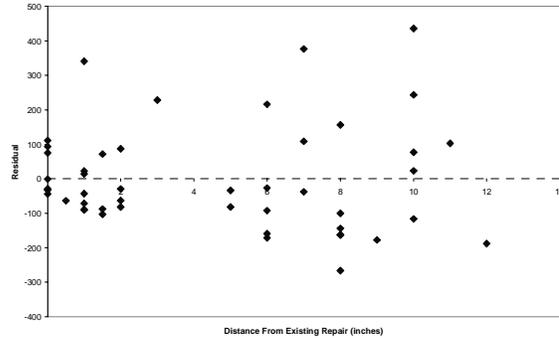
Figure 9 shows a plot of the residuals versus the age of the aircraft. This plot shows that each value of x has a high rate of variance, from 400 to almost 800 square inches. While the plot shows no signs of a trend between variability and x value, the large variance shows that the error is too great for the results to hold any real validity. Another thing to note on the graph is that the lack of balance between positive and negative residuals is due to the fact that the analysis was done on an unbalanced design.



**Figure 9. Residuals vs age of aircraft**

Figure 10 shows a plot of the residuals versus the distance of the damage from an existing repair, and the variance of these values yields the same conclusions. While some of the variances on this plot appear to be more tolerable, this could be due to the fact that there are fewer data points at the x value. There also does not appear to be any trend between variability and x value, but the size of the

variances is still very large. These variances are actually not quite as high as in other plots. However, they still represent a very high amount of error in the model.



**Figure 10. Residuals vs distance from the existing repair**

#### 4. Conclusions

The results of applying the two different statistical tools to the data yielded much the same result. The multiple linear regression model concluded that at least one, if not both, of the factors considered were significant. While the single ANOVA tables analyzed the significance of three factors, the multiple linear regression model only analyzed the two factors that could be numerically represented which were aircraft age and distance from previous repair. However, the results from the multiple linear regression still reinforced the results from the single ANOVA tables, which were that the distance from an existing repair was the only factor that significantly affected the area of damage that occurred. In this analysis the single one-way ANOVA tables were done first, followed by the multiple linear regression. In future experiments, however, it may make more sense to apply the multiple linear regression first and then the single ANOVA tables second. That way, the multiple linear regression could be used to see if any factors are significant, and then the single ANOVA tables could be used to narrow down exactly which factors are significant.

Even though the results from the ANOVA tables and the multiple linear regression supported each other, the resounding conclusion through the entire analysis was that the error in this experiment was too great. The magnitude of the error was greater than the variability in the data. Unfortunately, this means that the results of these statistical analyses will not provide much help to engineers in preventing damage from occurring. Since the error is greater than the variability in the data, no valid trends can be found that would allow engineers to pinpoint which factors need to be addressed in order to prevent delaminations from occurring. While this experiment was unsuccessful, improvements could be made to this experiment that would allow it to yield accurate and useful results if performed again in the future. Simply collecting more data could improve this experiment. One of the problems in this experiment could have been the significant imbalance of the design. A more balanced design may reduce the error down to a more manageable level. Another way to reduce the error may be to select different categories of treatments for each factor. In this analysis, a fixed effect model was used because the treatments for each factor were specifically selected by the experimenter. Defining more narrow treatment categories for each factor may decrease variability in the data which would inevitably decrease the amount of overall error in the analysis. Finally, breaking down the experiment into smaller pieces may also cut down on the amount of error. For example, an experiment could be performed to analyze the effect of the three factors on damages that only fall in the range of 0 to 10 square inches. Then other experiments could be performed to analyze the factor effects on damages in various other size ranges. The main problem that is immediately noticed in the collected data is the large variances in the different sizes of the damaged areas. Grouping the damage sizes into tighter ranges would significantly lower the

variance in the data, and perhaps bring the error back under control.

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# Optimizing Outbound Logistics for Weitzen Paper Company

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## Abstract

STAR Consulting was presented with the task of generating solutions and recommendations for addressing the challenges facing Weitzen Paper Company. These challenges were outbound logistics costs and forecasting procedures. To address outbound logistics cost, we optimized volume allocations for 2008 and 2009 to allow Weitzen to enjoy the lowest shipping cost possible. STAR Consulting then calculated the appropriate number of distribution centers for Weitzen and the improved utilization. Furthermore, we showed the best forecasting method for Weitzen to use based on the lowest mean squared error. Finally, STAR Consulting showed Weitzen how they can maximize their usage of their current outbound logistics, while helping the environment, by implementing a sustainable supply chain.

## 1. Introduction

STAR Consulting, LLP is a consulting firm based in Tallahassee, Florida. It is owned and operated by four partners, Shannon Kirk, Tiffany Williams, Audreen Robinson, and Rayvin Julien. STAR Consulting was contacted by the management of Weitzen Paper Company to help optimize their outbound logistics costs, provide a recommendation, and present findings.

## 2. Company Background

Weitzen Paper Company was founded by Rob Weitzen in the early 1970s as a newspaper company covering stories within Indiana. Years later, the company converted into the paper production business, leveraging the strong business experience they acquired in the newspaper sector. They are currently a niche player in the paper production business serving the mass-market paperback industry.

Weitzen prides itself on delivering low prices and exceptional service. The company

operates three distribution centers (DCs) in Indianapolis, IN; Pittsburgh, PA; and Rochester, NY, supporting a total output of 615 tons per year.

## 3. Industry Background

Weitzen is in the paper production industry, which is a cyclical and capital intensive industry. Companies in this industry make a variety of paper grades that are used for newspapers, magazines, books, copy machines, advertising, and labels. Many paper grades are considered commodities, thus price is elastic, and heavily affected by demand. The decline in demand is due in large part to the eco-conscious trend and the availability of online information transfer and communication. Production for several paper grades has been reduced over the past several years due to overcapacity. According to Standard & Poors Net Advantage, further production cutbacks are necessary to maintain the current operating rates, especially in lieu of rising pulp prices.

## 4. Assumptions

- Weitzen is a company that produces, stores, and transports paper.
- Weitzen purchases mechanical pulp for production.
- Weitzen only distributes paper to the mass-market paperback industry.
- Weitzen is currently experiencing a profit.
- Each distribution center is capable of outputting 350 tons per year.
- Weitzen Paper Company is not currently producing or handling recycled paper.

**Figure 1. SWOT analysis  
 (see 14. Figures and Tables)**

### 5. Case analysis

These distribution centers serve four publishers in Boston, MA; New York, NY; Chicago, IL; St. Louis, MO, demanding a total output of 610 tons.

**Table 1. Annual distribution center (DC) output**

Distribution Center	Annual Output
Indianapolis, IN	250 tons
Pittsburgh, PA	130 tons
New York, NY	235 tons
<b>Total Output</b>	<b>615 tons</b>

**Table 2. Annual publisher order amount**

Publisher Location	Annual Order Amount
Boston, MA	75 tons
New York, NY	230 tons
Chicago, IL	235 tons
St. Louis, MO	70 tons
<b>Total Order Amount</b>	<b>610 tons</b>

**Table 3. Outbound shipping costs to publishers**

From/To	Boston	New York	Chicago	St. Louis
Indianapolis	\$475	\$350	\$100	\$170
Pittsburgh	\$250	\$185	\$230	\$305
Rochester	\$215	\$170	\$300	\$420

### 6. Optimized Shipping Cost

In 2008, the outbound shipping cost for Weitzen Paper Company was \$127,000. However, this is not the optimized outbound shipping cost. Using a cost minimization method, we determined optimized total cost to be \$98,825, with a total savings of \$28,175.

**Table 4. Optimal volume allocation 2008 compared to current output (see 14. Figures and Tables)**

Assuming that publisher demand drops 3% from 2008 to 2009, the new optimal shipping cost is \$94,860.

**Table 5. Optimal volume allocation 2009 compared to current output (see 14. Figures and Tables)**

Assuming annual output amounts remain consistent, we used the utilization formula to calculate distribution center utilization rates.

$$\text{Utilization} = \frac{\text{Actual Output}}{\text{Design Output}}$$

Thus, the utilization rates for the distribution centers are: Indianapolis-71%, Pittsburgh-37%, Rochester-67%, resulting in total utilization 59%.

**Table 6. Distribution center 2008 utilization rates**

	Actual	Output	Utilization
Indianapolis	250	350	71%
Pittsburgh	130	350	37%
Rochester	235	350	67%
<b>Total</b>	<b>615</b>	<b>1,050</b>	<b>59%</b>

### 7. Appropriate amount of distribution centers

Based on Weitzen’s current position in a shrinking industry, cost minimization is paramount to remain competitive and survive as annual demand declines due to the trends of digitization and environmental preservation. As such, Weitzen should slash costs by closing the distribution center in Pittsburgh. The cost minimization method used earlier to optimize shipping costs, reveals that if the Pittsburgh DC was removed, there will be savings of \$36,375 as compared to the amount Weitzen is currently spending per year. The annual output of the Pittsburgh DC would be reallocated to the two remaining DCs (Indianapolis-55 tons and Rochester-75 tons). Under this optimized

reallocation, Weitzen’s shipping cost would decrease over 28% to \$90,625 per year.

**Table 7. Optimized shipping costs without Pittsburgh DC**

	Boston	New York	Chicago	St. Louis	Total
Indianapolis	-	-	228	68	296
Rochester	73	223	-	-	296
Total	73	223	228	68	592

Closing the Pittsburgh Distribution Center is the best alternative to reduce shipping costs. Savings would not be as substantial if any other DC was closed, and costs would increase if any combination of two DCs was to close.

**8. Forecasting**

Forecasting Method - Compound Annual Growth Rate

The CAGR given for mass-market paperback sales from 2002 to 2008 is -1.9%. However, STAR Consulting will use the optimized CAGR of -1.7%, which was calculated using sales from 2002 to 2008. The equation below represents CAGR:

$$CAGR = \frac{\text{End. Value}^{\frac{1}{\text{# of years}}} - \text{Beg. Value}}{\text{Beg. Value}} - 1$$

The CAGR formula was manipulated to solve for forecasts (ending value):

$$\text{End. Value} = \text{Beg. Value} (CAGR + 1)^{\text{\# of years}}$$

Thus, we solved for ending value to identify 2009 sales as \$1,058,134; 2010 sales as \$1,039,824; 2011 sales as \$1,021,831.

Forecasting Method- Regression

Another method we used to forecast demand is the regression method, using a linear trend. To

use a trend line, we needed to incorporate demand for each of the years 2002-2008. A linear trend line is represented algebraically as:

$$y = mx + b$$

Historical data was collected from The Association of American Publishers (AAP) Industry Statistics (see Appendix A). From the historical data, we plotted the 2002-2008 data and found the slope of the line to be:

$$y = -17672x + 4E+07$$

Using the slope (m= -17672) we forecasted the data for 2009-2011.

**Table 8. Mass-market paperback estimated sales with linear regression forecasts**

Year	Sales (\$)
2002	1,216,710
2003	1,196,026*
2004	1,089,580*
2005	1,091,759*
2006	1,141,980*
2007	1,119,140*
2008	1,085,566*
2009	1,063,707
2010	1,046,035
2011	1,028,363

\*The Association of American Publishers Industry Statistics

The optimized CAGR is the most effective way to forecast for Weitzen Paper Company because it has the lowest mean squared error of between 2003 and 2008. Using the optimized CAGR of -1.7%, STAR Consulting concluded 2009 sales to be \$1,058,134; 2010 sales to be \$1,039,824; and 2011 sales to be \$1,021,831.

## 9. Analysis of the book publishing industry

Barriers to entry: The cost of entering the market is low, but protecting intellectual property rights can get costly.

- Supplier power: With abundant materials such as ink, paper and glue, the availability of alternative suppliers is high.
- Threat of substitutes: There are thousands of books that cover similar if not the same subject matter that are priced competitively. There is also the threat of individuals participating in other activities such as watching television, listening to the radio, or surfing the internet instead of using printed material.
- Buyer power: Due to online book retailers, such as amazon.com and half.com, buyers are more informed and can negotiate and make more informed decisions. In addition, publishing companies do not have an impressionable brand; therefore, in most cases, customers will not be brand loyal.

In evaluating the book publishing market, several trends were apparent. The major trends are the growing use of e-books and move towards becoming more environmentally conscious. The effect of the e-books trend is that it is increasing the amount of piracy occurring within the industry. On the other hand, e-books are reducing distribution costs because distribution can occur cheaper and more quickly online than in hard copy. There has also been a 15% job loss in the industry as overall readership has dropped and publishers become victims of piracy due to increases in the online availability of books. A prominent trend in the book publishing industry is the slow movement towards becoming more ecologically friendly. Publishers nationwide have a goal to cut carbon emissions by 15% by 2020 and by 80% in 2050. This will encourage publishers to start making small changes now to position themselves for the major reduction in carbon emissions in forty years. Based on the analysis using Porter's Five Forces and analyzing the major trends in the publishing industry, it is evident that Weitzen

must make a fundamental change to its business to be successful in positioning their company for long-term success.

## 10. Recommendation: sustainable supply chain

The following assumptions are the underpinnings of the framework for STAR Consulting's recommendation to Weitzen Paper Company:

1. The book publishers have scrap paper and are willing to sell it.
2. Mass market paperback book publishers will use recycled paper in their books.
3. No jobs will be lost in the transition of the Pittsburgh DC.

To approach this recommendation, STAR Consulting offers the use the Blue Ocean Strategy (BOS), which has a primary goal of combining product differentiation and low cost to provide value, innovation, and propel the company forward. BOS is a way for companies to excel by making the competition irrelevant. Instead, a company can create a new niche market where they will be the only company in that market providing a particular good or service. This is an out-of-the-box approach to business that is focused on the big picture, and is very appropriate for Weitzen's business and business model.

The recommended Blue Ocean Strategy for Weitzen Paper Company is to fuel the economic recovery by integrating a sustainable supply chain using 100% recyclables. Once fully integrated, Weitzen will see results in the following forms:

1. Minimization of shipping expense by fully utilizing current outbound logistics
2. Creation of a conduit for scrap paper to be converted into recycled pulp
3. Transformation of existing positions into green jobs
4. Reduction to the destruction of trees
5. Reinvention of Weitzen's corporate image

Weitzen must convert from making paper using mechanical pulp to using deinked or recycled pulp. In the new system, all recycled paper made in the Weitzen Manufacturing Plant will be shipped to Pittsburgh, making it a distribution hub. Also, Weitzen must turn the Pittsburgh distribution center into a recycling sorting center where scrap paper can be sorted, packaged, and prepared for transport to a paper mill, which will pay Weitzen based on weight and ease of transport. The paper mills will pick up recycled paper from Weitzen's recycling sorting center and transport it to their own facilities. In essence, all outbound logistics will be maximized by ensuring that when the trucks return from the publishers after dropping off their paper deliveries, that the trucks do not return empty. Instead, Weitzen will pay the book publishers a minimal price for all their scrap paper, which will be loaded into the truck and returned to their respective DC's. From each DC, there will be trucks that transport the paper to the recycling sorting center in Pittsburgh. Finally, when the paper mills have converted the scrap paper into recycled pulp, they will transport it to the Weitzen Manufacturing Plant, and the cycle (recycling) continues.

## 11. Plan of Action

Weitzen Paper Company will close the distribution center located in Pittsburgh, but utilize the facility as a recycling sorting center. The project will be completed nine months from implementation. All supplies and materials that were used in the Pittsburgh distribution center will be reallocated to the Indianapolis and Rochester locations to supplement for the increased utilization. The collection of paper waste from the publishers will begin four months from implementation in order to allow time for the facility to be fully transformed into a recycle sorting center. All employees from upper level management to the front line workers will be extensively trained in the recycling process within the first three months.

## 12. Conclusion

STAR Consulting was presented with the task of generating solutions and recommendations for addressing the challenges facing Weitzen Paper Company. These challenges were outbound logistics costs and forecasting procedures. To address the first issue, STAR Consulting provided optimal volume allocations for 2008 and 2009 that will allow Weitzen to enjoy the lowest shipping cost possible. STAR Consulting then showed how Weitzen can save \$36,375 if they close the distribution center in Pittsburgh, thus running all distribution operations out of Rochester and Indianapolis. Furthermore, we showed the best forecasting method for Weitzen to use was an optimized CAGR of -1.7%, because it would yield the lowest mean squared error. Finally, STAR Consulting showed Weitzen how they can maximize their usage of their current outbound logistics, while helping the environment, by implementing a sustainable supply chain, with the former Pittsburgh DC as the hub for the company's 100% recycling operations.

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#### 14. Figures and Tables

Figure 1. SWOT analysis

<p style="text-align: center;"><b><u>Strengths</u></b></p> <ul style="list-style-type: none"> <li>- Manages cash and inventory effectively</li> <li>- Low pricing</li> <li>- Customer service</li> <li>- Several distribution centers, which increases accessibility</li> <li>- Revenue stream is not reliant on a single customer</li> </ul>	<p style="text-align: center;"><b><u>Weaknesses</u></b></p> <ul style="list-style-type: none"> <li>- Non-optimized logistics, specifically outbound</li> <li>- Less than complete utilization of DC's</li> </ul>
<p style="text-align: center;"><b><u>Opportunities</u></b></p> <ul style="list-style-type: none"> <li>- Growing use of recycled materials</li> <li>- Rising demand in higher education and adult paperbound book categories</li> <li>- China's publishing market will be more open to penetration due to recent World Trade Organization rulings</li> </ul>	<p style="text-align: center;"><b><u>Threats</u></b></p> <ul style="list-style-type: none"> <li>- Rising fuel prices</li> <li>- Trend towards digitized communication, services, and leisure</li> <li>- Industry consolidation</li> <li>- Stricter environmental regulations</li> <li>- Used book sales</li> </ul>

**Table 4. Optimal volume allocation 2008 compared to current output**

	Boston	New York	Chicago	St. Louis	Total	Current Output
Ind.	-	-	180	70	250	250
Pitt.	-	70	55	-	125	130
Roch.	75	160	-	-	235	235
Total	75	230	235	70	610	615

**Table 5. Optimal volume allocation 2009 compared to current output**

	Boston	New York	Chicago	St. Louis	Total	Current Output
Ind.	-	-	182	68	250	250
Pitt.	-	61	46	-	107	130
Roch.	73	162	-	-	235	235
Total	73	223	228	68	592	615

## How Do Aspiring Vocational Instructors Improve the Relevance of Their Courses?

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### Abstract

The current economic condition and globalization are exerting unprecedented burdens on our domestic industrial and manufacturing sectors. In turn these establishments are expecting more out of their employees, specifically recent graduates. In turn these graduates rightfully expect to be endowed with all the prerequisite skills required for a successful career. Therefore it falls upon the vocational educational institutions to provide a proper variety of training to meet these needs.

To further complicate the instructors' obligation is the rapidly changing state of technology. Graduates are expected to be familiar with the newest technologies; however the rapid evolution of this technology creates complications. Each semester the instructor may have to redesign the entire course for the replacement for last year's newest technology. The instructor may find himself teaching a new technology as fast as it is revealed.

While true for all vocations, this is especially poignant in welding. Once viewed as a dirty and dangerous process used by boilermakers and ironworkers, welding is now at the forefront of technology and automation. A graduate with a welding certificate is as likely to be found programming a robot as he to be hanging an I-beam to form the skeleton of a building.

This research is based upon open ended conversations held with instructors from 21 of Michigan's colleges which award a certificate or associates in applied science in welding or welding technology. The report concludes with a series of suggestions, or best practices, which the aspiring instructor can use to improve their

courses to meet the ever changing demand of the industry.

### 1. The Problem

The newly appointed vocational instructor faces a myriad of problems. Not only does he have to deal with the normal classroom issues of instruction, attendance, and organization, but he has to do so in a workshop setting.

Vocational instructors are often expected to usher their students towards employment. In truth vocational education's success is measured in the placement of graduating students. Without meeting the needs of the potential employers, the vocational program quickly loses its relevance and fades away.

So how does an aspiring vocational instructor keep his courses relevant and useful? To answer this question, the following research focuses on a specific vocation, welding. First a review of the relevant literature will reveal that vocational education and the industries they serve don't always communicate perfectly. Secondly a survey of postsecondary welding educators will show what they are doing to keep their courses relevant.

Welding was chosen because there is a well documented need for skilled welders in many industries. A major survey found that companies employing welders are often dissatisfied with the current avenues for welder training. This tome of information on the subject was released in 2002 when several related industrial organizations and government agencies published the "Welding-Related Expenditures, Investments, and Productivity Measurement in U.S. Manufacturing,

Construction, and Mining Industries Report.” Among the many statistics, two meaningful facts emerged. First, a majority of companies reported a welder shortage has adversely impacted their productivity. Secondly, the majority of companies are not satisfied with the welder training avenues [2].

**The Shortage**

As shown below just over half of all reporting companies have endured some negative impact caused by the shortage. However the problem is exaggerated when focused solely on the heavy industrial sector. Here over three-quarters of companies have been adversely impacted [2].

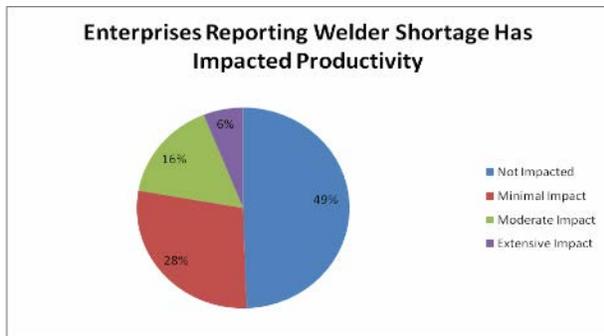


Figure 1 – [2]

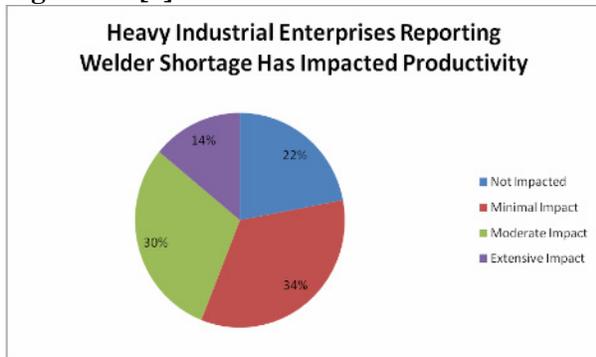


Figure 2 – [2]

**The Training**

In the same report nearly 80% of all companies reported less than complete satisfaction with current training. While 42% report their training needs are being adequately

met, a larger portion, of 46% report their needs are barely met or worse [2].



Figure 3 – [2]

Again matters appear worse when looking only at the heavy industrial sector. Here only 2% of companies reported that their training needs were completely met. 54% reported minimal or lower satisfaction [2].

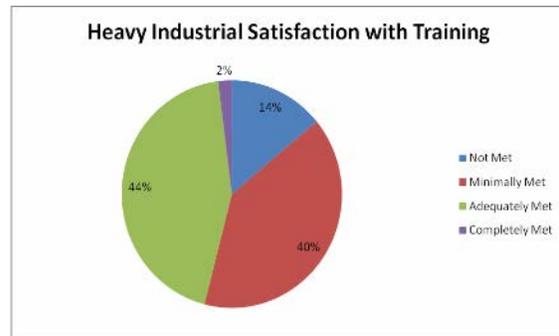


Figure 4 – [2]

In another dissatisfied sector, construction, only 7% of companies are completely satisfied while a full 60% are only minimally or less satisfied.



Figure 5 – [2]

### **An Instructors Response?**

So what is the aspiring welding instructor to do? There's a clamoring demand for skilled welders yet potential employers are not satisfied with the current training methods. The purpose of this research is to identify the activities that existing welding education institutes are taking to improve the relevance of their courses.

Two routes will be taken to answer this question. First a review of relevant literature, focusing on successful programs, and reviewing how they were able to better meet the needs of the industries they serve. Second, a survey of post-secondary training institutions, to see what steps they're taking to satisfy potential employers.

## **2. The Literature Review**

Hudson and Shafer found that rural schools were less likely to offer vocational training than urban and suburban schools. Of the 28 occupations studied 16 were offered more often in urban and suburban schools, while "rural schools were more likely, to offer vocational education programs for welding and agriscience." [7]. The authors acknowledge this is likely a reflection of the agro business in rural areas. This however, does not fully explain to propensity of welding education in rural areas. Inversely this could be viewed as insufficient welding educational opportunities in non-rural areas.

In a recent report it is mentioned that welding training is more effective if the student are working on a fabrication rather than just welding [6]. However building fabrications, or finished products, require extra material and a design. Both of these resources are readily available from local industries.

In the late 1990's Sumter Office for Economic Development and Central Carolina Technical College formed a partnership to improve the skills of the local workforce. Through this process they found "employers were discouraged with the inadequate work

force pool." [5]. After several brain-storming sessions the partnership "discovered that needs and remedies must be defined by the industry, education and community leaders" [5]. Meetings were held with local businesses and training was established in response to the industries needs. While this is just one of many success stories, it is unique significance is that the education leaders acknowledged that the industry was a 'client' and a 'customer'. The schools are the 'provider' or the 'supplier'.

In 1996, Arizona's Department of Education compiled a list of 17 successful strategies for vocational education. Most of the 17 involved partnerships with industry [3]. Below are some examples.

AlliedSignal and East Valley Institute of Technology partnered to create a 3-week summer apprenticeship program. Dysart High School used job shadowing to improve their Hotel / Guest Relations Program. Mammoth-San Manuel school district partnered with a local mining and health care facility to create an internship for 20 students each year. After a recent revamping Star Tech Professional Center, in Phoenix, now regards outsiders as 'customers' and they 'sell the Center' whenever possible. In Tucson graduating seniors and potential employers were given the opportunity to meet at an annual job fair. The building trades program at Sahuarita High School collaborated with local businesses and community organizations. Somerton Middle School brought in guest speakers to 'create a more obviously link to real life'. Over the past decade Tempe's entire school system faced the goal of 'all students demonstrating competency is employability skill in all curriculum area. The school district responded with job shadowing in junior high school and defined path of study for all four years of high school.

### 3. The Research

#### The Vocational Training Institutions

The subjects were limited to post secondary vocational welding training institutes located in Michigan. The following institutions were requested to participate in the study. The study was completed anonymously, so it is not possible to acknowledge specific institutions for their cooperation.

- Bay de Noc Community College
- Delta Community College
- Ferris State University
- Grand Rapids Community College
- Kalamazoo Valley Community College
- Kellogg Community College
- Kirtland Community College
- Lansing Community College
- Mid Michigan Community College
- Monroe County Community College
- Montcalm Community College
- Mott Community College
- Muskegon Community College
- Oakland Community College
- Schoolcraft College
- Siena Heights University
- Southwestern Michigan College
- St Clair County Community College
- Washtenaw Community College
- Wayne County Community College
- West Shore Community College

#### The Survey

Instructors of the aforementioned institutions were asked to participate in a brief survey. The survey was hosted on a 3<sup>rd</sup> party provider. Responses were anonymous. Questions asked included:

1. Has new or potential student interest been increasing or decreasing?
2. Are there employers that have hired several graduates?

3. If 'Yes' to #2, does that employer have any (formal or informal) relationship with the program?
4. If 'Yes' to #2, has that employer suggested potential improvements for the welding program?
5. How are the needs of potential employers measured?
6. How does the welding program insure it is meeting the needs of potential employers?
7. How does the welding program insure equipment is reflective of what is used in the industry?
8. What recent changes have been made to the welding program?
9. Do you have a particular book you find helpful for creating welding assignments?

#### The Responses

In response to the first question, all the institutions have witnessed increased interest.

The second question also returned unanimous results. Every institution has had employers hire multiple graduates.

Five of the institutions responded that the employers had a relationship; two reported that they did not.

Six institutions responded that the employers suggested potential improvements; only one institution did not receive feedback from employers.

In response to the 5<sup>th</sup> and 6<sup>th</sup> questions the institutions cited advisory committees, joint meetings and surveys as methods of receiving employers' feedback.

Likewise the institutions reported that meetings and advisory committee insured that they were using the newest welding equipment. One respondent stated that they systematically change out the equipment every three years.

When responding about their recent changes, the 8<sup>th</sup> question, the institutions stated several equipment improvements; CNC plasma cutting table, improved robotics, new ventilation

system. Two respondents stated they had been modifying the program structure by combining low enrollment courses as well as expanding higher demand courses. They also referenced recent additions of pipe welding and metallurgy.

The ninth question, regarding books, yielded an interesting result. Four of the seven respondents answered that they do not use any text book. The remaining three stated they use *Welding Technology*, *Bowditch*; *Welding Principles and Applications*, *Jeffus*; *Lincoln Procedure Handbook*; and *AWS Handbooks*.

#### 4. Summary

Similar to the schools in the literature review, many these Michigan vocational education institutes see partnerships as a way of bridging the gap between education and employment. Also reflecting the numerous examples in the Arizona, each training institution had a unique approach to working with industry. Although they all had the same aspects; each is distinct based upon the schools potential employers.

Responses to the first two questions correspond with the *Welding Related Expenditures Report*, regarding continued demand for welders.

Many of the responses to question three through eight highlight how these Michigan training institutions are working with potential employers.

#### Industry Relationship

All respondents stated that they have had at least one employer hire multiple students. The most common words contained in the responses were partnership and alliance. These words were used to describe the relationship with potential employers. Their similarity implies that nearly all the respondents viewed the industry as an important stake holders in the student success.

Another important factor was the frequency of the interaction. Many of the training

institutions mentioned, committee or advisory board when explaining their relationship with industry. This indicates that there is a formal and ongoing relationship, rather than an ad hoc temporary association.

#### Course Materials

There are plethora of books on the subject of welding, it is therefore not surprising that there was not a consensus of which book is most appropriate for the classes room. However the proportion of instructors forgoing text books is astounding.

Initially this might appear as a detriment. However the institutions stated they replaced formal text books with their own course packs. This offers the institutions the distinct advantage of being able to customize the training materials to reflect the industries the most often serve.

Based on the various examples its apparent that the most effective way for an instructor to make the course valuable for the students is to tailor them so the meet the needs of the potential employers. A partnership, either formal or informal is an effective way to learn the needs of the industry.

#### 5. Resources

Below is a brief list of potential resources the is aspiring welding instructor can use to improve the relevance of their courses.

The James F Lincoln Foundation offers teaching aids and educational materials at reduced and no cost to instructors. Materials include books, DVDs, and calculators. The Foundation also offers monetary awards to students for providing technical papers on the application of arc welding to design and production [8]. The Foundation can be found at [www.jflf.org](http://www.jflf.org).

The Lincoln Electric Company, although sharing the same namesake as the James F Lincoln Foundation, independently offers their own resources to welding instructors. Lincoln offers a series of computer CDs. Each CD

focuses on a particular welding process. Contained on each CD is power point presentations. These are typically broken into section which can be presented over the course of a semester. The instructor may edit the presentations to best fit his course.

Likewise the Miller Electric Company offers a series of high quality books on various welding processes. Several include a test which can be returned to the company. If the test is successfully completed the company will return a certificate of completion.

The Resistance Welding Manufacturers Association, RWMA, offer a series of technical bulletins. Although resistance welding is not often taught at most institutions, this is an efficient way to convey the theory of resistance welding directly from the experts.

Also regarding resistance welding, Roman Manufacturing offers frequently asked questions and several technical publications on their website. These can be accessed at [http://romanmfg.com/resources\\_faqs.html](http://romanmfg.com/resources_faqs.html).

Welding Magazine is an industry publication which instructors can subscribe to at no cost [10]. Each issue contains several articles about the industry. There are often examples of fabrications that could be used in the welding courses. Penton also offers a sister publication, Gases & Welding Distributor at no cost. Registering for either subscription may be done at <http://subscribe.penton.com/wdf/>.

The American Welding Society offers the Schools Excelling through National Skills Education program SENSE [1]. SENSE is comprised of three levels. Upon successful completion of each level of the standards and guidelines, students may test to receive a certificate of completion. Level I is designed for application at grades 10-12 or entry level training. Level II is designed for two year career and technical education programs or for those with welding experience. Level III is for those in

four-year programs or those with advanced experience [1].

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# The Relationship Between Oral Class Participation and Computer Mediated Communication With a Student's Gender and Ethnicity

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## Abstract

Research shows that student participation is a positive element of face to face learning, but its exact role in the classroom continues to be one of debate. This discussion has intensified with the increasing frequency of online courses in higher education. This is because some instructors now incorporate class participation as a significant portion of a student's grade.

At the same time, there has been an influx in the enrollment of foreign students in US educational institutions. For most of these students, English is not their first language, which means their lack of proficiency and self confidence with English may inhibit their participation in class discussions, placing them at a grading disadvantage. Similarly, in some cultures, female students are discouraged from asking or answering questions, making gender another element in the paradigm.

This session will present the results of a study that evaluates these issues. It will discuss why some international graduate students who participate very well in computer mediated discussions, are unable to participate effectively in oral discussions in a face to face classroom. It will also report on the relationship between participation and student's gender and ethnicity. Lastly, it will present recommendations on how to customize the class discussion format to maximize participation from a particular ethnic-gender mix of students.

## 1. Introduction

Students from all over the world are attracted to American universities because of the high quality of education. The problem starts when they join a University in America, and find out that the teaching methods in the States involves a fair amount of oral and computer mediated discussions. These foreign students soon start becoming frustrated, when they are unable to communicate with others, at the level expected in a higher learning institution in America.

Oral participation has always been challenging for students for different reasons. The main idea behind developing the skill to speak in front of peers and the instructor is to develop critical problem solving skills. Dallimore and Hartenstein (2004) recommend using different techniques such as grading the participation or cold calling in the class to make certain all students have the opportunity to participate. Wayne and Mitchell (1992) think that the development of communication skills is very important, it has been identified that written and oral communication skills are the most important workplace skills for employees. Harnett (1997) believes that there has been considerable research done on how to improve writing and speaking skills.

Research has also been done according to Allen and Bourhis (1996) on the fear of communicating with others. Berlin (1987) believes that oral and written communication share a rhetorical tradition and Hjortshoj (2001) is of the opinion that it makes sense to examine them together, since both focus on skills acquisition in transforming ideas into words by

developing, organizing, supporting, and presenting arguments (as cited in [2]).

## 2. Rationale

Brookfield and Preskill (1999) are of the view that class discussion has become very important as an interactive learning strategy however, despite the increasing support for its use, not all students are equally likely to participate, limiting the value of discussion for the whole group of students. Bean and Peterson (1998) think grading class participation can motivate students to participate in the discussions and send a signal to students about the kind of learning style the instructor wants. Ewens (2000) is of the opinion that compared to traditional lecture method, the discussion leads to reflective thinking, problem solving, application and analysis, as well as the information collected through discussion is retained better by students than in the lecture method (as cited in [3]).

Billingsley (1999) suggests that good relationships among students and a sound understanding between the students and the tutor are essential for developing an environment of comfort, trust and mutual respect, where open discussion, exchange of ideas, as well as active participation are not inhibited by any kind of fear. It has also been observed by Tompson and Tompson (1996) that without trusting relationships learning is stunted. They find theoretical support in Maslow's model of 'hierarchy of needs', where individuals are unlikely to engage themselves in self-actualization activities, such as challenging intellectual debates and discussions, unless security, social and esteem needs have already been satisfied (as cited in [5]).

Oral classroom participation is a skill that most U.S. classrooms, encourage. However, international students, who mostly come from teacher-centered educational cultures, where students normally do not speak without being called on, find the rules of classroom participation in the United States to be unfamiliar, intimidating and complex. In most graduate courses in U.S., oral classroom participation is highly valued; however it becomes very challenging for new international

graduate students to produce immediate responses and compete with native speakers, and at the same time sound competent and intelligent in a foreign language. Their situation becomes intensified with the high oral participation of some U.S. students, who can become dominating in classroom discussions [4]. Xu (1991) observes that foreign students problems with using and understanding the English language and a lack of proficiency in English have been the two greatest factors that have hindered the adaptation of international students to U.S. academic culture. Church (1982) further suggests that apart from language difficulties, cultural differences are also thought to play an important role in shaping the classroom participation of international students (as cited in [4]).

Smith and Smith (1994) have observed that some instructors try to improve participation by assigning roles in discussions and Arbaugh (2000) thinks this can also be achieved by utilizing online discussions. Students in the multicultural classroom do not always welcome student-centered learning. For example, Pun (1990) is of the opinion that when Chinese students initially come to USA, they feel uncomfortable with participatory classroom activities. For some international students, interactive lectures and class participation represent a new way of learning as compared to what they have experienced in their home country, which may have featured only the traditional, lecture-based, tutor centered approach. While some other students may be hesitant to participate actively due to shyness or because, in their cultures, reticence and the avoidance of contention is considered good behavior. Chalmers and Volet (1997) are of the viewpoint that Southeast Asian students hold different beliefs from many Western students regarding the appropriateness of speaking out in class. Many of these students are not willing to bring attention to themselves by asking what they perceive to be an unnecessary question in front of the whole group. Burns (1991) thinks that the most prevalent reason, however, that prevents most international students from participating in class discussions is the fear of not being understood and, in the extreme case, of becoming subject to ridicule (as cited in [5]).

Frost and Fukami (1997) suggest that there may also be a possibility of gender based differences in class participation patterns between online courses and classroom based courses. Student learning and class interaction in Internet based courses do require further study. Canada and Bruscha (1991) mention that previous research have pointed out that men see Internet based education as a way to provide education to the masses more quickly and cheaply. It is also suggested by them that men communicate via the online medium in a competitive mode, either elevating their own status or lowering that of others. Contrary to this, women tend to see cyberspace as a means of developing increased collaboration and support networks, for increasing learning and communication of the entire group (as cited in [1]).

Although most current research on classroom interaction recognizes that gender and ethnicity affect students' communication styles (Henley & Kramarae, 1994, as cited in [6]), still very little is known how these two variables interact to influence discourse in the classroom. Research on computer mediated communications (CMC) indicate that there are significant differences between gender discourses in this environment as opposed to that found in classroom settings [6]. Similarly, minority students participate much better in CMC environment as compared to the traditional classroom. However, further research is required to make visible the different conventions and expectations governing privileged and marginalized communication styles [6].

Previously, research has been done on ways to improve oral participation in the classroom [6]; however, there is limited research available why some participants cannot perform as well in oral participation as they do in written discussion. An effort will be made to identify those participants and determine how to make them reach their potential in oral participation in the class room. It has been observed, that presently only a few students dominate the oral discussions in graduate classes, however with this research an effort will be made to make a detailed analysis of the reasons that inhibit

participation of some students, and how can that be eliminated.

This research will highlight the advantages some students feel one communication environment has over the other. From previous research it has been observed that in the face to face discussions some students have pointed out that the facial expressions, non verbal cues and tone of the students helps in interpreting the message of that student, at the same time, some students believe that the non interference in the on line computer discussion helps them to convey their message easily [6]. Comparing computer mediated and face to face discussions can provide researchers with multiple resources to test the hypotheses about the conversational patterns of students from different ethnic backgrounds [6]. Therefore, an effort will be made in this study to find out how to get the maximum contribution in the discussions in both the environments, by eliminating students concerns and inhibitions, and at the same time customizing the class discussion format that can get the most contribution out of a particular ethnic-gender mix of students.

### **3. Hypothesis 1**

A relationship exists between ethnicity and the frequency of oral participation.

### **4. Hypothesis 2**

More female students will feel comfortable in participating in computer mediated discussions as compared to oral discussion in the class.

### **5. Research Design**

The research was a descriptive quantitative research, in which multiple regression analysis was performed to explore possible relationship between the different variables like gender, ethnicity and frequency of oral class participation, frequency of computer online participation, case preparation, comfort in oral participation and comfort in computer online participation.

## 6. Population samples and subjects

The population selected for this research were Engineering Management graduate students at Eastern Michigan University. A convenience sample of 30 students was taken, who were studying in three different classes in Fall 2009 semester. The researcher was working as an Adjunct Lecturer and Graduate Assistant in these classes. All 30 students were invited to voluntarily participate in this study.

## 7. Data collection

An electronic survey questionnaire having ten questions, based on Likert 5 point scale, was utilized to collect data from the group of 30 students selected in this study. A few open ended questions were asked from the participants, such as what factors are affecting their oral participation and computer online participation. The identity of the students was kept anonymous. Out of the 30 students 28 students voluntarily participated in this survey.

## 8. Data analysis

To draw conclusions, the percentage of student responses to different questions was determined, along with the mean and standard deviation. From Table 1 it can be observed that overall students participate more frequently in the classroom with a mean of 4.17 as compared to online discussion for which the mean was 3.92. The reason for this difference appears to be that in the online discussion the students are only required to participate one time, whereas in oral participation students have the opportunity to participate multiple times. At the same time overall the students feel more comfortable while participating online with a mean of 4.17 as compared to oral participation which has a mean of 4.03 as shown in Table 1. Again the main reason for this difference is because female students feel more comfortable in online participation. Multiple regression analysis was done on the independent variables ethnicity and gender and the dependent variables frequency of participation, preparation for participation and comfort for participation. A relationship was found to exist only between ethnicity and the frequency of participation. Since the P value is

less than 0.10 as shown in Table 4, there is a statistically significant relationship between these two variables at the 90% confidence level.

## 9. Results

This study on class participation began in the fall semester of 2009 on three graduate engineering management hybrid classes. These classes had a mix of American and international students. The international students were mainly from India, China, some South American countries and various Middle Eastern Arab countries. In one of the classes the students were required to discuss different case studies, while in the other two classes the students had to discuss their team projects. These classes also had online discussion boards, where the students not only discussed the problems they were facing, but also different topics and questions assigned to the class.

It was generally observed that the white male students dominated the oral discussions, and the other students were lagging behind as shown in Table 2. White student's oral participation frequency mean was 4.42 whereas the overall class mean was 4.17 as shown in Table 1. As the semester progressed, the international students did improve their participation, as they became more comfortable in the classroom environment. It was also evident that the female students required continued encouragement for them to contribute in the discussion. The other interesting aspect was that these same students, who could not speak effectively in the classroom, could demonstrate their analytical skills through the computer mediated discussion boards. It seemed that the advantage that some students had because of their fluency in spoken English language was neutralized on the computer discussion boards.

The results that came out of this survey did confirm some observations made about the student's participation during the Fall 2009 semester. In the oral participation in the classroom, the results demonstrated that the white students were the most frequent participants, with 60% of the students participating multiple times in the class, as shown in Figure 1. A relationship was found

between ethnicity and frequency of participation as shown in Table 4, and thus Hypothesis 1 was accepted. If we segregate this group further we find that out of ten white students seven were male. Therefore this result confirmed our earlier belief that white male students dominate oral class participation, and participate multiple times in a class session. On the other hand the Asian students which were the largest group in these EM classes did not participate multiple times, however they did participate at least once in every class. The main reason for the comparatively less active participation for the Asian students was because of the language problem. It appeared that sometimes the Asian students could not follow a discussion. This could be due to some words they did not comprehend, or because of the different style of delivery of the native English speaking student.

The survey also showed that although the six female students were far fewer than the twenty two male students, however, overall their participation was better than the male students in both the oral participation and the online computer mediated discussion. One other noticeable item is that female students feel more comfortable while participating in the computer mediated online discussion as compared to oral participation, as shown in Figure 2 and 3 thus Hypothesis 2 can be accepted. The reason for this particular behavior is that the female students usually do not like to interrupt another person in the ongoing classroom discussion, but, while participating in the online discussion forum they have all the time they need to respond to some topic our question posted by the instructor.

It also was clear from the results that the white male student's dominance in the oral participation was no more evident in the online discussion forum. One of the white male students also commented in the survey that he felt that the in class oral discussions were much more useful than the online discussions, and hence more emphasis should be placed on the in class discussions. The results also showed that the Asian students also improved their participation considerably in the online forum, as compared to the live class.

## 10. Recommendations

These results have shown that there is a relationship between ethnicity and participation; however the relationship between gender and participation could not be established because of the very few female students in the sample selected. It is recommended that a comprehensive study be undertaken, so that results can be generalized.

## 11. Conclusion

The results of this study illustrated that white American students will continue dominating class room discussions, unless students from Asia and other non English speaking nations improve their speaking and listening abilities in the English language. The foreign students who intend to study management and business courses should first be asked to take some prerequisite English language courses, which should improve their speaking and listening skills. In a class where foreign students outnumber the American students, it is recommended that each student should get an opportunity to make some presentations in the class. This will not only improve their presentation skills, but also improve their participation in the class. It is also very important to give reasonable weight age to oral participation in the overall grade this will motivate students to come prepared and participate more frequently. As far as the female students are concerned, they have to be encouraged by the instructor to participate, so that these students can also realize their full potential in a live class. The best way to do this is by giving them a chance to participate whenever they indicate that they would like to speak. The instructor can also give a schedule to students when they will be asked to open the discussion in the class. The female and foreign students can also benefit if small discussion groups are made in which they will be able to participate more easily, and express themselves better.

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Table1. Mean and Standard deviation of student's oral participation

Descriptive statistics: Oral and online computer participation results					
Anchor points					
Survey Question	n	M	SD	1	5
What is the frequency of your oral participation?	28	4.17	1.84	Very rarely	Very frequently
Are you prepared for participation in class?	28	4.03	1.85	Never	Always
Do you feel comfortable while participating in class?	28	4.03	1.85	Never	Always
What is your frequency of online computer discussion?	28	3.92	1.86	Very rarely	Very frequently
Are you prepared for on line computer discussion?	28	4.21	1.83	Never	Always
Do you feel comfortable while doing on line computer discussion?	28	4.17	1.84	Never	Always

Table 3. Multiple Regression Analysis  
Dependent Variable: FOP

Parameter	Estimate	Standard Error	T Statistic	P Value
Constant	1.28582	0.31471	4.08573	0.0004
E	0.221491	0.108537	2.04069	0.0520

Table 4. Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F Ratio	P Value
Model	2.48562	1	2.48562	4.16	0.0520
Residual	14.9218	25	0.596871		
Tot (Corr.)	17.4074	26			

Table 2. Mean and Standard deviation of white student's oral participation

Descriptive statistics: Oral and online computer participation results					
Anchor points					
Survey Question	n	M	SD	1	5
What is the frequency of your oral participation?	7	4.42	2.01	Very rarely	Very frequently

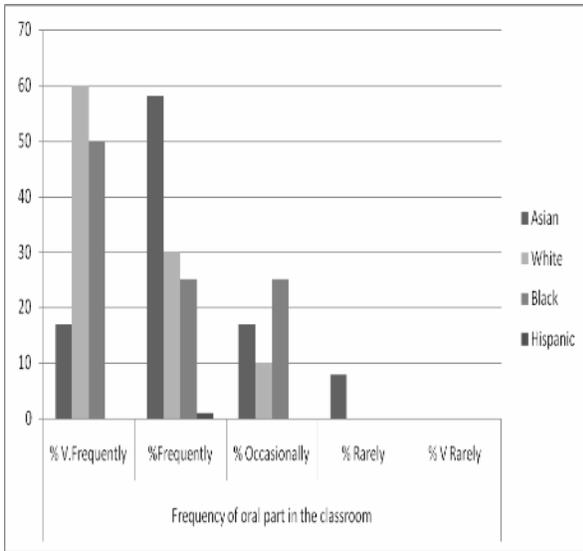


Figure1. Frequency of oral participation

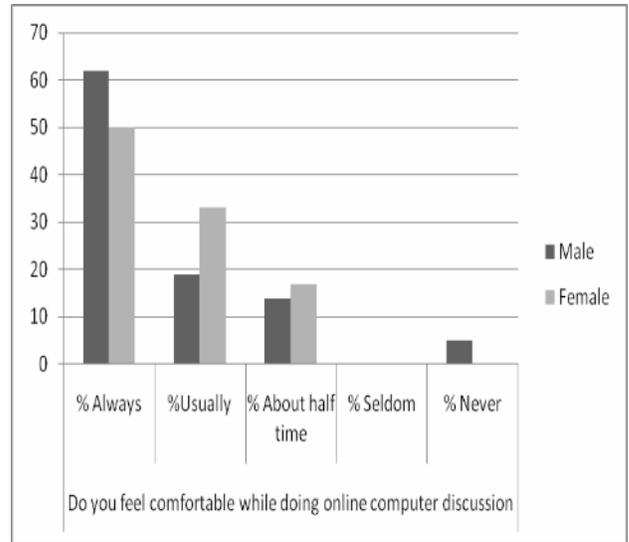


Figure3. Level of comfort during online computer mediated discussion

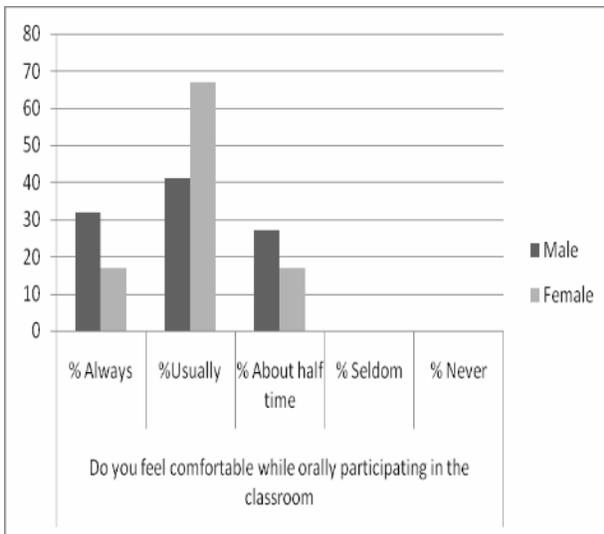


Figure 2. Level of comfort in oral participation

# The Effects of Different Stimuli on Procrastination

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## Abstract

Numerous prior studies suggest that procrastination is a widespread phenomenon among both students and industry professionals. Prior research also demonstrates a positive correlation between time management skills and students' achievements as well as their personal satisfaction. This article will evaluate those time management skills from a variety of perspectives. Specifically, this article will report on the results of study to determine the factors that influence the development of students' time management skills.

The study evaluated the effects of a positive stimulus – extra credit for work submitted early and negative stimuli – a point loss for submitting assignments too close to the deadline. The research also accounted for participants' background to see if any correlations existed between time management skills and a participants' upbringing or work experiences.

This research will ask and answer a number of questions, including:

- 1) What personal background (if any) influences a student's time management skills?
- 2) How did the pattern of student submission change over time?
- 3) What was more likely to produce the desired effect (positive or negative stimulus)?
- 4) How significant was the measured effect of each stimulus?

5) What could be implemented to enhance the teaching process and help students develop good time management skills?

6) What can/should be studied further, how, and why?

## 1. Introduction

Procrastination, also called “student syndrome,” is a well known phenomenon, plaguing both industry and academia. A number of studies have explored this phenomenon and its effects. This study focused on countering procrastination and ways to enhance student time management skills.

## 2. Study background

A number of publications, including *Critical Chain* [2] and *Time Trap* [3], explore time management and procrastination as a way of handling tasks to deliver results on a deadline. Some studies, including Wilkinson & Sherman [8], Weilbaker, Shah, & Tillman [7], and Weilbaker, Popkov, Colletti, & Tillman [6] looked at procrastination as a phenomenon in a distance education setting. These studies suggest that procrastination could be a wide-spread phenomenon, affecting both industrial and academic environments, and a common characteristic at least to some degree for a wide range of people.

Recent studies, however, do not offer a solution to the problem of procrastination. Further review of the literature, including reports by Darren, Sinikka, Emory, Shannon, & Tabitha [1], and Sansgiry, Kawatkar, Dutta, & Bhosle

[5] suggest that the time management skills influence student performance. Yet, research seems to offer little guidance how to develop those so important time management skills. Sansgiry, Kawatkar, Dutta, & Bhosle went as far as evaluating if time management is influenced by the academic progression, but found no correlation.

With an apparent lack of proven solutions to motivate time management, a general theory of conditioning originated by Pavlov, and used in education and training for skills development will be applied to motivate better time management in this quasi-experimental study.

### 3. Study goals

This study pursued two goals:

1. To find an effective method to develop proactive behavior, and better self and time management skills in engineering management students; and
2. To add to the motivational theory body of knowledge, by evaluating the ways current and aspiring management professionals respond to different forms of time management motivation.

### 4. Study design

The study was conducted in one Midwestern university, in a graduate program in engineering management. Most students had professional work experience, and many of them had management experience. The study used a convenience sample from students already enrolled in the program on-line courses. These courses had a number of stimuli intended to enhance students' time management skills.

The stimuli included

1. An award for being the first to post, which was a positive, enforced stimulus;
2. A point reduction for participating too close to the deadline, which was a negative and enforced stimulus; and

3. Lastly, a point reduction for doing too much too close to deadline, which was the negative stimulus. This however, was not enforced.

The time of the submissions, particularly the times of the discussion posts, were dependent variables. The stimuli and the students' backgrounds formed independent variables.

Researchers enrolled students in this study by contacting them via e-mail and offering them to review a consent form. Those students who chose to participate had to fill out and submit a survey. The consent form and the whole study were reviewed and approved by the university Institutional Research Board. The survey had eight multiple choice questions covering a student's background and load, with the number of answer choices ranging from 4 to 8 per question. Of the total of 28 students enrolled in two courses, 20 consented to the study and returned completed surveys. This number constituted a 70% response rate.

Collected data was then organized in a uniform way to look for patterns. Submission timing, for example, was logged along units' duration to establish pattern trends from one unit to another. Once categories of students with different time management patterns were established, survey data was partitioned and analyzed for any predictors of the time management skills among students.

### 5. Study assumptions and limitations

The study assumed that

- Skills develop through repeated behavior;
- Encouraging correct behavior and discouraging wrong behavior can facilitate the desired development of skills; and
- The time of submission does not directly relate to the quality of work

The latter assumptions were confirmed through observations in the study, as more

proactive students also seemed to perform well otherwise. Additionally, the bulk of submissions in the course were comprised of the on-line discussion entries. Each of those entries was on average a couple of sentences to a paragraph long, and did not require hours or rigorous preparations. Consequently, it was reasonable to expect that such short contributions to the class on-line discussions could be done throughout the study unit and with high quality. The study limitations included conducting it in one university and one graduate program, leading to a limited number of students participating in the research. Another limitation was the number of questions and the resolution of the response intervals in the demographic survey.

### 6. Study findings: Submissions

The study found that there were three distinct categories of students: the first one was very proactive (black line in Figure 1), the second one was middle-of-the-road (white line), and the third one included very pronounced procrastinators (gray line). Figure 1 provides an example of the submissions frequency distribution for each of these three categories along the duration of one study unit. The days of the unit were plotted along the x-Axis, with the unit deadline to the far right.

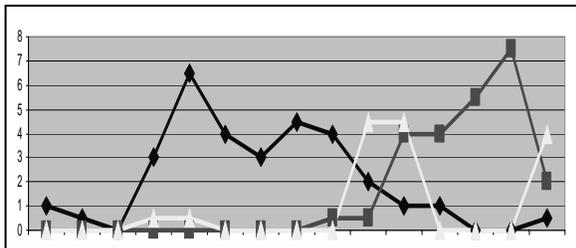


Figure 1. Three categories of students

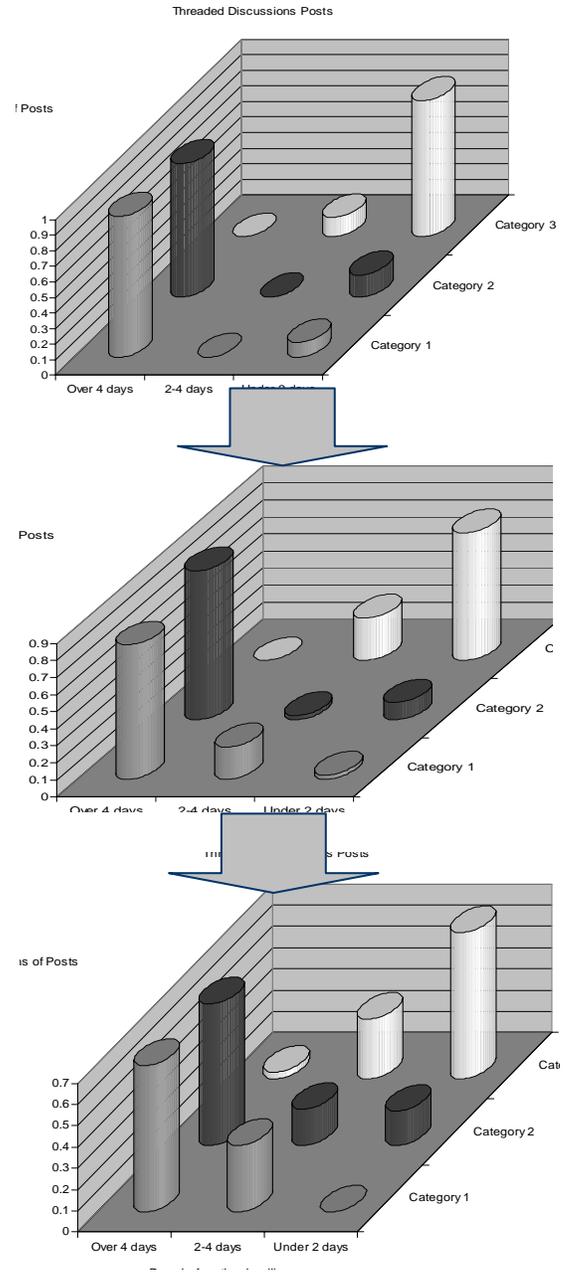


Figure 2. Submission frequency pattern change

Another consistent observation in the study was that students responded to stimuli by either keeping or adjusting their behavior. Figure 2 details how students' submission frequency changed from one unit to another in response to different stimuli and feedback.

Normalizing frequency distributions allowed to compensate for unit-to-unit and course-to-course variations and afforded a fair comparison and trend evaluation. Tables 1-7 show how students responded to positive stimulus, negative enforced stimulus, and negative unenforced stimulus. Positive stimulus offered a reward of extra points to the student who was the first one to post to the course discussion. This was awarded in each unit and for each topic posted.

**Table 1. Positive stimulus response**

	Day 1	Day 2	Day 3	Day 4	Day5
Unit1	1	0	0	1	1
Unit2	1	0	1	1	1
Unit3	1	0	2	1	1
Unit4	1	0	0	1	1
Unit5	1	0	1	0	0

Table 1 shows the number of students beginning their participation in the first five days of the unit in Course A of the study. It appears at first students were trying to go for the prize, getting closer to the beginning of the unit from unit 1 to 2 and then 3. As only one of them, however, kept reaping the prize points, others eventually lost interest, as is evident from the unit 4 and 5 submissions patterns. These results suggest it may be advisable to ensure more than one person can benefit, if positive reinforcement is to be used effectively.

Tables 2 through 4 details the frequency of submissions in various parts of the unit where an enforced negative stimulus is involved. Table 3 shows frequencies for the most proactive category of students. Table 4 illustrates the frequency of posts for mid-range students, and Table 5 demonstrates results for the

“pronounced procrastinators.” The columns represent the number of days before the deadline. Occasionally the numbers do not add up exactly to 1 due to rounding.

**Table 2. Negative enforced stimulus response of proactive students**

	4+ days	2-4 days	0-2 days
Unit 1	0.90	0.03	0.07
Unit 2	0.91	0.00	0.09
Unit 3	0.69	0.31	0.00
Unit 4	0.79	0.19	0.03
Unit 5	0.94	0.06	0.00

**Table 3. Negative enforced stimulus response of mid-range students**

	4+ days	2-4 days	0-2 days
Unit 1	0.83	0.17	0.00
Unit 2	0.86	0.00	0.14
Unit 3	0.67	0.17	0.16
Unit 4	0.88	0.03	0.10
Unit 5	0.60	0.25	0.15

**Table 4. Negative enforced stimulus response of procrastinating students**

	4+ days	2-4 days	0-2 days
Unit 1	0.50	0.50	0
Unit 2	0.00	0.13	0.88
Unit 3	0.03	0.28	0.69
Unit 4	0.00	0.25	0.75
Unit 5	0.00	0.25	0.75

Tables 5 through 7 show the frequency of submissions in the different parts of the unit where the negative stimulus is not enforced. Notably, proactive students were never late, mid-range students had submitted assignments late at least once, and procrastinators were late more than once. The most the procrastinating students were late in one unit was in 22% of their submissions. Note that Tables 5 – 7 have late submissions added to the “0-2 days” column.

**Table 5. Negative unenforced stimulus response of proactive students**

	4+ days	2-4 days	0-2 days
Unit 1	0.35	0.57	0.08
Unit 2	0.53	0.21	0.26
Unit 3	0.44	0.39	0.17
Unit 4	0.42	0.48	0.10
Unit 5	0.51	0.49	0.00
Unit 6	0.60	0.40	0.00
Unit 7	0.63	0.33	0.04

**Table 6. Negative unenforced stimulus response of mid-range students**

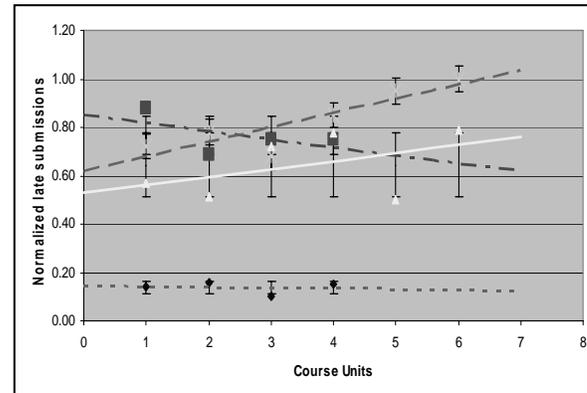
	4+ days	2-4 days	0-2 days
Unit 1	0.16	0.47	0.37
Unit 2	0.16	0.27	0.57
Unit 3	0.08	0.41	0.51
Unit 4	0.00	0.28	0.72
Unit 5	0.03	0.19	0.78
Unit 6	0.11	0.39	0.50
Unit 7	0.00	0.26	0.74

**Table 7. Negative unenforced stimulus response of procrastinating students**

	4+ days	2-4 days	0-2 days
Unit 1	0.29	0.67	0.05
Unit 2	0.17	0.08	0.75
Unit 3	0.03	0.28	0.69
Unit 4	0.14	0.19	0.68
Unit 5	0.00	0.15	0.85
Unit 6	0.00	0.05	0.95
Unit 7	0.00	0.00	1.00

Data suggests that the unenforced stimulus was still respected by the proactive students, and mostly disregarded by others. While mid-range students tried to stay within the class boundaries, procrastinators were often submitting at the last moment, and running late. The last unit in the class was a culmination of the procrastinators' performance. It had 100% of procrastinators' submissions done on the last weekend of the unit in the course with unenforced stimulus.

Figure 3 graphically presents how the trends for mid-range and procrastinators compare depending on the enforcement.



**Figure 3. Submission frequency trends**

The solid line illustrates the trend for mid-range students with unenforced stimulus, as opposed to the dotted line demonstrating the trend for mid-range students with an enforced stimulus. The dashed line shows the trend for procrastinators with an unenforced stimulus, as opposed to the dash-dot trend line for procrastinators with an enforced stimulus. The standard deviation confidence limits are also plotted. An analysis of these plots suggests that the differences in students' behavior were not due to chance or noise alone, and providing feedback, in this case through points' reduction, has an influence on the timing of students' submissions.

## 7. Study findings: background

In order to look for predictors of strong or weak time management skills, the study looked at the students' backgrounds. This was accomplished through a demographic survey, which explored:

- The number of years since receiving his or her undergraduate diploma;
- The years of total work experience;
- The years of project leadership;
- The years in functional leadership;

- Work load;
- Study load;
- Other commitments; and
- Upbringing

Since only one student grew up outside the US or Canada, the last question had to be dismissed. Collected data was grouped for three categories of students as discovered in the data analysis of submission. Wherever the graphs were skewed, upper and lower control limits were calculated to see if any predisposition existed or if variations could be due to noise alone. Only work experience analysis (Figure 4) suggested that extensive work experience could be a predictor of better time management skills.

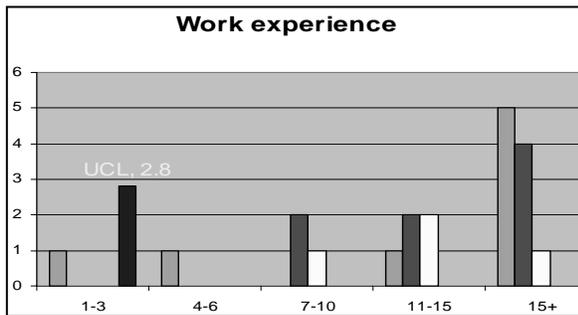


Figure 4. Work experience durations

Other variables failed to produce considerably skewed patterns. Figures 5 through 7 illustrate examples of other distributions.

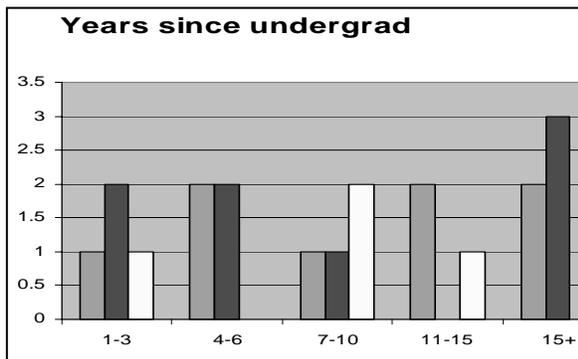


Figure 5. Years since students graduated from undergraduate program

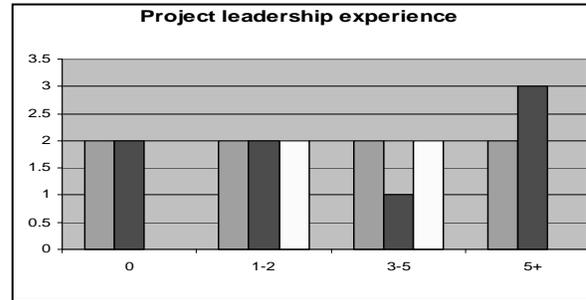


Figure 6. Students' project leadership experience

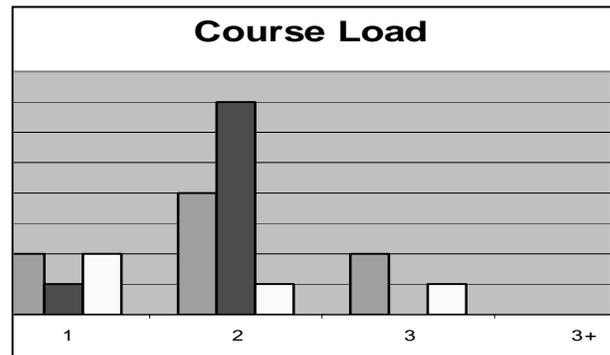


Figure 7. Students' course load

Estimating students' total work loads based on their work, study, and other commitments, yielded results well within the tolerance of the study variables. Consequently, in this study it was not possible to find a correlation between the total personal and work time commitments of students and their classroom time management.

## 8. Findings and conclusions

The study found that all students could be approximately divided into three categories:

1. Proactive students who learn and adjust time constraints proactively and stay safe; who have time management skills already developed; who respect constraints regardless of enforcement; and only need encouragement and positive reinforcement.
2. Mid-range students who learn the constraints, but who tend to wait to the last moment; they respect stimuli and do

not risk losing points; they learn some time management by spacing work, but these students need some form of enforcement to help stay consistent.

3. Procrastinators learn from only losing points (the “hot stove” rule); they disrespect the stimuli if there are no consequences; they try to manipulate the system as much as possible; they need constant enforcement and a system of stimuli to guide them toward the correct behavioral patterns.

The study also found that stimuli worked best if instructors provided feedback that students care about. This feedback could be in a form of either an attainable reward, or a reprimand they would want to avoid. In this sense the development of the time management skills seem to go along the path similar to ones used to impart other knowledge and skills in educational settings. This similarity can make an educators’ job of helping students develop time management skills easier.

It is thus possible, beneficial, and advisable to incorporate time management stimuli in course materials. Such stimuli must be supported with some form of feedback.

## 9. Future studies suggestions

Repeat studies of stimuli impact on time management, with larger samples and in diverse settings could add to the size of the data and help to test conclusions of this study.

If predictors of good time management exist, one likely needs to look for such predictors in categories of background other than explored by this study. Such explorations could take a form of semi-structured interviews to look for new categories in participants’ backgrounds.

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# Design of LED Backlighting System for Aircraft Cockpit Displays

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## Abstract

The goal of this paper is to design, build, and test a backlighting system for aircraft cockpit displays using LEDs (Light Emitting Diodes). The current technology for backlighting the displays uses fluorescent bulbs. LEDs have explored the use as an alternative to the existing backlighting system. LEDs have been chosen because of the following advantages over fluorescent bulbs: smaller and lighter backlighting system, improved performance over temperature variations, manufacturing and handling the backlighting system is less strenuous, and LEDs have a longer life expectancy than fluorescent bulbs.

The current technology used for backlighting aircraft cockpit displays uses fluorescent bulbs in order to generate light needed to see the liquid crystal display (LCD) screen. The bulbs are typically arranged in either a side-lit or direct-lit configuration. The double side-lit design was the best alternative to take into the building and testing phase. The major reasons, as proven by merit analysis, are the usage of a minimum number of LEDs, the best light distribution, the minimum system power dissipation, and the best viewing ability [1].

## 1. Introduction

The current technology for backlighting aircraft cockpit displays uses fluorescent bulbs to generate light needed to see the liquid crystal

display (LCD) screen. The bulbs are typically arranged in either a side-lit or direct-lit configuration.

The side-lit configuration consists of placing fluorescent bulbs along the length of either one or both sides of display case. Both of these side-lit methods use light guides, which are composed of a clear plastic material that channels the light from the sources on the sides of the display case towards the LCD screen. Large display screens typically require placing fluorescent bulbs along both sides of the casing. This produces a more even distribution of light, and therefore prevents one half of the LCD screen from appearing brighter than the other half. On the other hand, smaller display screens are often lit by fluorescent bulbs placed along only one side of the casing. However, because of their smaller size, these displays do not experience the problem of one side of the LCD screen appearing brighter than the other side [2].

There are a growing number of industries throughout the world that are turning to LEDs as light sources. For example, the computer and television industries are currently researching the possibility of using LEDs as backlights for display screens. In addition, LEDs are now starting to show up in terms such as traffic lights and home lighting applications where brightness is a key factor for success. Due to their increasing popularity, LEDs would be advantageous in the cockpit display industry for several reasons. First, LEDs provide improved

reliability and longer life expectancies (typically 100,000 hours for LEDs compared to around 10,000 hours for fluorescent lamps). Second, LEDs make smaller and lighter backlighting designs possible. This is because fluorescent lamps require a more complicated drive circuit and larger, more complicated mechanical packaging. Third, LEDs provide improved performance over temperature variations because fluorescent lamps require a heater and heater control circuit at cold temperatures. Finally, manufacturing and handling and LED backlighting system will be less tedious because LED boards can be built on an automated surface mount assembly machine while fluorescent lamps are fragile and require hand wiring and assembly. All of these characteristics are important when considering the rigorous specifications that must be met in order for electronics to be implemented in the aircraft industry [3].

## 2. Design of LED lighting system

The goal of this project was to replace the fluorescent bulbs of an 11.7" x 8.62" x 1.885" aircraft cockpit display system with LEDs. The LEDs will become the new light source for the display system's LCD screen. In making this replacement, a driving circuit and the arrangement of the LEDs in the location of the existing fluorescent bulbs had to be designed. The project goal also consisted of designing a backlighting system such that it produces a variable amount of light intensity out of the LCD screen. This range of light intensity includes being bright enough so that the pilot of the aircraft can view the information on his display screen under direct sunlight.

The backlighting system design must meet the same set of basic specifications that the fluorescent bulbs are required to meet. These specifications are determined as follows:

1. The design must cost less than ten thousand dollars to build.

2. The display must dissipate no more than 140 Watts.
3. The display system must generate at least 160 foot-lamberts of light intensity out of the LCD screen for daytime use.
4. The display system must be dimmable in order to generate no more than 0.05foot-Lamberts of light intensity for nighttime use.
5. The LEDs must be driven at 60 Hz.

### 2.1. Design alternatives

The major benefit of choosing to make design alternatives the same as with the current fluorescent lamps is that these designs allow to alter as little of the existing display assembly as possible. This helps to minimize the amount of new mechanical hardware that must be manufactured in order for the light source replacement to occur [4].

#### **Alternative 1: Direct-lit configuration:**

This method would require LEDs to be placed along the back of the display case (parallel to the LCD screen). LEDs would have to be evenly distributed throughout the back surface of the display case in order to produce an even distribution of light. In addition, this design would require the use of a heavy diffuser to scatter the light before it reaches the LCD screen. This would help to prevent bright spots from appearing on the LCD screen in areas directly above the LEDs.

#### **Alternative 2: Single side-lit configuration:**

This method would consist of placing LEDs along the length of one side of the display case. This design would require the use of a light guide, which is a clear plastic material that channels the light from the side of the display case towards the back of the LCD screen. In order to produce an even distribution of light, the light guide used for single side-lit is designed to allow more light to pass through it at distances further away from the light source. In

order to ensure that the maximum amount of light gets directed into the light guide, it would only be beneficial to place LEDs in the 11.1” x 0.960” area along the side of the display case. This area is the same dimension as the side of the light guide through which light from the LEDs enters. As with the direct-lit, this design also incorporates the use of a light diffuser. However, it is thinner and allows more light to pass [5].

**Alternative 3: Double side-lit configuration:**

This method would consist of placing LEDs along two opposite sides of the display case. Like the single side-lit, this design would require the use of a light guide. However, the amount of light that passes through this light guide does not depend on distance from the light source. This is because supplying light from two opposite sides of the display case produces a more even distribution of light than from a single side. In addition, the same light diffuser that is used for the single side-lit design is used here. The double side-lit configuration allows for twice as much surface area for LED placement than the single side-lit. Again, the LEDs are placed in the area that is the same as the side of the light guide through which light from the LEDs enters [6].

**3. Design computations**

**3.1. Luminance calculations**

A day brightness rating of 160 foot Lamberts were required. This number was used to calculate the number of lumens needed to meet this specification:

$$fL = \frac{lumens}{ft^2} \frac{2\pi}{radiation\_steradians}$$

(1)

After the light passes through a light guide and optical diffusion film, the surface through which luminance passes is considered lambertian. A lambertian surface is described as one that adheres to Lambert’s cosine law. Lambert’s

cosine law states that the reflected or transmitted luminous intensity in any direction from an element of a perfectly diffusing surface varies as the cosine of the angle between that direction and the normal vector of the surface. As a consequence, the luminance of that surface is the same regardless of the viewing angle. For a lambertian light source, the radiation steradians are  $2\pi$  and the second term of the above equation equals one. This gives:

$$fL = \frac{lumens}{ft^2} \quad lumens = fL \cdot ft^2$$

(2)

Solving the above equation for lumens:

$$lumens = 160 fL \cdot 0.486 ft^2$$

(3)

$$lumens = 77.76$$

Here,  $0.486 ft^2$  is the surface area of the LCD screen. Now the transmittance of the LCD screen has to be taken into account, which is only 4.5% of lumens emitted by the backlight. This greatly increases the number of lumens needed as can be seen below:

$$lumens_{bkl} = \frac{lumens}{0.045} \quad lumens_{bkl} = 1728$$

For a side-lit backlight, a light guide and optical film are used in order to diffuse the light. The light guide has a transmittance of 70% and the optical film’s transmittance is 90%. This further increases the amount of lumens needed from the LEDs:

$$lumens_{LEDs} = \frac{lumens_{bkl}}{0.7 \cdot 0.9 \cdot 0.95}$$

(4)

$$lumens_{LEDs} = 2887$$

Thus, it is necessary to produce a total of 2887 lumens from LEDs to meet the requirement of 160 ft Lamberts luminous output.

### 3.2. Number of LEDs required

To produce the correct shade of white light, the total luminous output needs to be composed of 24.9% red, 64.4% green, and 10.6% blue. In order to calculate the number of each color of LED, the following equation had been used:

$$\begin{aligned} Total\_lumens_{Red} &= lumens_{LEDs} \cdot 24.9\% \\ &= 2887 \cdot 24.9\% \approx 719 \end{aligned}$$

$$\begin{aligned} Total\_lumens_{Green} &= lumens_{LEDs} \cdot 64.4\% \\ &= 2887 \cdot 64.4\% \approx 1859 \end{aligned}$$

$$\begin{aligned} Total\_lumens_{Blue} &= lumens_{LEDs} \cdot 10.6\% \\ &= 2887 \cdot 10.6\% \approx 306 \end{aligned}$$

Once the number of lumens of each color was calculated, the number of LEDs required to produce that amount had been determined as below:

$$LEDs_{Red} = \frac{total\_numbers_{Red}}{lumbers / LED_{Red}} = \frac{719}{3.478} \approx 207$$

$$LEDs_{Green} = \frac{total\_numbers_{Green}}{lumbers / LED_{Green}} = \frac{1859}{2.675} \approx 695$$

$$LEDs_{Blue} = \frac{total\_numbers_{Blue}}{lumbers / LED_{Blue}} = \frac{306}{0.7} \approx 438$$

Based on the above calculations, 207 Red LEDs, 695 Green LEDs, and 438 Blue LEDs will be needed to produce white light.

### 3.3. LED drive circuit

The LED drive circuit is chosen using several criteria. First, the circuit must be capable of dimming the LEDs in a manner that will allow

in achieving minimum and maximum brightness. The LEDs using pulse width modulation was chosen. Therefore, the duty cycle of the pulse will determine how long the LEDs are on and off (a longer duty cycles will result in brighter LEDs). The second criterion was that the LEDs must be driven at 60 Hz. The backlight will be pulsed at 60 Hz to keep it synchronized with the vertical refresh rate of the display. If the backlight is pulsed at a different rate than the display update, it can get some flickering or other visible effects. Therefore, it was realized that a drive circuit needed to be capable of driving many LEDs. This would reduce the total number of LED drivers required by this design. The TLC5921 LED driver is a 32-pin package, which operates as a current sink, which pulls constant current (in a range of 1 to 80 mA) through LEDs tied to the 16 output pins. Since red, green, and blue LEDs each required a typical current of 20 mA, the current range that is offered by this driver is sufficient for the application. The BLANK pin will be used in order to control turning the LEDs on and off. When BLANK is low, the output is turned on if data latch value is 1, and turned off if data latch value is 0. When BLANK is high, all outputs are forced to turn off. The BLANK pin will tie to a pulse width modulation signal where the duty cycle of the pulses determines the brightness of LEDs. These pulses will occur at a frequency of 60 Hz to keep the backlighting system synchronized with the vertical refresh rate of the display. In order to generate the clock signal, pulse width modulation, and digital high signals, a microcontroller was used. The TLC5921 had been chosen as the LED driver for this design [7].

## 4. Results and discussions

After the specific kind of LED had been chosen and the driver circuitry determined, the next step was to determine the number of LEDs needed per circuit and the total power the system

would dissipate. As stated before, the system needs 207 red LEDs, 695 green LEDs, and 438 blue LEDs. The maximum voltage drop per LED is as follows: red = 2.8 V, green = 3.0 V, blue = 3.8 V. In addition, each color LED has a typical operating current of 20 mA. For LED driver, the maximum voltage that can be dropped at each of the 16 output pins is not to exceed 17 V. In order to ensure that not to exceed this rating, a DC power supply was used to generate 15 V to power each string of LEDs. The double side-lit design consisted of a printed circuit board on each side of the display. In order to generate an even distribution of light, each circuit board contained the same number of red, green, and blue LEDs. Therefore, equal numbers of red, green, and blue LED drivers on each side were used.

The following calculations were performed to determine the maximum number of LEDs that could string in series at each of the output pins and the maximum number of red, green, and blue LEDs that could be used with each driver:

**Red:**

- 5 LEDs \* 2.8 V/LED = 14V. Each output can string 5 LEDs and not to exceed the supply of 15 V.
- 15V – 14V = 1V. Therefore 1V will appear at the output pin when LEDs are on.
- 5 LEDs/pin \* 16 pins = 80 LEDs/driver. Therefore, each driver can drive a maximum of 80 red LEDs.

**Green:**

- 4LEDs \* 3.0V/LED = 12V. Each output can string 4 LEDs and not to exceed the supply of 15 V.
- 15V – 12V = 3V. Therefore 3V will appear at the output pin when LEDs are on.
- 4 LEDs/pin \* 16 pins = 64 LEDs/driver. Therefore, each driver can drive a maximum of 64 green LEDs.

**Blue:**

- 3 LEDs \* 3.8 V/LED = 11.4V. Each output can string 3 LEDs and not to exceed the supply of 15 V.
- 15V – 11.4V = 3.6V. Therefore 3.6V will appear at the output pin when LEDs are on.
- 3 LEDs/pin \* 16 pins = 48 LEDs/driver. Therefore, each driver can drive a maximum of 48 blue LEDs.

The exact number of red, green, and blue LEDs and LED drivers were calculated as needed. Each printed circuit board needed an even number of drivers.

**Red:**

- 207 LEDs/80 red LED drivers= 2.6 drivers. Four drivers were chosen (two per side).
- 4 drivers \* 52 LEDs per driver = 208 red LEDs. This is one more than 207 LEDs as predicted. It is necessary to divide the LEDs evenly among the 4 drivers.

**Green:**

- 695 LEDs/64 green LED drivers = 10.9 drivers. Twelve drivers were chosen (6 per side)
- 12 drivers \* 58 LEDs per driver = 696 green LEDs. This is one more than the 695 LEDs as predicted. It is necessary to divide the LEDs evenly among the 12 drivers.

**Blue:**

- 438 LEDs /48 blue LED drivers = 9.1 drivers. Ten drivers were chosen (5 per side).
- 10 drivers \* 44 LEDs per drive = 440 blue LEDs. This is two more than the 438 LEDs as predicted. It is necessary to divide the LEDs evenly among the 10 drivers.

Therefore, the total number of LED drivers needed to purchase is 26.

Next step was to calculate total power the system would dissipate. Tables 1, 2, and 3 show the number of LEDs per output pin, the volts dropped on each output pin, the power dropped on each output pin, and the power dropped on all LEDs. The charts lead to conclusion of how much total power is dissipated by each driver

and its corresponding LEDs. From this, the total power dissipated by all red, green, and blue drivers can be calculated.

**Table 1. Power Dissipated by Red LEDs and Red Drivers**

RED				
Output Pins	LEDS per pin	Volts at Output Pin	Power Dropped on Output Pin	Power Dropped on LEDs
1	5	1 V	20 mA * 1 V = 0.02 W	5 LEDs * 2.8 V * 20 mA = 0.28 W
2	5	1 V	0.02 W	0.28 W
3	5	1 V	0.02 W	0.28 W
4	5	1 V	0.02 W	0.28 W
5	5	1 V	0.02 W	0.28 W
6	5	1 V	0.02 W	0.28 W
7	5	1 V	0.02 W	0.28 W
8	5	1 V	0.02 W	0.28 W
9	5	1 V	0.02 W	0.28 W
10	5	1 V	0.02 W	0.28 W
11	2	8.4 V	20 mA * 8.4 V = 0.168 W	2 LEDs * 2.8 V * 20 mA = 0.112 W
12	0	0 V	0 W	0 W
13	0	0 V	0 W	0 W
14	0	0 V	0 W	0 W
15	0	0 V	0 W	0 W
16	0	0 V	0 W	0 W
<b>Totals</b>	<b>52</b>		<b>0.388 W</b>	<b>2.912 W</b>

**Table 2. Power Dissipated by Green LEDs and Green Drivers**

GREEN				
Output Pins	LEDS per pin	Volts at Output Pin	Power Dropped on Output Pin	Power Dropped on LEDs
1	4	3 V	20 mA * 3 V = 0.06 W	4 LEDs * 3 V * 20 mA = 0.24 W
2	4	3 V	0.06 W	0.24 W
3	4	3 V	0.06 W	0.24 W
4	4	3 V	0.06 W	0.24 W
5	4	3 V	0.06 W	0.24 W
6	4	3 V	0.06 W	0.24 W
7	4	3 V	0.06 W	0.24 W
8	4	3 V	0.06 W	0.24 W
9	4	3 V	0.06 W	0.24 W
10	4	3 V	0.06 W	0.24 W
11	4	3 V	0.06 W	0.24 W
12	4	3 V	0.06 W	0.24 W
13	4	3 V	0.06 W	0.24 W
14	4	3 V	0.06 W	0.24 W
15	2	9 V	20 mA * 9 V = 0.18 W	2 LEDs * 3 V * 20 mA = 0.12 W
16	0	0 V	0 W	0 W
<b>Total</b>	<b>58</b>		<b>1.02 W</b>	<b>3.48 W</b>

**Table 3. Power Dissipated by Blue LEDs and Blue Drivers**

BLUE				
Output Pins	LEDS per pin	Volts at Output Pin	Power Dropped on Output Pin	Power Dropped on LEDs
1	3	3.6 V	20 mA * 3.6 V = 0.072 W	3 LEDs * 3.8 V * 20 mA = 0.228 W
2	3	3.6 V	0.072 W	0.228 W
3	3	3.6 V	0.072 W	0.228 W
4	3	3.6 V	0.072 W	0.228 W
5	3	3.6 V	0.072 W	0.228 W
6	3	3.6 V	0.072 W	0.228 W
7	3	3.6 V	0.072 W	0.228 W
8	3	3.6 V	0.072 W	0.228 W
9	3	3.6 V	0.072 W	0.228 W
10	3	3.6 V	0.072 W	0.228 W
11	3	3.6 V	0.072 W	0.228 W
12	3	3.6 V	0.072 W	0.228 W
13	3	3.6 V	0.072 W	0.228 W
14	3	3.6 V	0.072 W	0.228 W
15	2	7.4 V	20 mA * 7.4 V = 0.148 W	2 LEDs * 3.8 V * 20 mA = 0.152 W
16	0	0 V	0 W	0 W
<b>Total</b>	<b>44</b>		<b>1.156 W</b>	<b>3.344 W</b>

As seen in Table 1, the total power dissipated by red LEDs and one driver is  $0.388W + 2.912W = 3.3W$ . So, the total power dissipated by all red LEDs and red drivers = 4 drivers \*  $3.3W = 13.2W$ .

As seen in Table 2, the total power dissipated by green LEDs and one driver is  $1.02W + 3.48W = 4.5W$ . So, the total power dissipated by all green LEDs and green drivers = 12 drivers \*  $4.5W = 54W$ .

As seen in Table 3, the total power dissipated by blue LEDs and one driver is  $1.156W + 3.344W = 4.5W$ . So, the total power dissipated by all blue LEDs and blue drivers = 10 drivers \*  $4.5W = 45W$ .

So, the total power dissipated by the backlight is  $13.2W$  (from the red LEDs and red drivers) +  $54W$  (from the green LEDs and green drivers) +  $45W$  (from the blue LEDs and blue drivers) =  $112W$ .

### 5. Conclusions

The double side-lit design was the best alternative to take into the building and testing phase. The major reasons, as proven by our merit analysis, are the usage of a minimum number of LEDs, the best light distribution, the minimum system power dissipation, and the best viewing ability.

This design meets and exceeds the feasibility criteria for the project in the several ways. First, the backlighting system will only dissipate 112 Watts, which is below the maximum of 140 Watts. Second, engineering analysis shows that the display system will generate at least 160 foot-Lamberts of light intensity out of the LCD screen for daytime use. Third, by using the TLC5921 LED Driver by Texas Instruments and the appropriate microcontroller, the display system will be dimmable, due to the usage of pulse width modulation, and will allow generating no more than 0.05 foot-Lamberts of light intensity for nighttime use. Finally, they will be able to drive the LEDs at the required 60 Hz by programming microcontroller to generate a pulse width modulation signal with a frequency of 60 Hz.

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## Selecting a Course Management System- Decision Making at Medium Sized Public Universities

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### Abstract

This presentation is regarding a study conducted to understand the decision-making processes and factors involved in the selection of a course management system (CMS) at medium sized public universities within the United States. The study will address the myriad of variables that a higher education institution must take into account in a complex decision-making process, namely the structure and methods used by the self-directed individuals and groups such as selection committees, the extent to which system features meet institutional needs, the ease of incorporating new tools and features into the teaching-learning environment, and the costs of acquiring and maintaining the system and having 24/7 support available to faculty and students.

The study reflects the complicated multi-criteria decision-making process within socio-technical systems such as the selection committees. Drawing from technology management theory, the researcher will identify the common institutional and business factors affecting the final decision.

Using extensive analysis of literature in the field, the researcher will present the study results and the important variables considered in such a pervasive decision. The decision makers could be the institution leadership, the IT experts or selection committees which could be representative of –faculty, faculty senate, faculty union, students, administrators, continuing education, information technology and other

departments. This study will demonstrate that decision making is socio-technical in nature; it utilizes collective experiences and knowledge of the entire group to arrive at an optimal decision instead of relying on just the information available to decision makers.

### 1. Introduction

Institutions of higher education are offering an increasing number of web-enhanced courses to meet the time and distance needs of current students. Universities are faced with the challenge of selecting web-integrated course management systems that are institutionally appropriate and affordable.

Course Management Systems (CMS) have become a mission-critical part of universities. There are many types of CMS available, and the task of selecting an appropriate one is complex, requiring consideration of the institutional needs and the business environment within the educational technology sector. In the absence of guidelines or standards available, universities have to rely upon their own research and experience to make decisions that have implications on cost and pedagogy. An integrated decision making framework that encompasses the myriad of factors involved is required. An assessment of the common denominators that impact the decision making process and affect the cycle time of the selection process could provide a strong foundation with which to approach such complex decisions.

## 1.2 Significance of the Problem

Universities have experienced many pressures and changes in the past decade to balance costs, provide access to learning and make available more flexible learning options. As Hanna (2003) has observed, “institutions will need to become more focused on customizing programs to serve students where they are—physically, economically, and academically” (p. 27).

The growth in CMS adoption has been rapid. In 2002, over three quarters of all colleges and universities in the US had adopted a CMS and nearly one fifth of college courses used CMS as per the Campus Computing Project (2002). According to Molenda & Bichelmeyer (2005), by 2004 such systems could be considered “ubiquitous on college campuses” (p.4). According to the ECAR Study of Undergraduate Students and Information Technology (2009), 70.4% of the undergraduate students surveyed were using CMS during the semester the survey was conducted.

Institutions in higher education – both public and private – are expected to develop innovative and customized learning systems at the same time that they face budgetary challenges and constraints. Universities face complex task of choosing the optimal CMS technology for both short-term and long-term needs at the time of purchase.

According to the 2003 EDUCAUSE Center for Applied Research Report on Faculty Use of Course Management Systems, “the growth in their size and complexity, the cost of licensing and supporting them has skyrocketed resulting in major funding challenges for universities.” A poor selection of CMS results a costly undertaking that result in loss of significant time, effort and funds. In addition, the initial and on-going costs of using the CMS are often not correctly estimated by selection committees trying to reach a delicate balance regarding the

institutions’ needs which change as per student requirements. As with the adoption of any technology, certain institutional and business factors influence the decision-making process. The number of commercially available CMS has declined due to acquisitions and mergers within the education technology industry leaving Blackboard as the largest commercial provider. Universities planning to select or replace a CMS are very concerned about a perceived monopoly within the industry. Like other proprietary systems, Blackboard restricts modification and customization hence adding to the complexity of decision of acquiring a CMS.

Course Management Systems (CMSs) are “web-authoring tools that integrate technological and pedagogical features of the Internet and the World Wide Web into a single, template-based authoring system to facilitate the design, development, delivery and management of web based courses and on-line learning environments”(Dabbagh, 2004, p.38). According to the Morgan (2003), “in both pedagogical impact and institutional resource consumption, CMS are the academic equivalent of ERP systems”. CMSs also bring an important element to pedagogy according to Osguthorpe & Graham (2003), CMSs are used to “support and supplement face-to-face instruction, a “blended” approach in addition to delivering fully online course content”.

There are three major types of CMSs: vendor-based (e.g. Blackboard, WebCT), open source (Sakai, Moodle), and proprietary (in-house systems that individual universities develop and host). According to Harvey, Buckley, Noviceic and Elfessi (2002, p.47) “CMS succeeds because it has the ability to promote “deeper” learning because it can provide a framework within which faculty members can develop such learner-centered practices.” Faculty members can design a three-part learning environment that combines (a) lectures with online discovery activities, (for

example-online simulations, discussions) with activities that "emulate the process of professional investigation," b) research using the university library databases and research resources (allowing customized integration within the course) and (c) assessment which can be in the form of grade books where students can check their performance in the course. Course Management Software allows for student feedback so the faculty can work on better planning the course delivery. Courses can be delivered in different formats- fully online courses, hybrid courses (those that meet face-to-face some weeks and online other weeks), and Web-enhanced campus-based courses utilizing online components are tools that meet those student requirements.

There is a paucity of research literature on the processes that universities use to select CMSs. Powell (2008) performed a comparative analysis of the decision-making procedures used at six different higher education institutions. Landon (2002) developed a tool describing and comparing key features of course management systems to promote a protocol for rational decision-making; that tool has since been further developed to the now widely available comparison at the Edutools website.

## **2. Purpose of the Study**

This study will examine the decision-making process undertaken at medium-sized public universities in the United States, to select or replace existing course management systems. It will consist of an analysis of the procedures undertaken by this university to acquire new systems or replace existing CMS. This study will look into the factors that the institution must take into account in the decision-making process, namely the structure and methods used by the CMS selection committee, the extent to which system features meet institutional needs, the ease of incorporating new tools and features

into the teaching-learning environment, and the costs of acquiring and maintaining the system and having 24/7 support available to faculty and students. Moreover, the educational institution must be cognizant of the business environment in which the CMS vendors operate, which have a direct impact on the cost and longevity of CMS systems.

## **3. Research Questions**

The study attempts to address the following research questions regarding educational technology acquisition:

1. What are the formal processes that medium-sized public universities utilize to decide upon the selection/ replacement of Course Management Systems?
2. How do institutional and business environment factors affect decision-making process?

## **4. Definitions**

Course Management System (CMS) refers to web authoring tools that integrate technological and pedagogical features of the World Wide Web into a single, template-based authoring system to facilitate the design, development, delivery and management of web based courses and online learning environments (Dabbagh, 2002, p.5).

Electronic learning (e-learning) refers to instructional strategies enhanced by technology (Waterhouse, 2005, p.3).

Decision process refers to a dynamic interrelated unity of pre decision, decision and post decision stages (Zeleney, 1982).

## **5. Conceptual Framework for the Study**

The literature review was conducted in the context of relevant theories from Technology Management and Decision Sciences.

## 5.1 Technology Management

Technology Management is a systematic approach to planning, selecting, implementing, and managing technological change in organizations. The emphasis is on systems integration in all phases of the decision-making process. "The management of technology is the linking of different disciplines to plan, develop, implement, monitor and control technological capabilities to shape and accomplish the strategic objectives of an organization"(White and Burton, 2007).

To make certain that the objectives of this integrated approach are reached and none of the existing strengths are compromised, a decision regarding the selection of appropriate technology must include: a clear understanding of the institution's mission and objectives, a clear needs assessment, a cost-benefit analysis for tangible and intangible costs and an appreciation of the changing education technologies. The process should include a SWOT (Strengths, Weaknesses, Opportunity and Threats) analysis so as to distinguish between the factors that influence the selection.

Some of the important elements from technology management theory to be considered are:

- ❖ Integration of "business"/organizational strategy & technology adoption goals. What is the overall mission of the institution and how does adoption of this technology improve the attainment of organizational objectives.
- ❖ Technology Planning, the exercise that involves all the elements in the acquisition, implementation and eventual upgrading or maturation issues of technology.
- ❖ An exhaustive needs assessment- the reasons for acquiring new technology or updating the technology in use need to be clearly evaluated and understood. Such an

objective needs assessment will allow clarity when looking for a best fit technology for the organization's purpose. A good place to begin with a clear needs assessment is by understanding the strengths, challenges, opportunities and threats (SWOT). This can be an important exercise for an organization especially when faced with the challenge of forecasting the future technological needs of the institution.

- ❖ Next the organization should assess its goals and any variances achieving them by way of conducting "variance analysis" (Haddad, 2002). This can pin point directly to technological shortcomings and point the company towards useful technology to acquire.

- ❖ Readiness for change, it is very important to make certain that all the stakeholders within the organization are prepared to make the change. This would mean willingness to undergo training and instruction.

- ❖ Cost-benefit analysis: A cost benefits assessment is way to create a financial snapshot of the usefulness of any technology acquisition. Roztocki & Needy (1999) argue that a combination of activity based costing (ABC) and economic value added (EVA) may be useful approach for an integrated understanding of the cost implications. It is important that the costs are assessed as both tangible and intangible. (Haddad, 2002). Examples of tangible costs are evident as a dollar amount; however, the intangible costs can be much harder to estimate, such as ongoing support costs.

Some other issues to consider are: Training/HRM policies, Implementation issues, migration from one system to another, archiving, knowledge protection, privacy issues, on going technological evaluation and system management.

Socio-technical systems theory- The term “socio-technical” refers to the relationships between the social and technical parts of a system, particularly those involving information flow, communication and technology in organizations. One of the most relevant STS principles includes “concepts of minimalist design, multiple perspectives, support for congruence, consideration of information flow, and human values”, (Cherns, 1976).

Coakes (2002) describes the aim of socio-technical design as being able to produce systems capable of self-modification, of adapting to change and of making the most of the creative capacity of the individual for the benefit of the organization.

According to Haddad (p.45), important barriers to STS integration that can affect complex decision making are – “narrow orientation of people from different functional groups, technological determinism practice, organizational culture not conducive to participation, lack of empowerment of employees, and lack of business manager familiarity with technology”. For this reason special emphasis is given to the discussion of Strategic Partnership/Shared Governance in Universities involving the stakeholders in the decision process is elemental to successful outcomes. Universities often have unions as major stakeholders, it is imperative to involve members during selection for successful adoption and implementation.

## 5.2 Decision Science

Decision Science provides a background to understand how decisions are made. Common criteria for effective decision making include: decision quality, decision implementation, decision cost and decision development (Vroom, 2001).

Zeleny (1982), proposed two approaches to decision making when faced with multiple

criteria in a group decision context:

The outcome oriented approach- where “if the outcome is predicted, then one obviously understand the decision making process itself.” Being able to predict the outcome of the decision correctly is at the center of this approach. Usually give the answer to the question-what rather than why or how.

The process oriented approach is based on the fact that “if one understands the process of decision-making, then the outcome can be clearly predicted.” This approach is a descriptive approach and assists with the understanding of the how and why the decision was made.

This study focuses on understanding the process to understand how other complex decisions involving multiple criteria can be made. This involves in depth study of the decision process to enable understanding of the most important variables and the dynamics of those involved in the process.

## 6. The CMS Industry and Higher Education

The CMS industry and its impact on higher education today comprise of the - Business Environment factors. The trends within the industry affect the decisions that involve the use of licensed services of vendors. These are “off-the shelf software” products that require customization inputs on from the university.

The CMS industry business environment/trends (mergers, acquisitions, etc.) are of special interest to decision makers who are seeking contracts of specific duration. The 2009 acquisition of Angel Learning Inc. by Blackboard has brought forth an important issue of reliability. The dynamic business environment has forced decision makers to become nervous about a company that is consolidating its hold on the market. The uncertainty bears direct impact on issues of product cost, changes in technology, customer

service and support issues and customization capabilities of the newly formed entity.

## **7. Limitations**

This study focuses on decision-making within medium-sized public universities in the United States. Since decision-making is a complex process and involves many variables, hidden variables may emerge as the study progresses.

Substantial research has not yet been conducted with a focus on this specific selection process hence the paucity of literature is a major drawback.

There is no uniformity in the approach to the decision process in universities. Some institutions constitute committees; others rely on the expertise of the information technology department, or the institution's administrative leadership.

The study identifies similar factors only. The researcher can compile these for future study; however, specific institutional factors form a rich resource which needs to be utilized.

## **8. Conclusion**

Where many studies have focused on the perceptions and preferences of the faculty, staff, students and administrators regarding their choice of course management systems, not much emphasis has been given to the complex decision-making process involved in the selection of this campus wide system.

The institutional factors and business environment of the learning management industry play a major role in the final choice of which CMS is deemed "appropriate" for a particular institution. Some common factors

have been identified and presented in Figure 1.

With emerging knowledge management and distribution issues, more research needs to be done to provide a reliable framework to the participants in this decision-making process to better account for rapidly changing technology, student demands for course delivery and the restricted costs when making a selection that affects the whole enterprise. There is need to have available more research in an effort to investigate decision-making from an integrative systems approach at the institutional level in relation to external business factors within the learning management industry. Recommended approach to research would be multiple case studies. Each institution's decision making process can be assessed as an individual case study. The uniqueness of the institutional factors will translate well and it can be compared with the current business factors. Multiple case studies can then be analyzed for a better understanding of the decision process which would lead to efficient decisions and reduced cycle times.

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## Engineering Leadership: Team Teaching, Team Learning

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### Abstract

Engineers are taught to work with things. In today's global marketplace, engineers must have people skills to be effective on the job: especially, leadership. Management has been replaced by leadership in an effort to better prepare engineers for the workplace of tomorrow. The move to leadership was initiated by the Industrial Advisory Board due to concerns about a perceived lack of people skills of their new employees. Using an interdisciplinary instructor team (Management and Engineering) with a combined 65 years of leadership experience in vastly different industry and academic environments, students develop their leadership skills. The course is taught as both a lecture and active learning forum. The faculty member's experience, the texts used and the active learning produces a classroom environment that is lively and frank. Students are required to teach the material in two books and find that teaching is good for learning while overcoming concerns and gaining confidence when presenting to their peers. Students are required to relate life situations where they experienced leadership successes and failures, to perform a personal assessment, and to make a plan for future development. The results are astounding and worth discussion.

### 1. Background

Most engineering and engineering technology curricula contain a very comprehensive compendium of technical courses designed to insure students are competent upon graduation. ABET accreditation requirements necessitate the need

for adequate and in depth coverage of the technical content in each discipline. Accreditation ensures a high academic standard exists in every program receiving ABET accreditation.

On the other hand, a typical engineering or engineering technology undergraduate education usually lacks a very critical element for succeeding in the workplace; the skills necessary to work effectively with other co-workers, clients and constituents. Undergraduate students must learn and develop the skills and abilities associated with becoming effective when working with a wide variety of people. The word 'leadership' finally surfaces as the area where the students are deficient. At this point discussing this educational shortcoming takes on a whole new meaning especially since it has never been addressed before in the undergraduate curriculum.

Conventional wisdom defines leadership as a skill and as such it can be learned [1]. The question is where to begin when teaching leadership skills? Researching the voluminous amount of leadership material available to industry clearly indicates the starting point must be with the individual focusing on themselves [1]. Students of leadership must first scrutinize their trustworthiness and integrity ensuring they are genuine and authentic in their personal character [2]. Once they have ascertained their trustworthiness, the students then focus on the level of trust they must develop with others to have a positive influence on them so as to create a synergistic relationship with the various members of a team.

The premise for teaching leadership is best summarized by a famous quote from a much respected general and president of the United States. It states, “The one quality that can be developed by studious reflection and practice is leadership”. - General Dwight Eisenhower. This course was developed to provide students with both tenants ensuring a thorough understanding and comprehension of leadership.

## 2. Course development

The Civil Engineering Technology program at the University of Pittsburgh at Johnstown has a Construction Management thread and one of the courses offered was Engineering Management. In recent years, the emphasis from ABET, the desires of graduates, the experience from faculty who do regular consulting and the evolving understanding for the need of leadership training for graduates fueled a redesign of the Engineering Management course to specifically address leadership. The course name was recently changed to Engineering Leadership which more adequately reflects the new content taught to the students.

Research by the authors with extensive experience in the area of leadership, along with input from the Engineering Technology Advisory Board, served as the basis for the major course revisions necessary to convert the ‘management’ course to one with primary emphasis on leadership. With leadership considered a skill, efforts focused on identifying the various fundamental components important in the study of leadership. Much of the current national attention on character and integrity necessitated teaching these subjects to the students. It was also realized these two critical areas needed to be taught at the beginning of the course to help students understand how important character and integrity are to their personal and interpersonal effectiveness. After exposing the students to this essential need, the next step in the leadership skills development

process required that students be given specific understanding of how to develop the leader which exists in every person [3]. This step was crucial since the entire premise of this course revolved around leadership being a skill which can be learned and “developed by studious reflection and practice . . .”

Two excellent bestselling books served as the texts for the course in its early years. The first book is *The Seven Habits of Highly Effective People* by Dr. Stephen R. Covey [2]. This book specifically addresses the character and integrity development desired by the instructors for the course. The second book entitled *Developing the Leader Within You* by Dr. John C. Maxwell [3] became a perfect match for the objectives for this portion of the course set by the instructors. In 2008, with the retirement of the original course developer, a new team took over the course and made several modifications. Since neither faculty member was ‘Covey Trained’ the Covey book was dropped. It was determined that the Maxwell book had sections on character and integrity so it was retained to address these Covey topics along with several others. Two additional texts were adopted to address attitude and the practical aspects of leadership in industry. *The Difference Maker* by Dr. John C. Maxwell [4] and *Secrets of Effective Leadership* by Fred A. Manske, Jr. [5] completed the new book set thus addressing every aspect of leadership from personal reflection through attitude to application in an industrial environment.

There were additional modifications to the course that include two team teaching presentations on chapters of the texts, one presentation related to a book review on a leader of choice, and several team activities including the origami frog construction competition [6], the blind maze [7] and ‘ALL ABOARD’ raft building exercise [8]. The actual team structure utilizes triads with the project leader role being rotated at some point in the term to each team

member. Thereby, each student leads a project and experiences the ‘hands on’ of leadership. Each of these presentations and exercises exposes the students to leadership opportunities within their group and to other leadership styles demonstrated by their peers. The model for student learning in this segment was developed based on ideas from books on teaching that remind us that the best way to learn is by teaching the material. [9,10] There are now two faculty who team-teach the course serving as role-models actively demonstrating leadership traits in class. Both have extensive leadership experience and use the texts and ‘real world experience’ anecdotes to reinforce leadership principles. Finally, the class votes on the meeting time and format (two days a week for 80 minutes or three days at 50 minutes): the former allowing expanded class time necessary to practice leadership on in-class exercises. To date, each class has voted for the expanded time meeting at 7:30 AM twice a week.

The course has several other goals aside from teaching leadership. As a speaking enhanced course, team presentations of text materials are evaluated by the class based on a speaking rubric. Each student receives feedback from the teachers and peers in an effort to improve speaking abilities. Before the second presentation, each student is required to list those things being addressed in an effort to improve and to obtain specific feedback on said improvement. This has been very beneficial to the students as they develop their communication skills. Likewise, the book review on their chosen leader encourages the students to showcase the leader’s application of leadership principles and traits particularly learned from the course texts and is thoroughly graded and returned to provide positive constructive feedback. Before submission, the book reviews are evaluated by peers so that suggestions can be offered on improving the writing before submission. Peer reviewers are

required to sign the paper and take on some measure of responsibility for the resulting grade [8]. Finally, leadership exercises are developed wherein the leaders of the day are required to lead team competitions in a certain exercise – often there are team members who are encouraged to have a bad attitude or make mistakes to test the leader’s abilities to influence and accomplish the task at hand. This motivational aspect of the course breeds creativity, competition, and innovation among the teams. The course is full and requires daily participation to acquire skills and practice them.

To date, the course has been well received by the students. Anecdotal evidence indicates that there has been good to excellent development in the areas of: speaking, leading small groups, development of self-discipline, and application of skills in such endeavors as senior projects. Several students claim that the skills learned in this class have been instrumental in obtaining employment after graduation. Members of the Engineering Technology Advisory Board indicate that new hires who have taken the course are better prepared for industrial situations. Unfortunately, the word anecdotal does not carry much weight when suggesting that this is the way forward: thus, it has been determined that a more aggressive study of the outcomes of this course needs to be undertaken. This is the topic of a future research effort and follow up paper that is currently in the planning stage.

### 3. Measures

With every good engineering course there must be outcomes that are traced to some need and related to the mission of the program. The mission of the Engineering Technology Division clearly states that the program will: *Ensure graduates have the requisite leadership, communication and technical skills to compete in the regional, national and global marketplace.* The technical skills are addressed

in the myriad of technical courses required of the graduates. Communication is addressed across the curriculum and is further addressed in the Engineering Leadership course. Leadership can be taught, learned and practiced at UPJ with this course being one of the experiences in the four year program. There are four outcomes that are sought by our constituencies that are addressed in this course:

- (1) The development of leaders who are sensitive to the motivational needs of their subordinates and peers.
- (2) The development of leaders who can communicate effectively across a broad spectrum of associates.
- (3) The development of leaders who are introspective and advance their leadership skills through critical analytical self evaluation.
- (4) The development of leaders who exhibit knowledge of the difference between leadership and management.

The constituents include the Engineering Technology Advisory Board, employers who seek our graduates, the students (current and incoming) and graduate programs. With the exception of graduate programs, each of these constituents knows the mission statement and approve of this change.

As previously stated, it is important to note that the employers who have hired graduates since the inception of the original course are very pleased with their training and the exhibition of their leadership skills. The Advisory Board interviews students and finds that this leadership course is highly valued by the graduates.

#### **4. How are we doing?**

As previously mentioned, there has been a lot of anecdotal evidence that indicates that we are doing well. One student used concepts taught in the course during an interview with the president of a company. The result was a job offer, not

only to this student, but to a second student from the same program. As this paper was being written, students were asked to send anonymous comments that could be included in this paper. The comments below are all those collected in a short period of time – 2 days. The comments are:

- (1) First of all it was the best way to start the day at 7:30 AM, the topics got me interested and motivated which woke me up and got me going till 9:00 when I had circuits.
- (2) Definitely something I'll use later on in life when I'm placed in a leading position.
- (3) It is a class that I actually enjoyed attending, the experiences and lessons learned were well worth it.
- (4) I feel this course has given me an edge in how to excel and become a leader in the workforce.
- (5) The class was a great benefit. If you are even thinking about being a leader in the future this class will definitely prepare you when the time comes. You will gain knowledge on how to run a meeting and present material, and the class activities gave some bad case scenarios for us to solve.
- (6) It was a very enjoyable and low stress class. Dealt with real world experiences and learned valuable skills.
- (7) Where else could we get a cool wristband or stick 30 people on a 4ft X 4ft board.
- (8) I'd probably take Engineering Leadership II if they offered it.
- (9) Leadership is usually a topic not talked about in most courses yet a key trait to moving up in a company. Engineering leadership will help you learn what kind of leader you are and how to grow as one.

- (10) This is one of the few classes that will help you learn something about YOURSELF.

The last comment was actually the last one received and speaks to what we wish to accomplish – development of the individual leader.

## 5. The way forward

The anecdotal evidence indicates that the course is proceeding as planned: however, considering the need to assess in-order-to have real validation there is much to be done to prove this course's worth. The evaluation of the course will employ several assessment techniques. The faculty team will develop a pre- and post-test to determine the growth during the course. The test will consist of a series of management and leadership questions that will focus on prior knowledge and thoughts about management and leadership as compared to post course knowledge and thoughts. One question that is already used asks the students: What is leadership? Many state going into the course that it is control of people, whereas, after the course the answer is influence. This is an important growth in their ability to lead as control often leads them to failed leadership. The test will include a series of approximately 30 questions. The exit interviews by the Engineering Technology Advisory Board will continue to be used as an assessment tool since many of the advisory board members are also employers. Specific questions will replace the question about how the students liked the course: these questions will be developed with the aid of the advisory board. Since there is a requirement to conduct surveys of employers and graduates as part of the ABET accreditation process, question regarding leadership will be included. There is a natural test group, Civil Engineering Technology graduates, and a control group, all other Engineering Technology

graduates, against which results can be compared. All students do receive some leadership experience, but only the civil students have a specific course on leadership. The accumulation of data will take approximately three years. Since communication is also covered in this course, that outcome may also be affected by the additional exposure experienced in the course.

## 6. Conclusion

The introduction of leadership as a topic in Engineering Technology courses appears to be important in the development of graduates who will enter industrial settings. There has been some evidence that students taking the course benefit during their senior project courses and during interviews for jobs. One student said that during his interview the president of the company remarked that he had extensive knowledge of the character and values of the kind of leaders being hired and was actually hired because of this knowledge. Without more information it would be difficult to attribute this to the course, but the student attributed his ready knowledge to the time he spent thinking about leadership while taking the course.

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# Evaluation of Radio Frequency Identification (RFID) Inventory Management for St. Cloud State University Library

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## Abstract

The Miller Center Library at St. Cloud State University currently uses bar coding technology for inventory management (the shelving process), which is time consuming and inefficient. The shelving process is very important because the shelves have to be “read” continuously throughout the year and kept in order using a call number system. If the shelves are not in proper call number order, patrons might not be able to locate books in their specified positions. This paper focuses on the efficiency of a RFID shelving process on the basis of time and accuracy at the Miller Center Library. A pilot study was conducted on 100 randomly selected books of different sizes on a dummy shelf. The books were tagged using the 13.56 MHz HF Square Paper Passive RFID tags and a 13.56 MHz HF Paddle RFID reader/writer was used to collect data from each tag. The data fed into each tag included the title and designated call number of each book. A dummy database was created which indicated the correct position of each book on the shelf and the status of the book. The dummy shelf was initially misarranged and then scanned using the RFID reader to show the status of the book and its correct position on the shelf. This paper will discuss the results of the pilot study and the advantages and disadvantages of using an RFID system for inventory management in a library considering the time, labor, and cost savings of a full level implementation.

## 1. Introduction

The St. Cloud State University Library currently uses Bar-coding technology for the shelving process which is time consuming and inefficient. The shelving process is a very

important process in a library since the shelves have to be scanned continuously throughout the year and has to be kept in order. If the shelves are not in proper order, the patrons trying to find a book using its designated call number might not be able to find the book at the specified position. Thus, shelving process contributes largely to the overall efficiency of a library.

The shelving process can be efficiently done in less time using Radio frequency identification (RFID). The books can be tagged using the RFID tags and a RFID reader can be used to read the data from the tag. This paper will discuss how a pilot study was conducted to calculate the efficiency of a RFID inventory management.

## 2. Nature and Significance of the Problem

The current Bar-coding process deployed for the shelving process at the St. Cloud State University library is inefficient and time consuming. A shelf at the library gets scanned approximately once in every two or three years. Due to this there is a high possibility that a whole shelf is misarranged or a book is missing from the shelf and will continue to remain in that state until the next scan. This can lead to further problems when users search for the books by call numbers designated to each books and are not able to find the books at the designated shelf. Under the current process a full inventory cycle is completed in approximately 2 to 3 years. So a shelf gets scanned once in 2 to 3 years.

When a book is not found in the designated shelf the status of the book is changed from “available” to “unavailable” in the database. After a specific time if the book is still not found the status is changed to “lost”. And finally the book is removed from the database permanently and is considered for replacement. This can all happen when the book is still misplaced and is still available somewhere in the library. So it’s very important for a library to make the shelving process very efficient in order to improve the overall efficiency and to make the replacement decisions more effective.

### **3. Current Inventory Management Process**

The current inventory management process at St. Cloud State University Library involves the student worker scanning the shelves using the bar coding reader on day one and checking for errors using the data collected on day one using the inventory software. On day two the student workers are again assigned to rearrange the shelves if there any errors. The whole process takes two days to complete.

### **4. Literature Review**

Radio frequency Identification (RFID) is the use of tags to identify or track an item or a person using radio waves. The tags are typically referred as a RFID tag. The tags can be read using a RFID reader. The RFID tag does not have to be visible to be read; instead, it can be read even when it is embedded in an item, such as in the cardboard cover of a book or the packaging of a product [1]. The read range usually varies according to the type of tags and reader. RFID can be applied in many fields like healthcare, inventory control, transportation and logistics, animal identification, and libraries.

There are three different types of RFID tags. The active RFID tag has an integrated battery and can transmit autonomously and a passive RFID tag transmits only when an external source

usually a reader tries to read the data. The third type of RFID tag is called battery assisted passive (BAP) which requires an external source to operate but have significant higher forward link capability providing great read range.

The two most widely used RFID frequencies in today's applications are High Frequency (HF) and Ultra High Frequency (UHF). HF RFID systems operate at 13.56 MHz and UHF RFID systems operate within the range from 860 to 960 MHz [2]. The HF tags which operate at 13.56 MHz usually has a read range of 10 to 20 cm and the UHF tags which operate at 860 to 960 MHz usually has a read range of 1 to 5 m. RFID reigns over barcode technology because of its contactless nature that enables multiple-item detection and also its memory capability that makes it more than just an identification technology but a data carrier that can update and transfer information on the fly [2].

The RFID can effectively replace the bar coding technology which is currently used in many libraries. There are many advantages of using RFID technology in libraries. Some of the areas where RFID can be used in libraries are the check-in / check-out process, inventory management and security. In the case of RFID inventory management in library, anyone managing an inventory of physical objects needs to do item-level functions, such as sales or lending, more efficiently and with less human intervention. A key fact is that library circulation, the primary function where RFID can be used, is increasing while library budgets and purchasing power are losing ground [3].

The major advantage of using RFID in library is that the tagging of books and other items in the library needs to be done only once unlike in a retail warehouse where tagging is a continuous process since the items come in and go. The retail sector is looking at RFID as a "throw-away" technology that gets an item to a customer and then is discarded. Yet the per item cost of including an RFID tag is much more than

the cost of printing a barcode on a package. In libraries, items are taken out and returned many times. This makes the library function an even better use of RFID than in retail because the same RFID tag is re-used many times.

Several libraries in the US such as the Santa Clara City Library in California, the University of Nevada, Las Vegas library, and the Eugene, Oregon public library have already tagged every book, tape, CD, or other item in their collections. The University of Nevada, Las Vegas (UNLV) has reported saving \$40,000 in replacement costs for the 500 "lost" items it found after tagging its 600,00-plus collection. California State University, Long Beach has reported that after implementing RFID they are able to do inventory at 5000 books per hour. [4]

## 5. RFID Pilot Study

An RFID Pilot Study was conducted with a sample of 100 books which were selected randomly. The selected books were tagged with ISO 15693- 13.56 MHz HF square passive paper RFID tags. The tag positioning is a very important factor as it may affect the reading efficiency. Dhanalakshmi & Mamatha (2009) conducted a study to determine the best tag position for the shelving process and the result of this study indicated that the detection rate for the "spine" position was highest at 96% [5]. For this study the tag position selected is "spine". A 13.56 MHz HF RFID paddle reader as shown in Figure 1 was used for the study.

The read distance of the reader was approximately 10 to 12 cm. The books selected for the pilot study were arranged in a order of from 1 to 100. The data which was fed into each tag included the initial position of the book, title of the book and the call number of the book. A dummy database which included the title of the book, call number and RFID tag number of each book was created using Microsoft Excel software. Five student workers were selected for

the pilot study. The student workers scanned the 100 books using Bar-coding reader and RFID reader and the time required to scan was noted.



**Figure 1. HF RFID paddle reader**

From Table 1, the results of the pilot study indicate that the time required to scan 100 books using RFID is much lesser than the bar-coding technology. The average number of books scanned in one hour using RFID scanner is approximately 2560 whereas using bar-coding scanner is 728.

## 6. Data Analysis

A probability plot was drawn using Minitab software for the data collected. The probability plot indicated that the data was in normal distribution. Since the data was in normal distribution a paired student's t-test was conducted for the data collected as shown in Table 2.

**Table 1. Pilot study results**

Student worker	RFID Scan (min)	Bar-coding scan (min)	Books scanned in 1 hr (RFID)	Books scanned in 1 hr (bar)
1	2.4	8	2500	750
2	2.5	7.5	2400	800
3	2.1	9	2900	650
4	2.2	7.9	2700	740
5	2.6	8.5	2300	700

Note: For Bar-Coding, the time recorded does not include the time required to generate the error report and time required to rearrange the shelf.

**Table 2. Paired students t-test**

Paired Samples Correlations			
	N	Correlation	Sig.
Pair-1 RFID & Bar-Coding	5	-.403	.501

The negative correlation value in Table 2 indicates that there is a negative correlation between the pairs and the large p value of .501 indicates that the pairs are significantly correlated.

From Table 3 paired sample statistics, the mean time required to scan 100 using RFID scanner is 2.36 minutes which is much lesser than the mean time for scanning 100 books using bar-coding scanner.

**Table 3. Paired students t-test**

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	RFID	2.360	5	.20736	.09274
	Bar-Coding	8.180	5	.58052	.25962

## 7. Summary and Results

From the RFID pilot study results, approximately 2700 books can be scanned using a RFID scanned in one hour. From the paired students t-test results, the mean time required to scan 100 books is 2.36 minutes. The St. Cloud State University Library has a collection of approximately 1.5 M books and using four RFID scanners, the time required to do a full level inventory will be approximately 120 hours. The other applications of RFID in libraries include automatic check in/out and enhanced anti theft systems. The other major advantage of implementing RFID will be customer satisfaction. Cost of a full level implementation of RFID technology at St. Cloud State University Library is estimated to be approximately \$ 2.5 M to \$ 3.5 M.

Privacy and other security issues still are a big concern and these areas need further research. The cost savings of implementing RFID will include labor and cost of tattle tapes used for security.

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## A Study of Students' Utilization of the Tools for Online Communication and Collaboration

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### Abstract

This paper will investigate students' perceptions regarding the availability of a virtual communication tool, ClassLive used in the online, graduate Engineering Management program at Eastern Michigan University in Ypsilanti, Michigan.

Online education offers flexibility of time and place, but the communication tools used in the online environment are different than those in face to face class. However, the biggest challenge for students working in virtual teams is which communication tool to utilize. Over the last decade the scope of the options for communicating across distances has increased enormously and has a positive effect on team performance both in the classroom as well as in business (Burke, 2002). This discussion will include an overview of the communication tools used by students when working in virtual teams and outside the class shell. Furthermore, if there is a relationship between students' readiness to use such tool and their computer self-confidence will be determined. In addition, the importance of the features offered by the different tools for online communication and collaboration will be rated.

### 1. Introduction

According to existing research, good communication between the virtual team members is crucial for success of the project. As college is a transitional setting, moving students into the real business world, virtual team

membership experiences have been included in many engineering management courses. With the appropriate tools for online communication and collaboration face to face meetings can be simulated, and a team's performance can improve.

Electronic collaboration has potential strategic value for the dynamic business environment [8] and for the high level education: online and face to face (f2f). Fink (2007) defines e-collaboration as a group coordination mechanism facilitating learning by boosting knowledge creation and sharing processes. Also, three organizational roles associated with efficiency impact are listed: coordination, learning, and innovation. Moreover Bruke (2002) states that the new technology is likely to change the group performance, interaction, and collaboration of technology mediated groups. Also, the author determined the three key changes occurring during the last decade in e-collaboration include: (1) the significant reduction of organizational overhead to enable e-collaboration given the availability of web-based tools and technologies, (2) the integration of existing systems and platforms with e-collaboration applications and (3) the increased flexibility in supporting different types of e-collaboration activities including communication, coordination and cooperation (p.1). E-collaboration has evolved to providing well-integrated, flexible solutions to working together for work groups in business and high education environment.

Similarly online education offers flexibility of time and place, but the communication tools used in the online environment are completely different than those in face to face classes. In online groups, communication and participation can be recorded [9], which is an advantage in comparison with face to face classes. On the contrary, Whatley (2004) argues that online teamwork is problematical, because of problems such as becoming familiar with the team members and their abilities, dividing tasks, communications, and keeping current with the progress of the project. Good communication skills between the team members working in a virtual team are crucial to the success of the project. Thomas (2005) suggests that incorporation of new technology as computer-mediated communication will be helpful for students to collaborate and for instructors to monitor collaborative projects. The biggest challenge for students working in virtual teams is which tools for online communication and collaboration to use. Fedorowicz insists that “The success of the virtual team will depend upon its ability to collaborate effectively across physical and cultural distances” [7].

EMU online offers a chat room and ClassLive (powered through Elluminate<sup>®</sup>), Microsoft<sup>®</sup> offers Windows<sup>®</sup> Meeting Space, and many other tools for online communication and collaboration exist. Fink (2007) defines e-collaboration as a group coordination mechanism with wider capabilities, enabling and facilitating the work of virtual groups. According to that author, in different environments different roles of e-collaboration should be emphasized. Pena-Sanchez (2008) suggests that the richness and immediacy of the communicational channels and the social context of the tasks must be considered. He also ranks communications. Pena-Sanchez states that the richest and immediate response channel is face to face, because the facial expression and body

language contribute to the communication. Telephone communication is the second richest channel and is as immediate as face to face. With the advance of the technology, the immediate response channels can be simulated using the tools for online communication and collaboration. Burke, K. (2002) states that over the last decade the scope of options for communicating across distances has increased enormously and the level of quality and technology support have a positive effect on team performance. Elluminate software (Class Live) and chat are offered to EMU students in their course’s shell; many other free tools for online communications are available from the Internet.

## 2. Purpose

The purpose of the study was to investigate which tools for online collaboration students use the most when working in virtual teams. Furthermore the importance of the features offered by the different tools was rated:

- Screen share
- Text Chat
- File transfer
- Audio conferencing
- Video conferencing
- Viewing when your teammates are online (as in instant messenger)

Also, the study evaluated if the students were familiar with ClassLive offered in their class shell (Elluminate software). It also reviewed what communication tools outside the class shell students used and why they were attractive. Lastly, the author wanted to ask the question if the students readiness to use such tools was dependent upon his/her computer self confidence?

## 3. What is ClassLive

ClassLive is a tool for online communication and collaboration used by Eastern Michigan University located in Ypsilanti, Michigan.

ClassLive tab is located under a readily accessible tab called “Live” in the EMU online courses. It has many advantages and disadvantages, depending on the point of view, such as:

1. The version offered in the class shell has only a chat option and a public screen, so the professor has to contact IT support and activate the other features.

2. The ClassLive audio works as a walkie-talkie and only one person can speak at a time.

3. When using ClassLive, there is a recording of everything: audio, video, screen share, and chat. Recorded files are saved in the class archive, and all students have access to those materials. Only the Course instructor is able to delete a session.

Advantages of ClassLive include:

1. Audio conferencing
2. Video conferencing
3. Screen share
4. Chat
5. File share

lluminate is the software supporting ClassLive. The communication between the team members working in a virtual team is crucial for the success of the project. In addition working as a member of a virtual team is part of many Engineering Management courses. With the appropriate tools for online communication and collaboration face to face meetings can be simulated, and a team’s performance can improve.

## 4. Methodology

A descriptive quantitative research design was employed for the study

### 4.1. Population and Sample

The population for the study was “generally a homogenous group of individual units”[11] In this case it included all students enrolled in the Engineering Management (EM) Program in the College of Technology at Eastern Michigan

University during the Fall of 2009. The appropriate sampling technique was simple random sampling: “the sample is chosen by simple random selection, whereby every member of the population has an equal chance of being selected” [11]. The sample included students currently enrolled in the EM 695: Ethics and Leadership course. As EM695 is a required core course for every EM student, students enrolled in this class constituted the equal chance participants.

### 4.2. Data collection

Survey questions were used to collect information about communication tools utilized by the students when working in virtual teams. Prior to distribution, the project was also reviewed and approved by the College of Technology’s Human Subjects Review Committee.

A pilot study was performed with the participation of seven students enrolled in a business education face to face class. As a consequence, based on the feedback some of the survey questions were rewritten and clarified

Survey Monkey was used for creation and electronic distribution of the survey. The first page of the research survey was the informed consent: the students were aware of the research procedure and that they can change their mind regarding their participation. The survey was anonymous; the participant’s names cannot be associated with their responses. An email request was sent to the students from EM695 Fall 09, 5 points of extra credit for participating in the survey was offered. The students received the extra credits after they emailed the instructor that they have taken the survey. A few of them took the survey without claiming the extra points, because completed surveys were more than received emails.

### 4.3. Research procedures

The data about communication tools utilized by the students when working in virtual teams was collected with Survey Questioner. The Survey consisted of 24 Questions, the first few questions were about demographic information such as gender, age, and the students' track in the EM program. The next set of questions was regarding student's experience working in virtual teams the tools for online communication and collaboration that they have utilized, their computer confidence and their familiarity with ClassLive offered in their class shell. Few of the questions were open ended, because it was expected that the students use and prefer different tools for online communication. Actually those open ended questions were skipped by few students when taking the survey.

### 4.4. Demographic information

An email request was distributed to the thirty one students enrolled in EM695 during the Fall of 2009. Twenty six of the students took the survey, which is response rate of 84%. Responders were 19.2% (5) female and 80.8% (21) male. Ages in the EM695 course ranged from 21 to 55 years, with the highest percent 30.8% is in 26-30 years group. Students were also enrolled in concentrations in the program which included:  
 Project/Program Management: 53.8% (14).  
 Design and Manufacturing: 23.1% (6).  
 Lean Enterprise Systems: 11.5% (3).  
 Project/Program Management +Lean: 7.7% (2)  
 EMU Graduate Quality Certificate: 3.8% (1)

When the survey was being developed, it was assumed that all of the students had experience working in a virtual team, as EM695 was one of the last classes in the program. So, 100% yes responses were expected to the question "Do you have experience working in a virtual team?" but three of the students reported that they did not have experience working in a virtual team.

### 4.5. Hypotheses

Hypothesis #1: There is a relationship between a student's computer self-confidence and his or her readiness to use the tools for online communication and collaboration.

Hypothesis #2: More than 50% of the students are familiar with ClassLive and use it when working in virtual teams.

Hypothesis #3: More than 50% of the students are not familiar with ClassLive, but they use communication tools outside the class shell.

Hypothesis #4: Students who are familiar with ClassLive, prefer to use communication tools outside the class shell.

Hypothesis #5 Videoconferencing will be rated as #1 of the student choices of tools.

Hypothesis #6 Students prefer software where multiple students can speak at a time.

#### 4.5.1. Hypothesis #1

Hypothesis #1: There is a relationship between the student's computer self-confidence and their readiness to use the tools for online communication and collaboration. The results were as follows:

88.5 % (23) of the students responded that they have a very high computer self confidence.

7.7 % (2) were neutral and

3.8 % (1) disagree with the statement for very high confidence.

92.3 % (24) of the students responded that are ready to try new software for online communication (if is not professors' requirement).

7.7 % (2) were neutral.

"High computer self-confidence" has a mean of 1.35 and a standard deviation of 0.797.

"Ready to try a new software" has a mean of 1.35 and standard deviation of 0.629.

There was only one student, who did not report very high computer self confidence, but he reported that is ready to try a new software.

One student with neutral computer self-confidence reported that s/he is ready to try new software.

One of the students with very high computer self-confidence reported that he/she is neutral about new software.

According to those three results, there was no dependence between the student's computer self-confidence and their readiness to use new software, so hypothesis #1 is not supported.

One student was neutral for both: very high computer self-confidence and a readiness to try new software.

Twenty two students agreed or strongly agreed that they have a very high computer self confidence and are ready to try a new software.

According to their responses there is a dependency between student's computer self-confidence and their readiness to try new software and the hypothesis #1 is supported.

The data was not sufficient for a reasonable conclusion.

#### 4.5.2. Hypothesis #2

Hypothesis #2: More than 50% of the EM695 students were familiar with ClassLive and used it when working in virtual teams

Two of the students reported that they are not familiar with the Elluminate, have not used it, but find it valuable. The students did not have experience with the software, so their responses were not objective and were not included in the analysis.

42.31% (11) of the EM695 students had used ClassLive.

81.8% (9) of the students who had used Class Live found it valuable.

But to the Question if they like it, 63.6% (7)of the students who had used ClassLive and found it valuable reported that they like it.

Hypothesis #2 is not supported by the data, because only 42.31% of the EM695 students were familiar with and had used ClassLive.

#### 4.5.3. Hypothesis #3

Hypothesis #3: More than 50% of the students are not familiar with ClassLive, and use communication tools outside the class shell  
57.7 % (15) of the students have not used and are not familiar with ClassLive.

Hypothesis #3 is supported by the data, because more than 50% of the students are not familiar with ClassLive. They use tools for online communication and collaboration outside the class shell.

66.7 % of the students not familiar with ClassLive listed email as their favorite tool for online communication.

#### 4.5.4. Hypothesis #4

Hypothesis #4: Students who are familiar with ClassLive, prefer to use communication tools outside the class shell.

For this this hypothesis only the data reported by the 11 students who are familiar with and have used ClassLive was used.

47.8% (11) of the EM695 students had used ClassLive

0% (0) of the students familiar with ClassLive listed it as a favorite tool

27.3% (3)listed Skype a favorite tool

45.5% (5)of the students familiar with ClassLive listed email as a favorite tool

Hypotheses #4 is supported by the data; students who are familiar with and like ClassLive prefer to use communication tools outside the class shell.

#### 4.5.5. Hypothesis #5

Hypothesis #5: Videoconferencing will be rated as #1, because its simulates a face to face meeting. So the question # 9 was: Rate the features offered by software for online communication from 1 being the most important to 6 being not so important.

The rating of the features by their importance according to Question 9 was:

1. Audio conferencing: mean 2.26
2. Screen Share: 2.30
3. To be able to see when the teammates are online: mean 2.43
4. File transfer: mean 2.59
5. Text chat: mean 2.91
6. Videoconferencing: mean 3.21

According to Question 9, the most important feature is audio conferencing, while videoconferencing is rated as not so important.

Questions 15-20 are similar to Question 9, but used a Likert scale: -2 Strongly Disagree, -1 Disagree, 0 Neutral, 1 Agree and 2 Strongly agree. According to questions 15-20:

1. Audio conferencing (Speaking with the teammates) is the most important factor with a mean of 1.31
2. File Transfer is next important factor with a mean of 1.19
3. Screen share: 1.15
4. Chat option: 1.04
5. Knowing when my teammates are online: 0.76
6. Video conferencing (to be able to see my team mates): 0.08

This means that the results do not support hypothesis #5

According to the results of both sets of questions, the most important is audio conferencing, and the last important is video conferencing.

**4.5.6. Hypothesis #6**

Hypothesis #6 is “students prefer software in which everyone speak at the same time.”

The reason for hypothesis #6 is that Elluminate works as a walkie- talkie, and only one person is able to speak at a time. Unlike others, the data supported hypothesis #6. The students preferred software in which everyone can speak at the same time. A Likert scale was used for questions

10 and 11: -2: strongly disagree, -1: disagree, 0: neutral, 1: agree and 2: strongly agree

Table 1

	N	Min.	Max.	Mean	Std. Dev
everybody speak at a time	26	-1	2	<b>1.08</b>	.935
one speak at a time	26	-2	2	<b>-.42</b>	1.137
Valid N (list wise)	26				

**5. Conclusion**

For 88.5% of the students that have taken the survey, there was a relationship between their computer self confidence and the readiness to try a new software, and for 11.5% of the students there was no relationship between their computer self confidence and their readiness to try a new software. The data was not sufficient for a reasonable conclusion.

Padilla-Melendez, Garrido-Moreno, & Del Aguila-Obra, (2008) suggest that “the students have poor perception about the availability and value of the IT infrastructure at their university” (p. 619). Only 42.31% of the students enrolled in EM695 in the Fall of 2009, had knowledge about the availability and value of ClassLive, the Elluminate software used by EMU for team collaboration. Moreover, the students familiar with ClassLive preferred to use tools for online team collaboration, outside the class shell. Even if over the last decade the scope of options for communicating across distances has increased enormously [1], the most favorite tool for online communication is still the email. Moreover audio conferencing was rated as the most important feature, while video conferencing was rated as not so important.

Students prefer to use software in which everybody speaks at the same time. It is not clear if there is a connection between ClassLive’s audio working as walkie-talkie and students’ willingness to use it, so more research

is needed. The two students, who reported that have used ClassLive and do not find it valuable, strongly agree that prefer software in which everybody speaks at a time, but the data was not sufficient for reasonable conclusion.

## 6. Recommendations

In future research, questions asking about the rating of the features have to be paraphrased from “Rate the features offered by software for online communication: from 1-the most important to 6-not so important” to “If you can choose only one feature, which will be?” and “If you can choose only two features, which two and so... “

Investigation of the relationship between student’s preference to use software in which everybody can speak at the same time and their willingness to use ClassLive is also needed.

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# Theory to Practice: How One Technology Management Student Implemented a Final Project in “The Real World”

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## Abstract

In the winter of 2009, Joe Bauer, a technology management student at Eastern Michigan University, created a technology implementation plan as a final project in one of his technology management courses. Because Joe is a student who also works full time he had the opportunity to write the plan with the intention of implementing it at an IT department at a major university in Michigan where he worked.

The plan was based on Haddad’s strategic partnership approach. Key elements of this approach were utilized in the final draft and during the implementation of the technology. At the core of the strategic partnership approach is joint planning. This involves working with all parties who will be impacted by the technology’s implementation.

Theory and practice are tightly linked and it is important that the theories of technology management taught in a classroom are practical and relevant to today’s working environment. In an ideal world a technology implementation plan created in an academic setting would easily transition to the workplace. As a classroom assignment the technology implementation plan was 23 pages long and contained 10 major content sections. The final document for the workplace had 52 pages and eight content sections. This paper follows the twists and turns the document took from classroom through to implementation on the job. Bauer shares his

observations about what his manager and co-workers stressed as important for the document, and lessons learned during the implementation of the technology.

## 1. Introduction

This paper is a report on the author’s experiences in implementing a class project in the workplace. The class was a technology management course on the topic of technology implementation and the place of work was an administrative information services department at a major university in Michigan. By introducing an academic paper from the classroom to the workplace the theories of technology management were put to test in a so-called real world environment. The intent here is not to supply a referendum on a particular class or professor, but rather to give one example of how a student was able to take a class project and apply it in the workplace.

### 1.1. From the classroom

One of the principles taught in the technology implementation class was Haddad’s Strategic Partnership Approach, which places an emphasis on strategic planning as a joint action from all layers of the organization, not just upper management [1]. It is a partnership between those who want to implement the change and those who would ultimately be the ones using the technology. Haddad’s full definition is: “A strategic partnership for the management of

technological change is a goal-focused collaboration involving two or more parties operating with equal influence and mutual respect, in which they jointly plan each step of the innovation process” [2]. The strategic partnership approach, as described by Haddad, frequently used examples from unionized manufacturing environments [3]. The workplace environment in this example is neither unionized, nor manufacturing based. However, it was possible to adapt the approach for a non-unionized information technology setting. In order to do so it is important to reflect on the theoretical foundations of the strategic partnership approach.

Though Haddad never states it specifically, the strategic partnership begins with the rejection of technological determinism as a basis for viewing the social relationship with technology. The strong use of sociotechnical systems theory and emphasis on social equality provide the necessary evidence that strategic partnership is not founded on technology determinism [4]. Technological determinism is a framework with many definitions and interpretations. Murphie and Potts sum it up as “. . . the belief that technology is the agent of social change” [5]. Bailey elaborates on this by saying technological determinism is “. . . the view that humans are essentially *homo faber*, or tool-making animals, and that technologies are value-neutral tools, products of inevitable scientific progress” [6]. From these definitions it would follow that a deterministic approach would assume that the social results are predetermined and, therefore, would not need to be addressed during an implementation process.

The social construction of technology is a closer match as a foundational framework for strategic partnership [7]. This framework suggests that “. . . nature does not dictate scientific facts” [8]. This basic refutation of objectivism maintains that the social interaction with technology is not as black and white, or

clean cut as we would sometimes like it to be. There is a very human purpose to technology that can be found in how the people interact with it and each other. The social construction of technology is a framework where “. . . neither an artifact’s identity, nor its technical ‘success’ or ‘failure,’ are intrinsic properties of the artifact but subject to social variables” [9]. An example that illustrates this point well is Barley’s research where two similar hospitals implemented the exact same CT scanner technologies and the results from each hospital ended up different [10].

The assignment for this technology implementation class was to generate a technology implementation plan that could be used at a workplace. Since the author was about to embark on a major project at work, the timing was perfect for applying a classroom exercise to the workplace.

## 1.2. In the workplace

As its name suggests, the Administrative Information Services department handles administrative information services for the rest of the University. These information systems support business processes such as donor and alumni gifts, grant proposals, financial reporting, and more. Some of the systems are designed and programmed in house, while most others are purchased from vendors and modified by developers locally to fit the specific needs of the school or college utilizing it. The Microsoft development platform, and Microsoft infrastructure technologies are relatively new to this department.

Because Microsoft technologies were new to this department they were implemented in a highly segmented fashion between functional teams, who were grouped together by tool type rather than process. The technologies were made to fit an already established organizational structure and culture that was based off of other technologies. For example, there was a different

team for maintaining the Microsoft based desktop computers (Desktop Support) and a different team for managing the Microsoft based enterprise servers (Enterprise Systems). See figure 1. Because these two teams had different membership who rarely interacted they also had different Active Directory domains. An Active Directory domain is a security and management boundary for infrastructure objects like computers, servers, and user accounts. Because the desktop computers were in a different domain from the enterprise servers, which housed the applications developers wrote, there were inefficiencies that caused much frustration as developers had to log into a remote desktop session on a server in the enterprise servers domain from their workstation to do their daily work. One developer described this situation like having to type with gloves on; it's difficult and frustrating and takes longer than it should. The proposed project was to create a trust between the domains and allow for the developers to develop directly on their workstations. Three technical support teams and three development teams needed to coordinate and cooperate in order for this project to work. A trust between the domains had been proposed several times in the past but had been rejected each time.

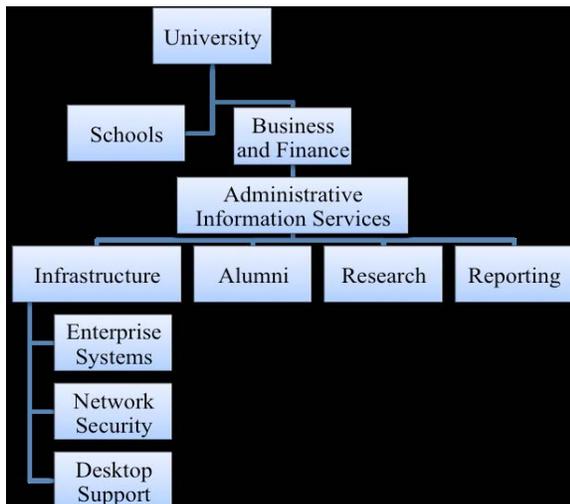


Figure 1. Organizational chart

## 2. From classroom to server room

The paper submitted for the class contained 10 sections and was 23 pages long. The final workplace paper had eight sections and 52 pages. It was unexpected that the final workplace document would end up being over double the length of the academic paper. Much of this space was filled with greater detail, or easier to follow graphical representations of information and concepts. The following is a section-by-section review of how the document evolved while moving from the classroom to the workplace.

### 2.1. Introduction

In the academic version of the paper the introduction section covered basic background information about the organization. This section proved to be very useful for the professor, who did not know this information, and gave the rest of the document some much needed context with which to understand it.

At the workplace, however, the feedback was largely that this section added little value because this context was already known, and it just made the document longer than necessary. This section was removed for the final workplace paper.

### 2.2. SCOT analysis

This step, also known as SWOT, stands for strengths, challenges, opportunities, and threats. By using this analytical tool an organization can get a larger view of trends and issues that are good or bad to learn more about where the organization as a whole stands. It is good to do this sort of analysis early on in a technology implementation because it can point out business processes, strategies, or tactics that may need some attention before even considering technologies.

Similar to the introduction section, at the workplace the SCOT analysis was widely

rejected as being more of what is already known. It was also thought that the process for performing the SCOT analysis was too involved and complex and the results were not easy to understand quickly. This section was left out of the final workplace paper.

### **2.3. Technology description and objectives**

This portion of the paper serves as the introduction to the proposed technology and the objectives of the implementation. In this project some of the goals were to improve development processes, make the new processes follow industry standards, reduce inefficiencies, and foster more integration between teams and technologies.

In the final workplace document, this section also served as the introduction to the paper. Throughout the process of writing the workplace version of this paper some of the technologies and some of the configurations changed from the academic version. With more people contributing from different perspectives in the processes it was possible to capture ideas that one team, let alone one person, could not have thought of on their own.

### **2.4. Needs analysis**

This section used a modified gap analysis to analyze the current development processes. Then ideal future state processes were drawn up and juxtaposed against the current state processes. The gap between the real and ideal was the need.

For the teams that supported the development teams this section was a real eye opener. There had been a popular perception that the developer complaints about the development environment were cosmetic and insignificant. This analysis showed that fundamental portions of the development processes were either broken or overly complex. It illustrated clearly that the current processes were impacting the developers' ability to do their jobs and the

organization's ability to deliver quality applications.

### **2.5. Cost-benefit justification**

In the academic version of this document a lot of the accounting exercises were done with false numbers that approximated best guesses by the author. At the workplace real numbers and figures were gathered from all the teams. This section was met with exuberance at the workplace, as all teams were eager to get involved in giving feedback on how much the changes would cost or benefit them. This was a section where people could easily find their ideas or their complaints reflected.

Included was a tangible and intangible cost-benefit exercise. The tangible analysis was a straightforward accounting exercise, where any costs or benefits, which could be directly related to dollar figures, were included. Some time spent with team budget managers, and accountants verified that the numbers were accurate and also uncovered extra items that were omitted from the original drafts. The intangible analysis included all the items that could not easily be assigned a dollar figure. These items included things like frustration caused by excessively complex processes. In an attempt to quantitatively weigh these costs and benefits, the items were put in a matrix, assigned a weighting, and then individually rated.

### **2.6. Readiness-for-change assessment**

This assessment checks to see if the people within the organization are ready for the technology implementation. It involved a survey, designed by Haddad, which asked questions on topics like how you feel the implementation would affect your job security [3]. For the academic document estimated guesses were used as the results. In the workplace the idea of performing this assessment was unexpectedly popular and every team took part in taking the survey. There were

few surprises in the results, but it was possible to provide managers with a few insights on where they could focus with their employees to make the implementation go smoother.

### **2.7. Organizational barriers assessment**

An organizational barriers assessment takes a good hard look at the organization to see if there are any structural or social issues that might impede the technology implementation. This section was quite valuable for the author while coordinating the effort of drawing up the final workplace document. However, managerial feedback was cautious. There was concern that this section could stir up old, long standing tensions. So, the section was left out of the final workplace paper. It is interesting to note that during the six-month process of working with all the teams to develop the final workplace document that many of the social barriers identified in the earlier academic document had dissolved.

### **2.8. Implementation design**

This section deals with the process by which the technology is implemented. It included step-by-step information on what would occur. By spending some time thinking about the implementation early on in the project lifecycle one can avoid design issues that may lead to an overly difficult implementation.

For the final workplace document this section was bolstered with logistical information about who would be doing which tasks. When it came time to write up our project plans the information here was a useful starting place.

### **2.9. Training program**

When new technologies or processes are implemented the people who use them need to know how to use them or else the effectiveness of the new implementation could be at risk. The final workplace document retained a very

trimmed down version of this section. Instead of any formal training, the technician who delivers the new workstation or software to a developer would show them how to use the new software. Development teams would also hold informal sessions to show their colleagues how the new processes work. This stripped down version of a training program is far from ideal, but was the best that could be reasonably negotiated.

### **2.10. Evaluation program**

Before an implementation is deemed complete an evaluation of the new technologies and processes can show how well the implementation went and if there is any room for improvement. The goal is not to complete a project, but to successfully implement a technology, so this step is crucial to the success of the implementation.

In the workplace this evaluation was done with a focus group. Representatives from all parties involved were gathered and the implementation was reviewed and feedback on possible improvements was discussed. This step was meant to be iterative and repeats until no more improvements are needed.

### **2.11. Future initiatives impact assessment**

This is a section that was not in the academic version of the document, but was suggested by a member of upper management. It was a clever way of capturing not only how the implementation will impact today's environment, but also any planned (or possible) strategic initiatives for the future.

## **3. Strategies for adapting the paper for 'the real world'**

A project utilizing the strategic partnership approach lacks the element of partnership if the planning process is started off by one party delivering an already completed implementation document to the other parties involved. For this reason the academic paper had to be shelved at

the beginning of the workplace project and only used as a source for ideas.

The first hurdle in the process of developing the workplace document was in breaking down some of the social barriers that existed between the teams that would be involved. Members of many teams had never met before. Some teams were outright suspicious of the abilities and intentions of other teams. One social tactic employed was to informally gather small numbers of members of these teams in neutral settings where they could socialize. A popular example was going to lunch with one person from each team. During the lunch a visible change could be observed while people became more familiar with each other. In some cases it was as if the members of the lunch party discovered they were all human.

In addition to informal small group social meetings, the author met individually with all the people who would be involved with the technology implementation. During these one-on-one sessions the general goals were described and then feedback, thoughts, opinions, feelings, and criticism were solicited. Each person was also asked how he or she would solve the problem if they were able to have it their way. This single question garnered more useful feedback than most any other question.

There was one case where someone seemed open and frank through most of the feedback sessions. However, at one point they started asking leading questions and sounding skeptical of the direction of a certain major aspect of the project. The mood was getting sour. No amount of probing and questioning could reveal the source of the discontent. Later that week on a particularly nice day the author invited this person to go for a walk. Outside of the work setting this person relaxed and by the end of the 10 minute walk they were sharing many of their fears about the office politics surrounding their portion of the project. More was gained in those 10 minutes outside than could have been

possible in the sterile and socially loaded confines of the workspace. This person was able to confide in a manner in which would not have been possible in an open cubicle with people walking by at all times.

After each informal meeting the received feedback was incorporated into the ever-growing document. Then, very soon after the meetings, the person involved was shown where their feedback was incorporated into the document. For many people this small step was surprising. The author got the sense that many people were used to being asked for their opinion, but then nothing happening with that feedback. Seeing that their voice was being heard usually had an uncorking effect, which unleashed even more.

A formal steering committee made up of representatives from each team that would be impacted by or involved with the implementation was formed. It had managers as well as employees and all voices were treated as equal during discussions. This was the formal forum whereby the document was periodically reviewed.

In order to gain institutional respect, the document eventually made its way through three different approval and governance committees. While these steps did little to enhance the actual content of the document, it did lend institutional credibility to it and the implementation project.

#### **4. Lessons learned**

It used to be the author's point of view that his job in managing a project was to defend it from criticism. In order to fully implement the strategic partnership approach, the defense of criticism was put aside and instead criticism was actively solicited. This did two things. First it improved the quality of the project by opening it up to and addressing a multitude of competing ideas and opinions. The second thing it did was it greatly increased the feeling of ownership even for people who were skeptical of the project.

The interesting thing about the strategic partnership approach is that because it involves people from all teams and of all strata (managers and employees) it is possible to instigate change from any position within the organization. While the author is a senior employee, he is not a member of management. Despite that fact it was possible to partner with the proper managers and employees to gain the necessary institutional momentum to initiate the project.

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# Particle Swarm Optimization for Location Problem

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## Abstract

This paper discusses a new algorithm for designing an expressway and the proposed algorithm introduces particle swarm optimization (PSO) as its basis. PSO is a swarm intelligence technique that is obtained by technological modeling of feeding behaviors of bird and fish swarms. In PSO, optimization is performed using two elements that constitute swarm intelligence: information about an individual and about a whole swarm. The proposed algorithm is designed to obtain a traffic route in which three elements – convenience, safety, and cost performance – are satisfied. The validity of the proposed technique is verified by simulation experiments.

## 1. Introduction

The design of an expressway, one of the largest public works, must take into consideration a number of different elements. First of all, from the viewpoint of convenience, the distance from a town or a residential area to an interchange (IC) should be short [1]. The importance of this is pointed out in emergency transportation, since a small difference in transportation time may worsen a patient's condition. For safety's sake, the distance between ICs also should not be too great; that is, the distance should be below a certain threshold value. From the consideration of construction costs, the best configuration would incorporate a short distance from a departure place (starting

point) to an arrival place (end point) and a small number of ICs.

In the present study, a new algorithm for designing an expressway is proposed that introduces particle swarm optimization (PSO) [2] as its basis. PSO is a swarm intelligence technique that is obtained by technological modeling of feeding behaviors of bird and fish swarms. In PSO, optimization is performed using two elements that constitute swarm intelligence: information about an individual and about a whole swarm. The proposed algorithm is designed to obtain a traffic route in which three elements - convenience, safety, and cost performance - are satisfied. The validity of the proposed technique is verified by simulation experiments.

## 2. Formulation of a problem

A starting point and an end point are set on a two-dimensional plane. On this plane, a residential area (town) has already been placed. The locations of the starting point, end point, residential area, and IC are to be defined by coordinates. In the present study, the expressway design problem is to be solved by determining a traffic route from the starting point to the end point, in which an appropriate number of ICs are arranged at appropriate locations, as shown in Figure.1. The purpose of the proposed algorithm is to find a traffic route in which the distance between each residential area  $(x_i, y_i)$  and each IC  $(x_j, y_j)$  is the shortest. The objective function used in this study is expressed by formula (1).

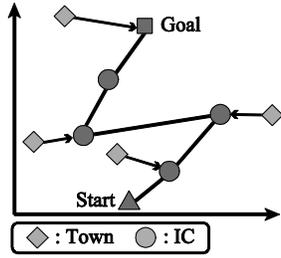


Figure 1 Example of the expressway design problem

In this formula, the nearest IC to a residential area  $(x_i, y_i)$  is represented by  $(x_j, y_j)$ .

$$f = \sum_{i=1}^n (\alpha_i \times \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}) \quad (1)$$

Here,  $\alpha_i$  represents weight parameter of each residential area. In this study, the maximum value is set for the total length from the starting point to the end point. Therefore, the proposed algorithm is to search a traffic route in which the total length  $L$  is below the maximum value and where the value  $f$  in formula (1) is the smallest.

### 3. Basic algorithm

As preconditions, the number of ICs is equal to that of residential areas in the initial state, and one 'Particle' expresses one solution (traffic route). Therefore, in the proposed algorithm, when the number of ICs is set at  $n$ , the  $2n$ -dimensional coordinate column is used. PSO is then applied to this coordinate column. The method for application of PSO is explained as follows:

*Step1:* A traffic route pattern of the first Particle is arranged on the straight line that connects the starting point with the end point. The coordinates of each IC are to be the same as those of each residential area (refer to Fig. 2). The values of the coordinates at that time are expressed by  $pbest$  and  $gbest$ .

*Step2:* Random arrangement of each Particle is performed again.

*Step3:* Using update rules of velocity and location in formula (2), PSO is executed.

*Step4:* For the obtained traffic route pattern, the nearest IC is assigned to each residential area. Any unassigned IC is integrated into a nearby IC (making the coordinates of the unassigned IC the same as those of the nearby IC).

*Step5:* The sum of each distance between a residential area and the IC that has been assigned to the residential area (objective function value) is calculated, and  $pbest$  and  $gbest$  are updated based on the PSO algorithm.

*Step6:* When the termination condition ( $k = \text{MAX}$ ) is satisfied, the final solution is expressed as  $gbest+$ . Based on this, the value  $f$  is calculated, and PSO is completed. Otherwise,  $k = k+1$  is set and PSO is executed from *Step3*.

$$v_{ij}^{k+1} = w \cdot v_{ij}^k + C_1 \cdot rand_1() \cdot (pbest_{ij}^k - x_{ij}^k) + C_2 \cdot rand_2() \cdot (gbest_j^k - x_{ij}^k) \quad (2)$$

$$x_{ij}^{k+1} = x_{ij}^k + v_{ij}^{k+1}$$

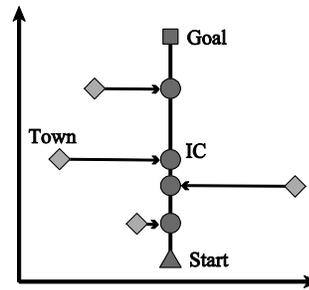


Figure 2 Initial state

Figure 3 shows an example in which no residential area has been assigned to an IC in *Step4*. Using this figure, the operations of PSO for IC, to which no residential area has been assigned, are concretely explained. As shown in Figure 3 (1), an update is first performed using the velocity vector. In this example, no

residential area has been assigned to IC<sub>2</sub>, as shown in Figure 3 (2).

Next, the coordinates of IC<sub>2</sub> are changed to those of IC<sub>1</sub>, as shown in Figure 3 (3). This is the operation of integration indicated in *Step 4*. The position of IC is then updated, based on the velocity vector. In this example, since the velocity vector of IC<sub>1</sub> differs from that of IC<sub>2</sub>, a division of IC may occur, as shown in Figure 3 (4).

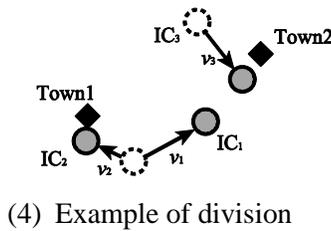
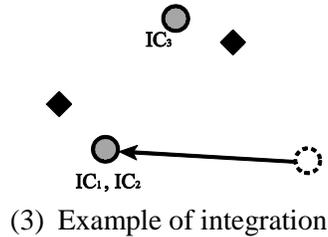
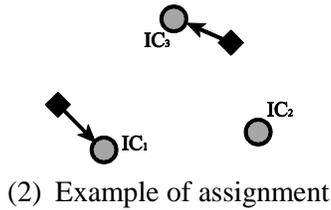
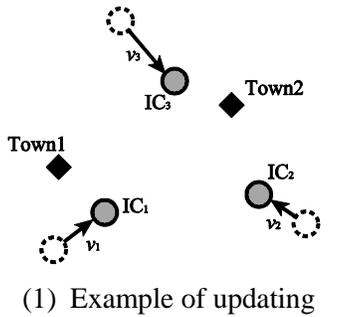


Figure 3 Examples of integration and division

#### 4. Evaluation with respect to safety and cost performance

First, the constraint condition is set for the distance between ICs, from the viewpoint of corresponding to a traffic accident and a disabled vehicle. In other words, the maximum value is set for the distance between ICs. In the proposed algorithm, a new IC added, at the midpoint between ICs, only when the constraint condition is breached. The distance is the largest in the traffic route and has been obtained by the basic algorithm. The actual processing procedure is explained as follows:

*Step1:* Traffic route *gbest* is obtained by the basic algorithm.

*Step2:* Each distance between ICs is separately calculated.

*Step3:* When all of the distances between ICs are below the constraint condition, Step 4 is omitted.

*Step4:* When the number of ICs is smaller than that of residential areas, a new IC is added at the midpoint between the ICs that have the largest distance between them in the traffic route. The processing is performed again from *Step 2*.

*Step5:* The final solution is expressed as *gbest* +. Based on this, the value *f* is calculated, and processing is completed.

Next, the number of ICs is minimized from the viewpoint of the expressway construction cost. In the proposed algorithm, formula (3) is used, which is the modified velocity update formula in the basic algorithm. In formula (3), the pattern of a traffic route in which the value *f* in formula (1) is small and the number of ICs is the smallest is substituted for *gbest2*.

$$v_{ij}^{k+1} = w \cdot v_{ij}^k + C_1 \cdot rand_1(\cdot) \cdot (pbest_{ij}^k - x_{ij}^k) + C_2 \cdot rand_2(\cdot) \cdot (gbest_j^k - x_{ij}^k) + C_3 \cdot rand_3(\cdot) \cdot (gbest2_j^k - x_{ij}^k) \quad (3)$$

### 5. Evaluation experiments

The proposed technique was validated by evaluation experiments. The number of residential areas is first set at 10, and the number of constraint conditions for the traffic route length is set at 17.

First, an evaluation experiment was performed for the basic algorithm. Table 1 shows the values of the largest distance between ICs, the largest distance from a residential area to IC, and the number of ICs, obtained by the basic algorithm.

Next, an experiment was performed in which the maximum value was set for the distance between ICs (Table 2). As shown in Table 2, although the largest distance between ICs could be significantly reduced, the number of ICs increased. The reason for this is that a new IC was added at the midpoint between ICs. Table 3 shows the results of an experiment in which a decrease in the number of ICs was taken into consideration. As shown in Table 3, although the number of ICs decreased, the largest distance between ICs increased. As shown in Tables 2 and 3, the decrease in the distance between ICs and the decrease in the number of ICs were in a trade-off relationship.

Finally, an experiment was performed in which all of the evaluation items (the distance from a residential area to an IC, the distance between ICs, the number of ICs, and the constraint conditions) were taken into consideration (Table 4). As shown in Tables 1 and 4, the proposed algorithm was able to reduce the distance between ICs and the number of ICs, which were in a trade-off relationship, and could reduce the largest distance from a residential area to an IC.

### 6. Conclusion

In the present study, PSO, obtained by technological modeling of feeding behaviors of bird swarms, was used to establish a new expressway design technique. In the proposed

technique, a new evaluation method is incorporated into PSO. Consequently, an excellent traffic route could be obtained. This traffic route simultaneously satisfied convenience, safety, and cost performance, which were in a trade-off relationship. The validity of the proposed technique was verified by evaluation experiments. In future, we will apply the proposed technique to other problems, such as facility location and logistics.

Table.1 Result of the basic algorithm

Distance from IC to town	10.691985
Traffic route length	17.000000
Distance between ICs	3.747844
# ICs	7

Table.2 Consideration of Distance between ICs

Distance from IC to town	9.695707
Traffic route length	17.000000
Distance between ICs	2.355622
# ICs	9

Table.3 Consideration of # ICs

Distance from IC to town	15.114266
Traffic route length	16.344033
Distance between ICs	3.994309
# ICs	4

Table.4 Result of the proposed algorithm

Distance from IC to town	13.372515
Traffic route length	16.980695
Distance between ICs	3.217707
# ICs	6

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# Testing and Analysis of the Fatigue Properties of Bone Cement: A Collaborative Project

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## Abstract

The objective of this research project is to determine the effect antibiotics and bone cement mixer type have on the fatigue properties of bone cement. Collaborators are the University of North Florida and the Department of Orthopaedic Surgery and Rehabilitation in the College of Medicine at the University of Florida.

## 1.0 Background

Bone cement is used in affixing implants to bone. In particular it is used in cementing hip joints, knee joints, and shoulder joints. A variety of different bone cements exists and their mechanical properties vary among brands. In studying the modulus of elasticity and ultimate tensile strength of Simplex P, Simplex P with Trobamycin, Palacos R, Palacos G, Cobalt™ HV and Cobalt™ G-HV it was found that Palacos R had the highest ultimate tensile strength of 42 MPa and the lowest modulus of Elasticity of 2.9 GPa [1]. In this study the effect of cement type and the inclusion of antibiotics on the modulus of elasticity were analyzed. It was found that the effect of antibiotics was significant ( $P=0.0127$ ) and the interaction between the cement type and antibiotics was significant ( $P= 0.0757$ ). Statistical analysis were also performed on the effect antibiotics and type of bone cement had on the ultimate tensile strength. It was found that no significant difference was present for the inclusion of antibiotics ( $P = 0.1103$ ) or for the interaction ( $P = 0.6475$ ) between antibiotics and cement type. However, the type of cement was found to be significant for the ultimate tensile strength ( $P=0.0486$ ) [1].

A second phase of the study investigated the effect the type of bone cement mixer has on the modulus of elasticity and the ultimate tensile

strength. These results are in the process of being published.

The third phase of the study is to determine the fatigue properties or strength-life curves of the bone cements and to investigate the significance of bone cement type, inclusion of antibiotics, and the type of mixer used in making the cements. The first step in this study is to develop a mold for making the specimens. Specimens will then be made in the operating room at the hospital. The mechanical properties will be determined using an MTS 858 servo hydraulic load frame by fully cycling the load through tension and compression. Lastly, statistical analysis will be performed to determine the statistical significance of the variables.

## 2.0 Mold Making

The mold has been designed using ASTM F2118-03 (Standard Test Method for Constant Amplitude of Force Controlled Fatigue Testing of Acrylic Bone Cement Materials) [2]. This method specifies the specimen size, makes recommendations on how to make the mold, specifies how to manufacture the specimens, and details how to test them.

A Computer-Aided Design (CAD) software was used in drawing the specimen as seen in Figure 1.

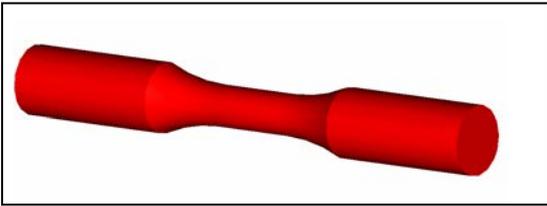


Figure 1: CAD model of specimen

The dimensions of the specimens are found in Figure 2.

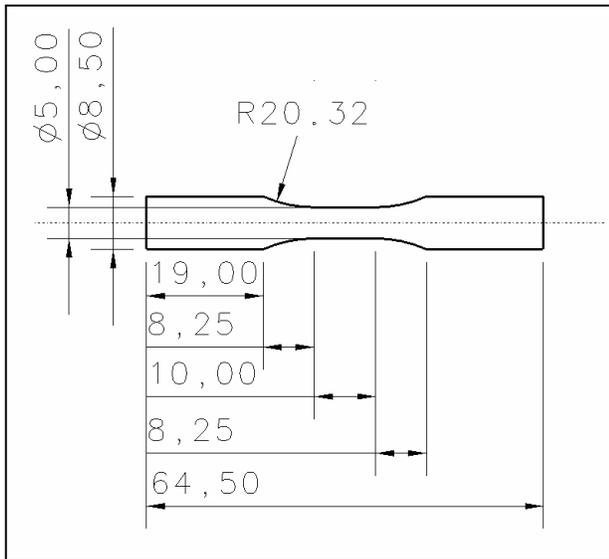


Figure 2: Dimensional sketch of specimen (mm)

Upon generating a CAD model of the specimens, the drawing was sent to a local machine shop as a CNC controlled lathe was needed to manufacture patterns for the mold. Six aluminum patterns (6061-T6) were made and are shown in Figure 3.



Figure 3: Metal specimens used as patterns

The mold was then fabricated by pouring a silicone rubber into a mold box surrounding the patterns. The mold box was built by designing a top and bottom plate with milled circular pockets for the patterns to sit in as shown in Figure 4.



Figure 4: top and bottom plates of mold box

After placing the patterns in the circular pockets, as seen in Figure 5, each of the specimens were coated with the silicone rubber mixture to minimize air bubbles at the surface of the patterns. A small drop of cyanoacrylate adhesive was placed at the end of each pattern to better square for mold assembly.

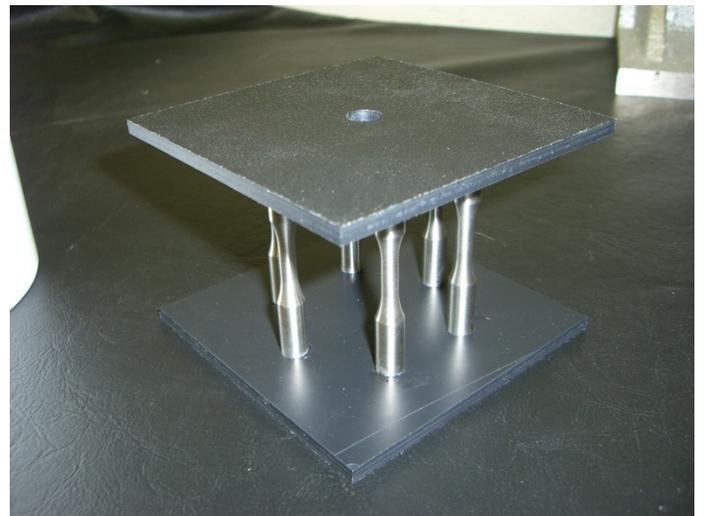


Figure 5: Patterns sitting in top and bottom plate.

The hole in the top plate was initially intended for gating but it was later learned that the mixture could more easily be poured from the side and this would minimize the amount of air bubbles trapped in the mold. Two additional walls were then attached to the mold box by using masking tape as shown in Figure 6.

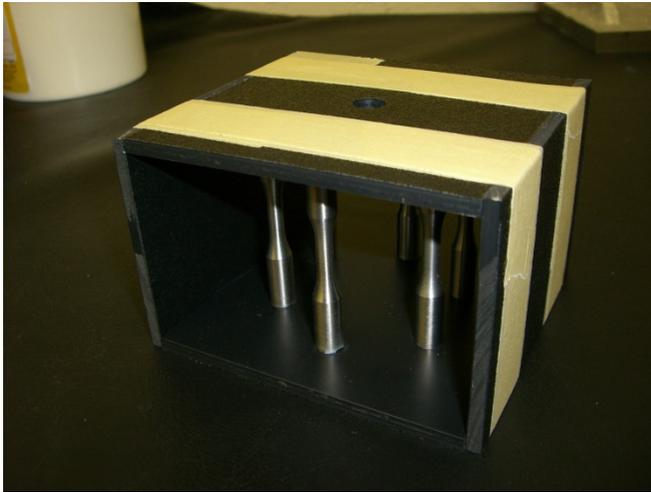


Figure 6: Mold box with four walls attached

A fifth wall was added to the mold box after which the silicone rubber (Smooth-SIL 935) was mixed and poured into it, as seen in Figure 7.



Figure 7: Mold box filled with silicone rubber

The silicone cured for 24 hours after which the walls were removed. The cured mold with the patterns intact is shown in Figure 8.

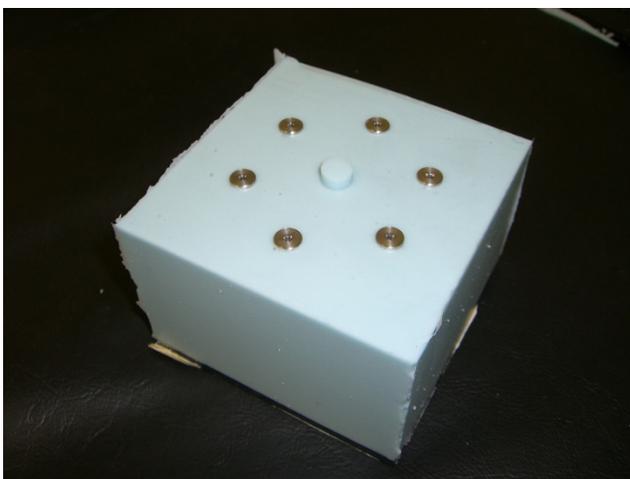


Figure 8: mold with patterns intact

The patterns were pushed out by using a rod. The mold was inspected and no obvious flaws were detected. This mold will be used to make bone cement specimens in an operating room.

### 3.0 Testing Procedure

Once the specimens have been made in the operating room at the Department of Orthopaedic Surgery and Rehabilitation in the College of Medicine at the University of Florida they will be brought back to the University of North Florida for mechanical testing. The specimens will be tested randomly to minimize user effect. The specimens will be tested to failure at 10, 12.5, and 15 MPa using a constant amplitude sine function using the MTS 858 seen in Figure 9.



Figure 9: MTS 858

Upon completion of the tests, strength-life plots will be developed for the cements and comparative analysis will be performed among the different cements and also between cements with and without antibiotics. Lastly, the effect of mixer type will be investigated.

### 4.0 Conclusion

A collaborative research project is undertaken between the Mechanical Engineering program at the University of North Florida and the Department of Orthopaedic Surgery and Rehabilitation in the College of Medicine at the University of Florida. Through this collaboration

the ultimate tensile strength and the modulus of elasticity for a variety of bone cements have been determined. The results have been studied statistically to determine the effect antibiotics and mixer type have on the mentioned mechanical properties. The current phase of the project is to develop strength-life plots of the bone cement types. The work presented in this paper outlines how the mold for the fatigue specimens was designed and manufactured.

## **5.0 Acknowledgements**

These efforts are sponsored by the Dean's Leadership Council of the College of Computing, Engineering, and Construction at the University of North Florida.

## **6.0 References**

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# Applying Lean Production System to Bus Maintenance in Public Transit Authority Activity

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## Abstract

This paper presents the challenges in the creation of a Lean production system in the Greater Cleveland (Ohio) Regional Transit Authority (RTA) bus maintenance program. It demonstrates that the Lean production system can be sustained in a partially-governmental and unionized environment through achieving tangible results, visible to the work force. This paper describes a pilot project in RTA, and is supported by interviews with another transit agency, statistical analysis, and a simulation of the future state of the pilot project.

Lean enterprise principles can be applied to a unionized job shop. This consists not only of various technical tools, but an underlying philosophy that must be established to change the corporate culture and work environment. After the onset of this project, many RTA employees believed that a Lean transformation in the existing environment would have been impossible. After analyzing the RTA system, it became apparent that a hybrid Lean system could initially achieve the most effective results. In order to achieve a true Lean system, a follow-up plan will be provided to ensure that RTA can sustain its transformation.

This paper demonstrates a pioneering approach to Lean enterprise transformation in a US transit authority, and brings a new transition state named hybrid lean transformation to the literature.

## 1. Introduction

Organizations have been implementing various production management systems more than ever for last two decades to reduce costs, improve efficiency and quality [1]. Most

corporations selected either Six Sigma to reduce variations in the process, or the Lean Production System to eliminate wastes.

The Greater Cleveland Regional Transit Authority (RTA) is a transit authority serving the greater Cleveland region since 1970. In 2009, RTA had an operating budget of \$241.8 million, owned 620 busses, and employed 2,653 personnel [2]. Over 200 people work at the Central Bus Maintenance Facility (CBMF), located on Woodland Avenue in Cleveland's east side. CBMF performs major bus maintenance, such as rebuilding engines, overhauling brake systems, and repairing bodies. In 2005, RTA faced a budget shortfall of almost \$9 million, which resulted in pay cuts and layoffs. This crisis environment prompted RTA management to explore a Lean Enterprise implementation as a means for long-term cost reduction.

The Lean transformation project described in this paper began in the engine rebuild department. Observation of the rebuild activities and processes allowed a pilot Lean project to be identified, targeting rapid returns. The implementation is supported by statistical analysis and simulation. The results from these activities are shown and analyzed in the conclusions section of this paper.

## 2. Lean implementation

The Lean implementation started with a thorough process observation, followed by value stream mapping and 5S implementation. Upon completion of the early stages of the transformation, job standardization and a *poka-yoke* implementation took place. A statistical analysis and system simulation were conducted

in order to analyze and justify recommendations the authors gave to RTA.

### 2.1. Process observation

In order to effectively implement Lean, the complete engine replacement and rebuild process was observed. This gave the authors an understanding of the dynamics of the system, and the difficulties and limitations facing the engine mechanics. Due to union regulations, a time study could not be conducted. Instead, historical data from RTA's database was used to determine the demand and the *takt* time, based on the rate of failure of bus engines.

The Lean transformation at CBMF began by observation of extant practices in the engine replacement department. This area had been previously selected for a pilot project by CBMF management, as engine replacement is a highly repetitive process.

RTA does not use a Material Requirement Planning (MRP) system. Rather, they use Ultramain®, an Enterprise Resource Planning (ERP) system developed by Ultramain Inc. (Albuquerque, NM). This software uses a suite of customer-selected modules to track logistics and maintenance activities in the enterprise.

Engine replacement starts when a driver calls RTA headquarters to report an equipment failure. If the roadside assistance truck diagnoses an engine failure, the bus is towed to an outside parking lot at the Central Bus Maintenance Facility. When an Engine Replacement Mechanic becomes available, the bus is moved to a hydraulic lift. Replacement consists of: disconnecting the engine from the bus; removing the engine; installing a previously-repaired engine from inventory, and; connecting the new engine to the bus. According to the Ultramain data, removing the engine from a bus requires 8-12 hours, and the entire replacement process requires 16-24 hours.

The lead time varies between mechanics. One roadblock in replacing an engine is obtaining the necessary materials from inventory. This is a universal concern across the RTA organization, as the delivery performance by the Inventory Department is very poor. Exacerbating this, the Engine Replacement Department is supplied not only by the Engine Rebuild Department, but also a central warehouse inside CBMF. This warehouse supplies hardware necessary to complete an engine replacement, such as washers and bolts. Inventory issues will be discussed later.

A three-week study of existing practices in the Engine Replacement department allowed problems in the system to be defined. A major problem observed was the lack of a standardized process in rebuilding engines. For example, the engine rebuild mechanics were inconsistent in the length of a certain hose attached to the engine. This particular hose is one of the final connections between the engine and the bus. If the engine replacement mechanic determined that the hose was too short, he would have to remove the engine in order to replace the faulty hose. In addition to the addition of non-value-added time, the lack of standards had a deleterious effect on the quality of the mechanics' work in the Engine Rebuild Department.

After these observations, the next step of the project was to develop a value stream map (VSM) for the engine replacement process, combining information from Ultramain, observational data, and input from CBMF personnel. The VSM, seen in Fig. 1, suggests that addressing (a) the bottleneck in Engine Rebuild, (b) excessive work, (c) *mura* (unevenness), and (d) hidden waste as opportunities for immediate improvement.

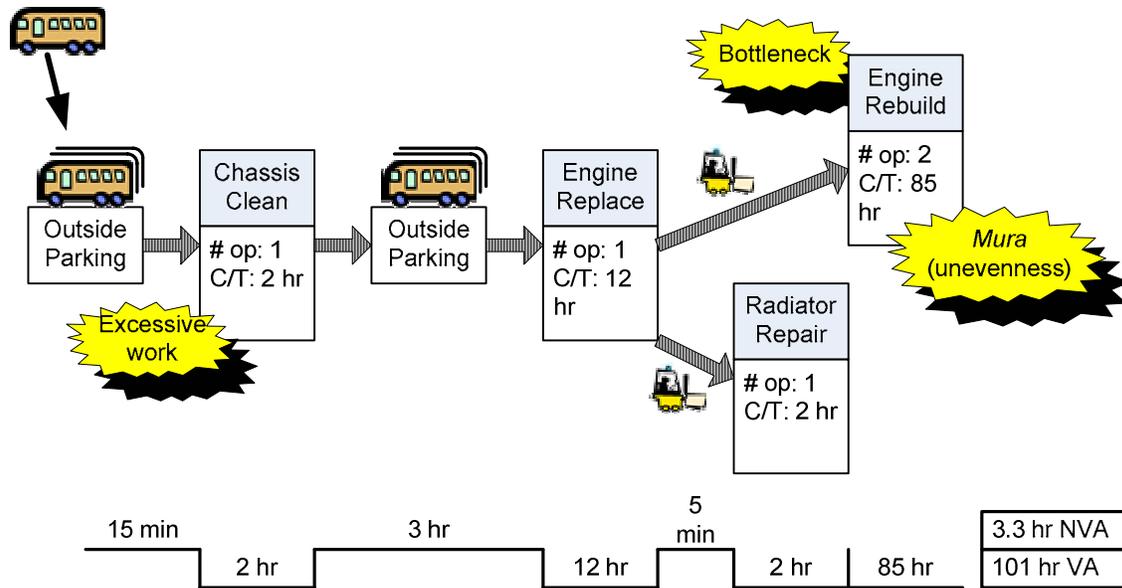


Figure 1. Value Stream Map of Engine Replacement at CBMF.

**2.2. 5S (Sort, Shine, Straighten, Standardize, and Sustain)**

5S is a series of activities developed by the Toyota Motor Company to keep the workplace clean and prevent defects, errors, and injuries. Liker [1] recommends starting a Lean implementation with 5S, as it eliminates some non-value-added activities and makes it easier to identify others. The Lean implementation at RTA began with a 5S implementation in the Engine Rebuild area, as it was identified as the bottleneck in engine replacement. The engine rebuild area was messy and full of clutter, which hid some wastes and created others. Clutter compelled the mechanics to spend extra time finding parts. In addition, the dirty workcell made it difficult to keep engine cylinders clean during a rebuild, which is necessary to prevent future damage to the engine.

The sorting of materials, occurring in the first week of the implementation, separated necessary items from unnecessary items. Mechanics and supervisors cooperated in the sorting, which provided a good starting point to establish joint involvement, ownership, and commitment for

the project. At this point, however, some employees were not yet comfortable with the idea of Lean. One mechanic commented at that time, “I do not want anything to change, I have been doing this job for over 6 years, I will keep doing it my way!”

After removing unnecessary materials, the workplace was organized (straightened). This demonstrated to the mechanics that a Lean philosophy can bring them tangible benefits. First, frequently-used items, such as belts, hoses, and common bolts were assigned to specific locations in the shop. Each of the four workstations in the engine rebuild area was arranged identically. The new arrangement gave mechanics easier access to materials and equipment.

Cleaning the work area (shining) was relatively easy. A team from RTA Facilities Maintenance was assigned to clean the area, and paint lines on the floor to identify work cells and equipment storage locations. At the same time, the engine mechanics arranged and labeled pegboards for holding tools and small parts. At the end of this one-day effort, the mechanics had a clean and organized work area, each having a

workbench with individual power outlets and overhead work lights.

Standardization was established through new work rules for housekeeping in the work cells, detailed in Appendix 1. The new standards, and the employees' commitment to them, helped to establish a sustaining stage for the Lean implementation.

### 2.3. Job standardization

After the 5S implementation, work standards (separate from the housekeeping standards) were developed. As discussed earlier, a significant problem in Engine Replacement is the rework arising from inconsistent work in the rebuilt engines. In addition to the hose length problem mentioned previously, other wires and hoses were often routed incorrectly, requiring further rework at engine replacement.

Each of the four teams in the Engine Rebuild area used their own methods. RTA had justified this practice by arguing that every engine required different treatment due to the uniqueness and complexity of the job. During this project, though, engine rebuild procedures were unified in terms of inspection, preventative maintenance, and corrective maintenance. New work procedures, detailed in Appendix 2, were developed to standardize these tasks. The anticipated result from applying these standards is an 80% reduction in rework.

### 2.4. Poka-yoke

An engine rebuild requires removing and re-installing more than 400 bolts, both common and special-purpose. Many of the special-purpose bolts are no longer manufactured by the original vendors, forcing RTA to order replacements from third-party vendors should the bolts be lost or broken. To avoid waiting for these bolts to be ordered and delivered, the engine rebuild mechanics have amassed and held on to their own private bolt inventories. The informal, unstated code in the Engine

Rebuild area prevents a mechanic from asking for a bolt from another mechanic's stash. To overcome this issue, an assistant supervisor in the Engine Rebuild department (Sam) recommended establishing a common-access stock area for bolts used in bus engines.

A simple procedure addresses the issue of lost bolts. Mechanics now start on an engine having a set of empty bins for holding bolts as they are removed from the engine (Fig. 2). After finishing an engine, these bins should be empty; the presence of a bolt indicates a bolt was not replaced in the engine. Bins are labeled so that a stray bolt's location in the engine will be known, thus guiding the corrective action needed. The use of these bins eliminates rework associated with incorrect bolt installation.



**Figure 2. Bolt holding bins for engine rebuild (*poka-yoke* device)**

An inspection step to check for correct hose lengths and routing was integrated into the process flow. According to Taiichi Ohno, inspection is a form of waste and should be eliminated when possible [3]. In order to sustain reliability and quality, though, inspection was deemed necessary. Even though it does not directly contribute to waste reduction, inspection will generate a long-term benefit by creating a suitable environment for further Lean implementation. It is expected that the inspection will be eventually be eliminated with further employee training and experience with the Engine Rebuild standards.

### 2.5. Results of Lean implementation

The 5S implementation resulted in freeing up 30% of the area in the Engine Rebuild Department. After the implementation, RTA elected to use that space to add a fifth engine stand, increasing capacity by 25%. At this time though, the fifth engine stand is not being used. In addition, the organization of the work area allowed some mechanics to be reassigned to other areas. Previously, two mechanics would work on a single engine. In the organized work area, only one mechanic per engine is needed. A fifth mechanic works as a floater, assisting the other four when needed. The estimated annual savings is \$150,000, based only on salaries.

### 3. Statistical analysis of failed engine arrival

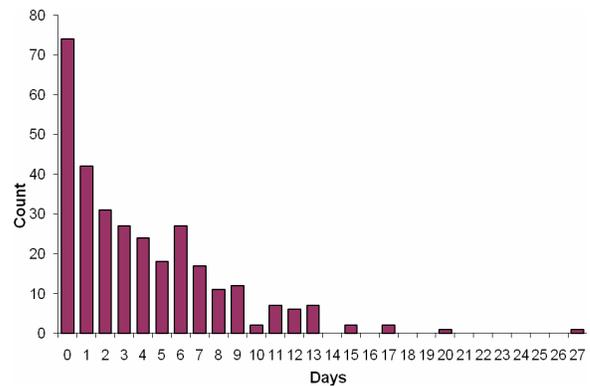
Statistical analysis was used to determine the failed engine arrival rate, which in turn would determine the *takt* time for an engine rebuild. Statistical tools were used in lieu of time studies as the latter was prohibited by the mechanics' union. Historical data for 313 engine failures, over a span of 40 months, was obtained from Ultramain® (Table 1). Minitab® was used to identify the statistical distribution of time-between-arrivals for this data. The best-fit distribution was found to be exponential distribution, having a mean of 3.88 days between arrival dates with a variance of 0.066 days (Figure 3).

Because engine breakdowns are not scheduled events, RTA is required to have some number of engines on-hand for replacement; otherwise, busses will be kept waiting in the Engine Replacement area. The authors proposed that RTA keep a specific number of ready-to-install engines for immediate use by the Engine Replacement, while matching the engine rebuild *takt* time of 3.88 days. The underlying goal was to prevent over-production and unnecessary inventory in the bottleneck operation, while at the same time preventing excessive waiting in

the Engine Replacement area. Having the right number of engines on-hand and maintaining a steady repair pace will assist RTA in eliminating waste.

**Table 1. Engine Arrival Data (abridged)**

Engine Arrival Date	Assigned Date	Interarrival time
1/9/2006	1	N/A
1/13/2006	5	4
1/24/2006	16	11
3/13/2006	64	48
3/13/2006	64	0
3/13/2006	64	0
		
5/1/2009	1209	0
5/1/2009	1209	0



**Figure 3. Historical distribution of days between engine failure.**

Assuming an exponential distribution of engine arrival times, a z-test ( $\alpha=0.95$ ) can determine the optimal number of repaired engines to keep on-hand in inventory. Table 2 lists the probability of meeting engine demand as a function of the on-hand inventory. After seeing these results, RTA executives decided to adopt a 5-engine inventory policy. With this, the Engine Replacement department will have an engine available 81% of the time, thus eliminating the bottleneck identified in the value stream map.

**Table 2. Inventory and Probability Correspondence**

Number of Engines	Probability of Meeting Demand
0	0.021
1	0.102
2	0.259
3	0.461
4	0.656
5	0.806
6	0.903
7	0.956
8	0.982
9	0.993

**4. Simulation and optimization of future state configuration**

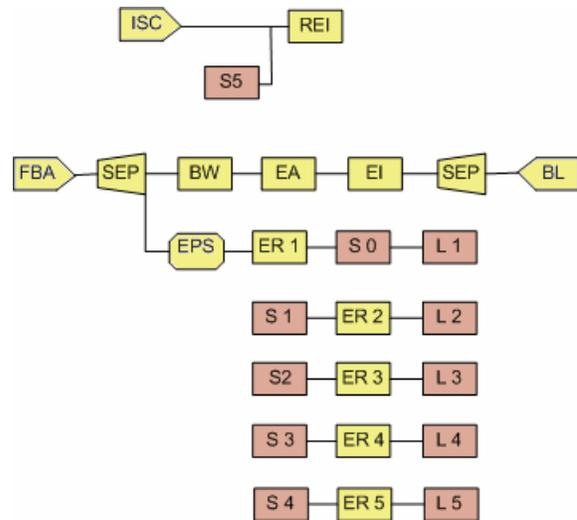
Beyond the Lean implementation discussed in Section 3, and the on-hand engine inventory optimization discussed in Section 4, the authors hypothesize that reorganizing how engines are processed in the Engine Rebuild area can improve engine availability and lower costs for RTA. Currently, an engine is serviced by a single mechanic as it is being rebuilt. The proposed layout would consist of five workstations, in which each mechanic performed a portion of the work needed to rebuild an engine. It is thought that, by introducing flow, RTA would be able to avoid the overproduction of rebuilt engines.

At this time, RTA is unwilling to implement such a drastic change to the work environment. Instead, the proposed change is modeled in Arena. The simulation found that three rebuild mechanics, instead of the five originally considered, would be able to meet the demand for rebuilt engines.

**4.1. Simulation model**

The simulation model is based on the value stream map from Fig. 1 and statistical analysis

discussed in Section 3. The model consists of a five-station engine assembly line and the proposed safety buffer of five engines. Currently, the average time to rebuild an engine is 85 hours. Separating an engine rebuild into five workstations with balanced times allows the predicted rate of engine production (17 hours) to match the time needed to reinstall an engine in Engine Replacement (12-16 hours).



**Figure 4. Simulation model**

Figure 4 shows the Arena model used in the simulation. The model uses the exponential distribution for failed engine arrival; triangular time distributions for workstation processes, and exponential time distributions for transportation of engines between workstations. The model accounted for the fact that RTA busses operate (and break down) 7 days a week, while the mechanics work 5 days a week, with lunch and coffee breaks. The number of workstations was treated as a variable, as was the number of mechanics in the Engine Replacement area. Both were bounded between one and twenty mechanics, with a suggested value of five. Cost was calculated using two factors: mechanics wages, and RTA’s assigned cost for a rebuilt engine. It is recognized that the cost function is not perfect, as it does not include benefits or overhead costs, and may double-count labor.

Details of the model are listed in Appendix 3. Arena’s OptQuest module was used to minimize cost, using the constraint that no more than three busses will be wait on an engine at any given time. The simulation covers a three-year period of operations.

The simulation shows that three Engine Rebuild workstations and one Engine Replacement mechanic will minimize RTA’s operating cost. Using the numbers in the model, the future-state layout will result in annual savings of \$213,000. The optimized model has a *takt* time of 26.66 hours, which is comparable to the engine arrival rate of 3.88 days (27.2 hours, using 7.5-hour shifts). The proposed model will sustain one piece flow and level out the production resulting in overproduction avoidance (*heijunka*).

**Table 3. Optimization output**

Number of busses waiting for an engine $\leq 3$	
Number of install mechanics	1
Number of repair mechanics	3
Safety buffer amount	5
Total cost over three years: \$960,000 (original cost: \$1.6M)	

**5. Discussion**

This study yielded both expected and unexpected findings. It was anticipated that Lean production principles would be applicable to a unionized, semi-governmental work environment. It was discussed by [4;5] that Lean production system can be implemented, but the impact may not be as dramatic as possible in a non-union environment. In this case, the implementation results were relatively dramatic, including:

- Increase in available space of 30%;
- Increase of 25% in capacity;
- Required staffing reduced from 8 to 5;
- Elimination of overprocessing and overproduction, and;

- Annual costs savings of \$150,000.

The unexpected finding is the requirement of statistical and scientific skills to obtain the optimal benefits from a Lean implementation. In the literature, Lean is discussed from a business perspective [6]. In many cases, though, scientific tools are required to better implement Lean tools. This study demonstrates that statistical analysis, and other scientific tools, are a necessary complement to Lean principles in providing tangible benefits to an organization. This was demonstrated by the simulation of flow in the Engine Rebuild Department, which identified the potential for RTA to increase its annual cost savings from \$150,000 to \$213,000.

**6. Conclusion**

This paper discusses the first steps of a municipal transit authority towards adopting a Lean philosophy. The authors worked with Cleveland RTA personnel to apply the Lean tools of 5S, standardization, and *poka-yoke* in the Engine Rebuild Department. Statistical tools optimized the number of engines to hold as a safety stock for Engine Replacement, which is Engine Rebuild’s customer. Simulation validated a proposed future state in which flow is introduced into the Engine Rebuild Department. These activities identified \$213,000 in potential annual savings for RTA. This paper also demonstrates that statistical and engineering analyses are a necessary complement to the tools and methodologies of Lean manufacturing.

**Acknowledgement**

The authors would like to recognize Dr. John Van Blargan’s help at the statistical analysis and simulation sections. Also certain RTA staff assisted to the project at various sections.

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**APPENDIX 1.** Housekeeping standards for Engine Rebuild Department

To maintain the improvements made by incorporating some LEAN processes into the Engine Rebuild area, the following processes shall be enforced by the Assistant Section Supervisor.

- PPE should be worn at all times.
- 2 red carts and 1 blue “stacked cart” per area (no exceptions).
- No other cart allowed in the area.
- Metal Dumpster shall remain in its designated location.
- Used oil drum shall remain in its designated area (when not in use).
- Wall lights will be turned on everyday and turned off at the end of the shift.
- No engine stands used to transport the engines via fork lift shall be left in the area.
- Forklift shall always be parked in its designated area (when not in use).
- Designated employee toolbox locations shall not be changed. Should an employee wish to permanently relocate his toolbox, he/she shall consult with the Performance Supervisor.
- When processing cores, Batch core processing shall continue, however; no core parts shall be left out by the supervisor’s work area. (cores will be processed immediately).
- Only use 1 red cart (1 per work station) for cores.
- All wash vat lids shall be closed nightly and radios, fans, and lights turned off.
- Non-work related books and magazines shall be removed from the area or kept in employee toolboxes during work hours.
- When it’s necessary to discuss changes in work process, employees should bring their ideas/concerns to the Assistant Section Supervisor. The Assistant Section Supervisor should document the idea/concern and bring it to the Performance Supervisor for action or address the concern and inform the Performance Supervisor of the issue and resolution. This will eliminate unproductive time and, at the same time, provide a way for employees to submit valuable ideas for continuous improvement.

## APPENDIX 2. Sample checklist for engine rebuild

**Detroit Diesel Series 50-EGR Engine Checklist**

Engine Serial Number \_\_\_\_\_

Date Completed \_\_\_\_\_

Technician \_\_\_\_\_

Item/Action	Inspected & Reused	or	New & Quantity
Starter			
Generator			
Engine Oil Cooler			
EGR Cooler			
V-Pod Modulator			
Transmission			
Trans Cooler			
Rear Crank Seal			
Tensioner			
Idler Gear Assembly			
Bull Gear Assembly			
Compressor Retro Kit			
Intake Rocker Arm			
Exhaust Rocker Arm			
Injector Rocker Arm			
Rocker Shafts			
SRS Sensor			
TRS Sensor			
Power Steering Pump			
Balance Shaft			
Thermostats			
Generator Belt			
Motor Mounts			
Oil Filters			
Primary Fuel Filter			
Secondary Fuel Filter			
Water Filter			

Kit Parts	New Parts Inspected & Installed
Cylinder Kits	
Head	
Head Bolts	
Turbo	
Injectors	
Cam Bearings	
Main Bearings	
Thrust Bearings	
Rod Bearings	
Cam Bolt	
Rocker Adjusters	
Gasket Set	
Front Seal	

Torque Verification	Torque Value Ft Lbs	Verified with paint
Item		
Head Bolts	220	
Cam Bolt	50 then 90 degrees	
Main Caps	400	
Rod Caps	125-130	
Rockers	75	
Injector Crab	50	
Exhaust Manifold	50	
Intake Manifold	50	
Rocker Box	15-18	
Valve Cover	15	
Oil Pan	15	
Bull Gear	85-90	
Front Damper To Crank	130	

**APPENDIX 3.** Simulation model details

Blocks	Description	Block type	Distribution	Parameters
FBA	Failed bus arrives	Create	Exponential	3 days
ISC	Initial stock created	Create	Constant	9999999
REI	Repaired engine inventory	Hold	N/A	N/A
SEP	Separate	Separate	N/A	N/A
BW	Bus waiting for engine	Hold	N/A	N/A
EA	Engine becomes available	Pick up	N/A	N/A
EI	Engine install	Process	Triangular	8,12,14 min
SEP	Separate	Separate	N/A	N/A
BL	Bus leaves	Dispose	N/A	N/A
EPS	Engine parameter set	Assign	N/A	N/A
ER 1	Engine repair 1	Process	Triangular	12,15,18 min
ER 2	Engine repair 2	Process	Triangular	12,15,18 min
ER 3	Engine repair 3	Process	Triangular	12,15,18 min
ER 4	Engine repair 4	Process	Triangular	12,15,18 min
ER 5	Engine repair 5	Process	Triangular	12,15,18 min
S 0	Station 0	Station	N/A	N/A
S 1	Station 1	Station	N/A	N/A
S 2	Station 2	Station	N/A	N/A
S 3	Station 3	Station	N/A	N/A
S 4	Station 4	Station	N/A	N/A
S 5	Station 5	Station	N/A	N/A
L 1	Leave 1	Leave	Exponential	5 min
L 2	Leave 2	Leave	Exponential	5 min
L 3	Leave 3	Leave	Exponential	5 min
L 4	Leave 4	Leave	Exponential	5 min
L 5	Leave 5	Leave	Exponential	5 min

# The Implementation of TRAX and How Technicians Effectively Participate in an Integral Diagnosis, Communication and Training Program

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## Abstract

This paper describes a case study of the change process for implementing TRAX, a maintenance, repair and overhaul (MRO) software solution for airline industries [1], within a low cost carrier in the Netherlands. We will describe the diagnosis phase before the implementation of TRAX, the use of an integral (diagnosis) model, a standardized questionnaire related to this model and the use of semi structured interviews. The results of the diagnosis phase gave direction for further steps in the implementation and how technicians could communicate and participate effectively in the training program that had to be set up before implementing TRAX. After about one year the use of TRAX and the complete implementation process was evaluated. We give conclusions for change processes in which technicians are involved and the important role they can play for user acceptance of new software among their colleagues and peers.

## 1. Introduction

In September 2008 the airline company in the Netherlands was already at the point of building and testing an MRO software solution for their complete fleet of 29 own aircraft. The overall project manager and the manager of the Maintenance, Repair and Overhaul (MRO) department discussed their feelings that they were confident with the physical implementation of the software and the system but they were

afraid of the ‘mental implementation’ by the 213 employees that had to start working with TRAX. Based on their experiences, the ‘stories’ [2] in the organization and the skeptical reactions on the shop floor they were looking for something that could help them to increase the level of user acceptance [3] amongst the technicians. Together with an external consultancy firm a diagnosis phase started in which we contacted different employees, both on management positions and in the hangar, interviewed a selected group of employees across the organization and performed an online questionnaire which was open for all the 213 employees working in the MRO department. The diagnosis phase was performed according to an integral diagnosis model and gave direction to further steps in the project. The second phase was a highly interactive training program in which the technicians themselves were responsible for setting up the training, actually give the training and do follow up activities. In the first week of February 2009 the new MRO software was operational and the old software was not further in use anymore. Nearly one year (December 2009) after implementing TRAX the change process was evaluated using the same online questionnaire again and by listening to the ‘stories’ within the different ‘corners’ of the organization. First we describe in short the situation of the airline company and the project background. Second we will go into more detail on the integral diagnosis model used in this case.

Third we will describe the different elements in the diagnosis phase (e.g. interviews, questionnaire, workshops and gathering the 'stories') and how this all cumulated into directions for the training phase. In the fourth place we will describe the processes that we have seen during the test and preparation before training could start. Finally we will present findings and conclusions.

## 2. Organizational situation and project background

The airline is operating mainly from the Netherlands (Amsterdam, Schiphol Airport) and has a fleet of 29 own aircrafts. During high season this number is increased to 36 by leasing aircrafts from other companies all over the world. The MRO department has in total 213 employees (October 2008) which work mainly in three departments; Aircraft Maintenance, Engineering and Purchasing & Logistics. Daily maintenance is performed on the platform (pre-flight and through-flight inspections) and in the hangar. The technicians in the hangar work in shifts (day, evening and night) from Monday until Friday. The airline company is despite the current economic slowdown operating successful.

The background of the project started in 2007 with the selection process for a new MRO software solution. The current system in use (METALS) was to be phased out because there was no guarantee that adequate service on the software could be maintained by the supplier. At the beginning of 2008 the project organization for the implementation of TRAX was formally in place. The project, now called MISTRAL, was realized by a project group which consists mainly out of two 'branches'. The ICT component in this project was major, so this was an important part of the project team. Their responsibility was to realize all ICT related work (e.g. building, testing, interfacing and data

conversion). On the other hand the business should make their acceptance criteria clear and had also to do the necessarily testing before acceptance could be given for production and implementation. The business team existed out of a group of super users who volunteered to join the project. Their background and work experience would make it possible to define acceptance criteria, give adequate feedback on test versions of TRAX and approve production versions before implementation. The overall project manager worked with the two streams which were the responsibility of the ICT project leader on one hand and the business project leader on the other. The overall project manager reported to the Project Board in which the Manager of the MRO department and the Manager Engineering were having a final vote.

The change process for the MISTRAL project consisted out of some generic 'rules' which may underpin the way of working together and the responsibilities. The five basic 'rules' were; 1) every department in the organization is responsible for functional implementation of the new system within it's own department, 2) The implementation is supported per department by implementation coordinators, 3) The training will be done according a 'Train the Trainer' concept, 4) The MISTRAL project will coordinate, facilitate and support the business with implementation AND 5) The MISTRAL project is responsible for a proper working ICT system and environment (data migration, interfacing, test, acceptance and production environment, etcetera) which is accepted by the business.

## 3. Integral Diagnosis model

In 1995 Ken Wilber published his 800 page opus *Sex, Ecology, Spirituality* [4]. The core of its argument was a call to integrate "the big three". The big three of art, morals, and science; or the Beautiful, the Good, and the True; or I,

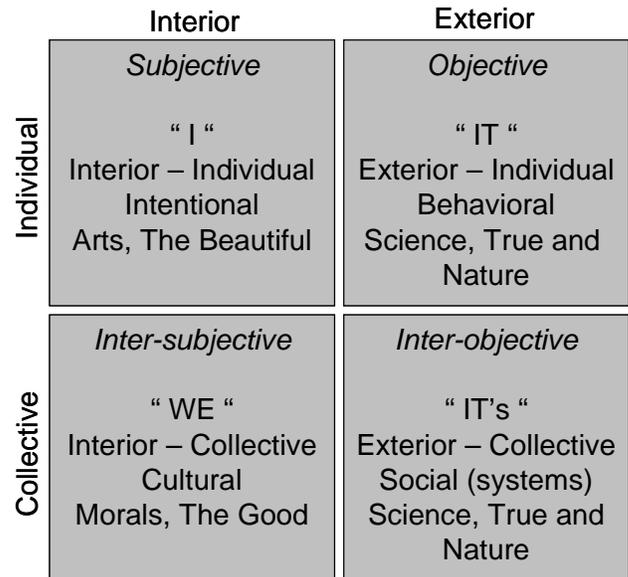
We, and It; or first-, second-, and third-person dimension. These are each associated with a pronoun as mentioned in Table 1 [5]. (Wilber, 1997).

**Table 1. The ‘Big Three’**

"Sir Karl Popper's 'three worlds'"	Subjective Cultural Objective
Plato	The Good (as the ground of morals, the 'We')
	The True (objective truth or It-propositions)
	The Beautiful (the aesthetic beauty in the 'I' of each beholder)
Habermas' validity claims	Subjective truthfulness of 'I'
	Cultural justness of 'We'
	Objective truth of 'It's'
Kant's three critiques	Science or 'It's' in the Critique of Pure Reason
	Morals or 'We' in the Critique of Practical Reason
	Art and self-expression or 'I' in the Critique of Judgment

Wilber (1997) calls his schematic summary of 'the four quadrants' model of existence: intentional, behavioural, cultural and social. These four quadrants are a summary of a data search across various developmental and evolutionary fields. Wilber examined over two hundred developmental sequences recognized by various branches of human knowledge, ranging from stellar physics to molecular biology, from anthropology to linguistics, from developmental psychology to ethical orientations, from cultural hermeneutics to contemplative endeavours, taken from both Eastern and Western disciplines, and including pre-modern, modern, and post-modern sources (Wilber 1995, 1996). Wilber noticed that these various developmental sequences all fell into one of four major classes (the four quadrants) and further, that within those four quadrants there was substantial

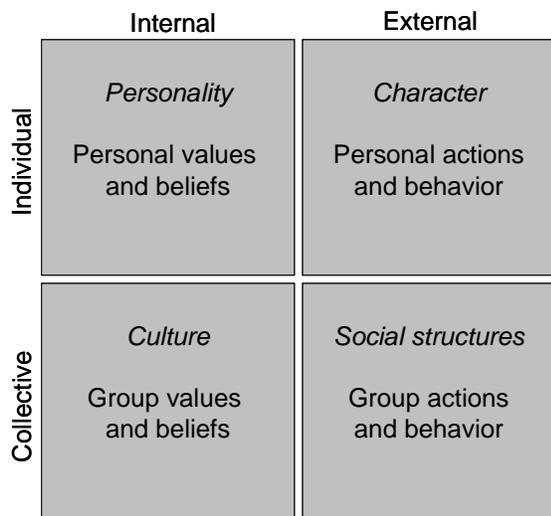
agreement as to the various stages or levels in each. Figure 1 is a simple summary of this data search. The 'four quadrants' thus represents an *a posteriori* conclusion, not *a priori* assumption (Wilber, 1997).



**Figure 1. Four Quadrants**

After the four quadrants model Wilber further refined his work and developed his so-called "integral theory of consciousness" [6]. Here he incorporates the physical, neurological, social, cultural, philosophical, and spiritual dimensions of human consciousness. This is known as All Quadrants All Levels (AQAL) model. Wilber holds on to the dimensions (interior – exterior and individual – collective) but adds the idea of different levels of consciousness development.. Although the AQAL model is complex and perhaps not scientifically proven applicable for organizational studies it forms a basic element of the conceptual framework for this study. This is because it is possible to build a conceptual framework with a 'stronger and better explanatory power' through the interplay between different perspectives (Edwards, 1995) [7]. Edwards (1995) terms the quadrants with consciousness (for personality) and behavioural

(for character). The collective quadrants are given the same names by Edwards (i.e. Cultural and Social). Consequently, the AQAL model can properly be regarded as a multi-paradigm and multilevel developmental framework that applies to the micro, meso and macro levels of social activity (Edwards, 1995). Also an idea behind the conceptual framework is the whole system approach of Barrett (2006) [8]. Barrett uses the work of Wilber but developed a more comprehensive model (see figure 2) which also exists out of four quadrants.



**Figure 2 Comprehensive model**

This much more simplified model by Barrett is applicable to groups, organisations and institutions. The four quadrants are described as follows: The *individual – external*. perspective stands for the individual, and his/her behaviour and skills. It is about what the individual does, what s/he shows in his actions, what s/he says in the communication, and also the way in which he or she does something. It is about the visible behaviour of the individual. In this perspective these things are visible and can be measured. In that sense it can be described as “the outside” because it is tangible. The *collective – external*. perspective stands for the visible social structures in which we live. This can be on the level of a social community, or on an

organizational level, or within our family. It is about systems, processes and external conditions like buildings, the climate, or the economy. In general this perspective is about the visible behaviour of a group of people, a team or an organization, and the relation with the surrounding environment, e.g. the social community. The *collective – internal*. perspective stands for the collective and inter-subjective relations between people. Here are group values, needs, motives, wishes, feelings, and collective experiences important. In general we define this perspective as the “culture” within a team or organization. In words of Schein (1997), this quadrant refers to the basic underlying assumptions. These taken for granted beliefs, perceptions, feelings and thoughts are part of this perspective. Finally the *individual – internal*. perspective is quite the same as in the collective quadrant but now it refers to every individual. Here we can address personal beliefs, values and other unconscious processes.

Barrett (2006) assumes that sustainable change must affect all four quadrants in some way in order to realize a whole system change. The basic idea behind this is that organizations can not change or transform, only people can change or transform. This human change then must affect the individual, internal and external quadrants for one employee. For the whole organization with many employees to change the collective, internal and external quadrants also has to be affected. Barrett (2006) uses these four quadrants and indicates that interventions in a change process should always take part in all four of the quadrants. These interventions do not have to occur at the same time, but the interventions should be done on individual and collective levels, and also on the external (objective) and internal (subjective) aspects. Barrett (2006) also addresses the consistency of interventions in the four quadrants. He indicates that if we want sustainable change, there have to

be interventions taking place in all the four quadrants and these interventions should be consistent with each other. Together with Barrett we also believe that the interventions done on the *inside – individual* and *inside – collective* quadrants are just as important as those done in the visible outside quadrants. Wilber uses two extremes in this sense. When all the attention is drawn to the external quadrants in favor of the internal quadrants we come into a ‘flatland situation’. When the opposite is down, only attention for the internal quadrants in favor of the external, we come into a ‘wonderland situation’. Both, internal and external, are necessary in the right balance. Barrett (2006) mentions this balance in four kinds of alignments which must be consistent. First the personal alignment on individual level between personality (internal) and character (external). This alignment refers to an individual’s values and beliefs with his or her action and behaviors. Barrett calls this authenticity. Secondly the (internal) values alignment between individual and collective. This alignment refers to an individual’s values and beliefs and the group values and beliefs. This will influence the group cohesion and may be important for collective action. Third the (external) mission alignment between individual and collective. This alignment refers to an individual’s sense of purpose or mission with the group or organization stated purpose or mission. This will also influence group cohesion and directs collective action. The fourth kind of alignment is structural on collective level between culture (internal) and social structures (external). This alignment refers to the collective group values and beliefs and their actions and behavior as codified in collective rules, laws, procedures and structures of governance. Barrett calls this integrity.

#### 4. Methods in the diagnosis phase

In the period September and October 2008 in total 27 interviews and 1 workshop were done. The focus in the interviews was different but were synchronized finally in the overall advise to the management team of the MRO Department. The interviews had on one hand focus on functional requirements and impact analysis regarding the new ICT system and on the other hand focus on organizational, change and the ‘mental implementation’. Also 4 interviews were done in which generic aspects regarding the change were discussed. With these interviews across the department we were able to collect some ‘stories’ of the employees and their perception on the change project. The workshop on September 4<sup>th</sup> 2008 was a first meeting organized with the management team of the MRO Department and the Project Managers for the Business and ICT implementation. The goal of this meeting was to make a first ‘picture’ of the different ‘power settings’ regarding the project. With this information the consultants started semi structured interviews throughout the MRO Department. These interviews were transcribed by the interviewee and corrected when necessary by the interviewed. The Factor 4 Index (F4I) [10] online questionnaire which was used has a similar background as the four quadrants model. The four quadrants are labeled slightly different; *Inspiration* covers the individual- internal quadrant. *Organization* covers the individual – external quadrant. *Culture* covers the collective – internal quadrant and *Technology* covers the collective – external quadrants. In every quadrant 4 categories are recognized and with every category four questions go along.

The respondents were asked to give a score (scale 0 to 10) for 64 questions in the Dutch language. For each question they had to give a score for the current (IST situation) and the desired (SOLL situation). The ‘gap’ between

IST and SOLL was assumed a ‘mismatch’ and therefore a ground for change as perceived by the respondents. Between October 3<sup>rd</sup> and October 15<sup>th</sup>, 2008 in total 213 participants were invited to fill in the standard questionnaire. After two weeks a response of 52% (126) was established. Table 2 shows the participation and Table 3 the age, education, years working for the employer and year in current function of the responders.

**Table 2. Participation**

	<b>Freq</b>	<b>%</b>	<b>Valid %</b>
<i>n</i>	126	59.2	59.2
<i>missing</i>	84	40.8	40.8
<b>Total</b>	<b>213</b>	<b>100</b>	<b>100</b>
<i>Male</i>	124	98.4	98.4
<i>Female</i>	2	1.6	1.6

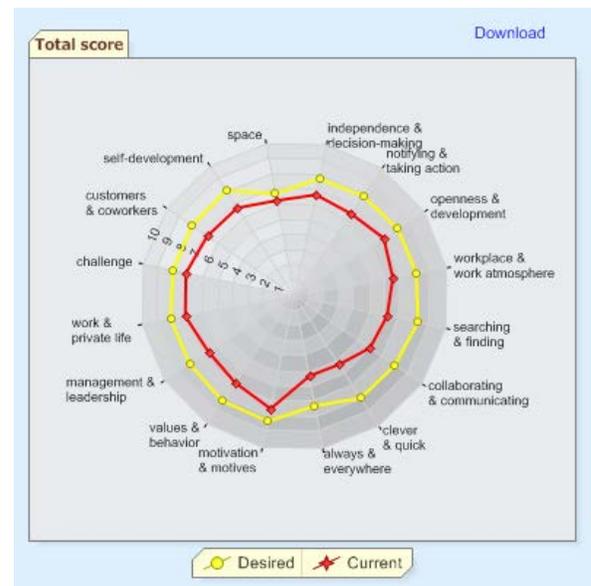
**Table 3. Background responders**

<b>Responders</b>	<b>Freq</b>	<b>Valid %</b>
<i>Age</i>		
< 25 years	15	11.9
26 – 35 years	33	26.2
36 – 45 years	34	27.0
46 – 55 years	25	19.8
> 55 years	19	15.1
<i>Education</i>		
University	4	3.2
University of applied science	45	35.7
High / secondary school	77	61.1
<i>Years with employer</i>		
< 2 years	25	19.8
2 – 5 years	20	15.9
6 – 10 years	20	15.9
> 10 years	61	48.4
<i>Years in function</i>		
< 2 years	49	38.9
2 – 5 years	24	19.0
6 – 10 years	26	20.6
> 10 years	27	21.5

**5. Results after diagnosis**

The results of the Factor4Index questionnaire were discussed on November 21<sup>st</sup> of 2008 in a workshop in which the management team of the

MRO Department and a cross departmental representation of employees was present. The main findings were; 1) a gap between current and desired scores on aspects regarding the Technology (e.g. information systems) used. Specific findings concerns the availability of information (seeking & finding, always & everywhere, smart & quick) but also the communication and the perception on cooperative working relations. 2) a gap between current and desired scores on aspects regarding the Culture. Specific findings concerns management & leadership and values & behavior. Figure 3 shows the average IST scores (red line) and the desired SOLL scores (yellow line). The greater the distance between those lines the more there is a climate and reason for change.



**Figure 3 Overview results F4I (2008)**

The results of both the interviews and the questionnaire were discussed on October 16<sup>th</sup> of 2008 for the management team of the MRO Department, the project leaders of the MISTRAL project and managers of staff departments like HR, Finance and Safety, Health and Environment. Based on the above mentioned interviews and the results of the F4I a

advise was given for the implementation of the new ICT system within the MRO Department. First the reactions of end users (*a receiver perspective*); “we do not know everything yet. There is a lot that can be improved but we also find it difficult to start with the training and after that work with the new system”. Second the reactions of super users and project members (*a sender perspective*); “we are enthusiastic and involved. But we also see that there is missing a long term vision. At this moment the possibilities of the new ICT system are not fully used. We do not know if this will happen in the future. Will we go on developing the system and really make improvements? We also find it difficult to give training on the system to our direct colleagues”. The third reactions were from the management team (*a sender perspective*); “we stand behind the implementation of the new system and the changes that ought to come along with that. We explicitly do not have a long term vision because that could give resistance towards the change process. We also want that the work is not getting more difficult for the employees or that it takes more time to administrate things”. The reactions as described can be divided in formal and informal reactions. The formal reactions were clearly outspoken in meetings but the informal reactions came to the surface during lunch time and coffee breaks.

The vision on the change process can be stated into two clearly divided directions.

1. It is basically a functional change and people have to learn to work with the new system.
2. The implementation of the new ICT system could be a perfect enabler for a organizational and behavioral change in the long term.

## **6. Advise for physical and mental implementation**

The advise after the diagnosis phase had to be practical but also had to establish a change in

attitude for the engineers. In this respect we used the diagnosis model en developed a program of ‘blended learning’. This consisted out of learning in a class room trained by colleagues on live cases out of the daily practice. The focus was on systems functionalities that would be needed in 80% of the practical working situation. Difficult and work situation that would be incidental (20%) would be trained on the job when they occur by the super users). After implementation there would be a permanent back up trainer for every ‘group’ in the organization (Maintenance, Engineering and Purchasing & Logistics). Due to the shifts this had to be arranged during daytime, in the evenings and even at nighttime. The role of the Management Team was to tell clearly during every training the consequences of the new system on the work processes and the shift in tasks. Especially the Maintenance Engineers in the hangar would get a direct registration function in the system instead of filling in the paperwork what than would be put into the system by collogues at the office. This quite ‘simple’ change in work content was considered a huge problem because now the engineers had to do administration as well and it had to be precise because they entered the data directly in the new system. Another aspect was that the systems follows a strict workflow which could not be passed by. In the ‘old days’ this was no problem, it was just paper work! These aspects should be discussed very clearly during the training and there would be also no ‘way around’. Before implementation in February 2009 the focus was on functional learning and creating a shift in attitude. After implementation the learning was continued on the shop floor and during daily operations. The new system was from that moment on providing management information and process parameters which were used as new input for learning to work according the new workflow. In the next two years after

implementation the system and work process would be improved.

## 7. The learning phase

The actual education program was organized in two steps. First, in December 2008, a preparation phase in which the training material and presentations were made according the training goals to be reached. Secondly, in January 2009, the actual training classes. In total 35 training classes were organized. The classes were scheduled in day time (07:00 – 15:30) and in the evening (15:00 – 23:30) so employees could follow the training in their regular planned shift. In total 256 persons followed the training classes. This number is higher than the total number of employees working in the MRO Department because several employees had to follow two or more different training classes because of their function and particular role. The preparation of the training material and presentations was done by the super users based on four different learning goals; 1) employees learn to work with the basic functionalities of the system, 2) employees learn in depth the routine functionalities for their specific department, 3) employees learn the whole work process so they can understand the relations in the workflow and the consequences of their dependencies with other departments and 4) employees discuss about the long term perspective as given by the MT in relation with their work and tasks. The first two goals can be found within the external individual and collective quadrants of the integral diagnosis model while the third and fourth goal are within the internal individual and collective quadrants.

During the preparation the super user group worked intensively together in their project room. They followed structured guidelines for setting up the training materials. The main steps in setting up this material were; 1) a general script for the training, 2) develop practical cases

with detailed work instruction slightly moving to practical cases with global work instructions for the system, 3) make a presentation to guide the training session and 4) copy all materials for actual use during the training. In this preparation the super users discussed together to complete workflow of the system and had several rounds in which they used a practical case to test the workflow and the actual outcomes. The preparation of training material was quite new for most of the technicians. To work in this way actually learned them to think about the most important practical cases (80% of the functionality) and not just focus on the incidents what they mostly used to do. During the preparation also some super users clearly told that they were afraid of giving a training for their sometimes very critical colleagues. They were afraid of resistance or a lack of interest or perhaps uncontrolled discussions and so on. The consultancy firm proposed to organize a didactical training day for the super users and learn them to cope with some of the most common issues that could appear during a training session. On top of this it was agreed that during the actual training a process advisor of the consultancy firm would attend the session and could interfere or help the super user / trainer when he was not able to handle the situation. Both the didactical training and the back up of an external consultant gave such a confidence and feeling of togetherness that most of the training sessions were very successful.

## 8. Measurement one year after implementation of TRAX

On November 23<sup>rd</sup> 2009 the same Factor 4 Index online questionnaire was used to measure the effect of the change process. This time the employees were having 3 weeks (until December 11<sup>th</sup> 2009) time for answering the questionnaire. A response of 56.8 % (121 out of 213 participants) is established within 3 weeks. The tables below show the participation and the

age, education, years working for the employer and year in current function of the responders.

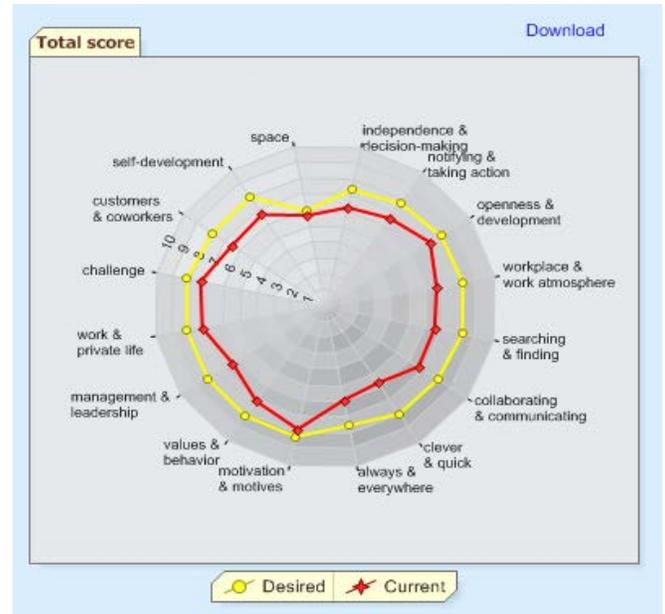
**Table 4. Participation**

	Freq	%	Valid %
<i>n</i>	121	56.8	56.8
<i>missing</i>	92	43.2	43.2
<b>Total</b>	<b>213</b>	<b>100</b>	<b>100</b>
<i>Male</i>	119	98.3	98.3
<i>Female</i>	2	1.7	1.7

**Table 5. Background responders**

Responders	Freq	Valid %
<i>Age</i>		
< 25 years	7	5.7
26 – 35 years	39	32.2
36 – 45 years	33	27.4
46 – 55 years	29	23.9
> 55 years	13	10.8
<i>Education</i>		
University	3	2.5
University of applied science	50	41.3
High / secondary school	68	56.2
<i>Years with employer</i>		
< 2 years	10	8.3
2 – 5 years	24	19.8
6 – 10 years	23	19.0
> 10 years	64	52.9
<i>Years in function</i>		
< 2 years	30	24.8
2 – 5 years	40	33.0
6 – 10 years	24	19.8
> 10 years	27	22.4

This second questionnaire shows again the perceived gap between the current (IST situation) and the desired (SOLL situation). But now this ‘gap’ must be seen nearly one year after the implementation of TRAX. Figure 4 shows an overview of the second Factor 4 Index questionnaire.



**Figure 4. Overview results F4I (2009)**

The main findings after this second questionnaire were the gaps between IST and SOLL situation for 1) the Technology quadrant (left below) in three categories (seeking & finding, always & everywhere, smart & quick). These are exactly the same categories which were found in the first online questionnaire and which was expected to improve (e.g. a smaller gap) after the implementation of TRAX. When we take a closer look at the scores on these categories we find some improvement. The Factor 4 Index calculates a ‘index’ number which is calculated by the formula (Desired Score - Current Score) \* Desired Score. The index can be positive (Desired > Current) and negative (Desired < Current). The higher the index, the bigger the ‘gap’ will be and the more there is the assumption that improvements must be made because employees are not completely satisfied with the current situation. When we just focus on the Technology quadrant and the four categories in this we see improvement on all the four categories (see Table 6).

**Table 6. F4 Index scores for Technology**

Quadrant Technology - Category	F4I 2008	F4I 2009
Searching & Finding	17	13
Clever & Quick	20	18
Allways & Everywhere	14	12
Collaborating & Communicating	15	11

In general we can see that after a period of nearly one year there is some improvement and the effect of the change process (implementing TRAX) is positive (e.g. smaller index scores). The biggest improvement shown here is the collaboration and communication between employees. This might be a side effect of the change and learning process in which especially the super user group got more connected with each other when preparing the training materials, executing the test sessions and after implementation still working together for realizing improvements in TRAX.

Beside this improvement mentioned above and only based on the index scores we also performed a paired T-test to find if there was a significant improvement. When we compared the current scores of 2008 with the current scores of 2009 (correlation .788) in the four categories (16 questions answered by all respondents) we found a Sig. (2-tailed) of .002 which is a significant improvement. We also compared the current scores of 2008 and 2009 (correlation .808) within all the 16 categories (64 questions answered by all respondents). This gave a Sig. (2-tailed) of .083 which is not a significant improvement. Table 7.1 to 7.3 show the output data as calculated in SPSS (version 17.0) related to the Technology quadrant.

**Table 7.1 Paired Samples Statistics**

Pair	Mean	N	StdDev	SEM
2008	5.656	16	.6831	.1708
2009	6.131	16	.8097	.2024

**Table 7.2 Paired Samples Test**

Paired Differences Current 2008 – current 2009				
				95% Confidence interval of the Difference
Mean	StdDev	SEM	Lower	Upper
-.4750	.5000	.1250	-.7414	-.2086

**Table 7.3 Paired Samples Significance**

Pair	t	Df	Sig. (2-tailed)
Current 2008/2009	-3,800	15	.002

The tables 8.1 to 8.3 show the output data related to all the four quadrants (e.g. 16 categories and 64 questions) and answered by all respondents.

**Table 8.1 Paired Samples Statistics**

Pair	Mean	N	StdDev	SEM
2008	6.519	64	.8252	.1031
2009	6.633	64	.8422	.1053

**Table 8.2 Paired Samples Test**

Paired Differences Current 2008 – current 2009				
				95% Confidence interval of the Difference
Mean	StdDev	SEM	Lower	Upper
-.1141	.5173	.0647	-.2433	-.0151

**Table 8.3 Paired Samples Significance**

Pair	t	Df	Sig. (2-tailed)
Current 2008/2009	-1.764	63	.083

## 9. Findings

What became clear during the sessions was the understanding of cross functional activities and the consequences of certain steps in the

whole process. This gave the super user group better understanding of the system and how to explain it later on in the training for their colleagues. What became also obvious was the kind of discussion that was going on in the group. Although the super users had been working together for quite a long time discussions always went in different directions. The super users were not able to discuss in a structured manner. The subjects changed frequently and it was very difficult to make decisions as a group. Most issues were put on a list and finally were addressed to management for taking the final decision. One other finding is the trustful relation between the management of the MRO department and the super users. In this case the management was quite at distance. They were involved and chaired the steering committee. But despite of their formal position they delegated the responsibility to the project team and the super users. In this project the management was waiting expectantly or in other words were watchfully anticipating (Seel, 2003) [11] but only interfering with the change process when asked or needed. Finally the results of both the questionnaires show some improvement in the four categories within the Technology quadrant especially in the category ‘collaborating & communicating’.

But when taking a closer look at these Index scores we also see that the improvement in the Technology quadrant is significant. So, the conclusion can be that the implementation of the TRAX application is successful. When we relate this to the AQAL model (figure 2) the focus is on the external – collective quadrant. As Barrett (2006) mentions, sustainable change must affect all four quadrants. The paired T-test which included all 16 categories (e.g. all four quadrants) does not give a significant improvement. So this might indicate that finally nothing actually changed. The organization has ‘just changed’ there ‘old’ IT system for

Maintenance Repair and Overhaul into the TRAX system.

## 10. Conclusions

This change process was first started as a technology project in which an old MRO system must be ‘replaced’ by a new MRO system. Most change projects are driven by some kind of ‘technology push’. Most change interventions are then focusing on the right side quadrants of the AQAL model. In the lower right quadrants there are interventions related to process redesign, other working structures and procedures. The migration of the software and database is a highly structured and organized way of working. In the upper right quadrant we see interventions like training and learning to cope with other skills or behavior as requested in the new situation. But on the left side of the AQAL model much less interventions are planned and organized. This is the ‘fuzzy logic’ of culture (lower left quadrant) and personal believes (upper left quadrant). Just because of the feelings of the management that perhaps ‘something more’ was needed to achieve acceptance and realize the ‘mental implementation’ the change project also paid attention to these aspects. This leads us to conclusions that first the diagnosis model (based on the AQAL model) can be a good conceptual framework to look at change processes in an integral way and discuss the interventions that need to be done. Second that within a technical environment (e.g. the MRO department of a low cost carrier) it is possible and necessary to plan and organize interventions in a structured manner by guiding and facilitating the technicians but not by telling them what to do. Creating a safe environment for them to work on the change process is more important than exactly telling them what to do. The third conclusion is that management of the MRO department made it possible to create trust in their employees and was watchful anticipating.

They hold track on the progress by clearly addressing the ‘playground’ (but not how to play) and make decisions when asked by the members of the project. The fourth point we want to state is that it is very important during the change process to create a setting in which ‘many voices’ are heard and employees of different departments and on different levels can sit together and discuss the issues rising during a system implementation project (Homan, 2005). The process of ‘understanding’ each other, although working within the same company but on different departments, can be something that is of great influence on the change result. Finally we conclude that the implementation of TRAX has been successful and realized a significant improvement. Relating it to the four quadrants there is no significant improvement. This might indicate that we cannot conclude this change process leads to sustainable changes in the Technical Department

## 11. Acknowledgements

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## Multi-Generational Descriptions and Marketing

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### Abstract

Multi-generational marketing is the practice of appealing to the unique needs of individuals within more than one specific generational group, with a generation being a group of individuals born and living about the same time [1]. Multi-generational marketing is based on two founding principles: (1) product needs change with life stages and (2) promotional messages and products targeting these generational groups or cohorts can reflect their generational values which in turn can drive their consumption behavior. As such, an understanding of multi-generational marketing is a very important marketing activity. [2, 3].

The purpose of this paper is to describe the various U.S. generations including the times in which they grew up as well as the characteristics, lifestyles, and attitudes of the group. The paper will conclude with general and specific tips for multi-generational marketing.

### The U.S. Generations

A U.S. generation or age cohort is a group of persons who travel through life together and experience similar events at a similar age. That is, they share a common social, political, historical, and economic environment.

An examination of written materials regarding the U.S. generations indicates that there are six American generations: Pre-Depression, Depression, Baby Boom, Generation X, Generation Y, and Generation Z. [4, 5, 6, 7, 8] Table 1 lists information specific to each of these generations, i.e., date of birth,

number of individuals, and age as of 2009. Each of these generations is described in detail below with regard to the times in which they grew up and to their characteristics, lifestyles, and attitudes.

Pre-Depression Generation. The Pre-Depression Generation was born before 1930 and are 80 and above as of 2009. Most were children during the Depression experiencing traumatic times, economic strife, and elevated unemployment rates. As young adults during WWII, their lives began with high expectations, which were shattered eventually by WWI and WWII. The Pre-Depression Generation has witnessed radical social and technological changes including glistening new schools, miracle medicines, and launched rockets. [6, 4] In terms of their characteristics, lifestyles, and attitudes, members of the Pre-Depression Generation are conservative, altruistic, and become less materialistic as they age. They are concerned about health, aging, financial and personal security, and the disposition of valued belongings. [10, 11, 9, 7, 12, 13]

Depression Generation. The Depression Generation was born during 1930-1945 and are in the 64-79 age range as of 2009. The individuals of this generation were small children during the Depression or WWII. They value rationing, saving, morals, and ethics. They were very patriotic and witnessed America's emergence as a superpower. Social tranquility and family togetherness are important to the Depression Generation. Conformity seems to be the ticket to success. [6, 10, 4] In terms of their characteristics, lifestyles, and attitudes, they rely on tried, true, and tested ways of doing things. Many are still in excellent

health and quite active. [14, 7, 11] Many have substantial wealth in the form of home equity and savings. [9, 5, 15, 13]

**Table 1  
American Generations**

Generation	Date of Birth	Number	Age (2009)
Pre-Depression	Before 1930	12 MM	80 and above
Depression	1930-1945	28 MM	64-79
Baby Boom	1946-1964	80 MM	45-63
Generation X	1965-1976	45 MM	33-44
Generation Y	1977-1994	71 MM	15-32
Generation Z	After 1994	29 MM	Less than 15

Baby Boomers. The Baby Boomers were born during 1946-1964 and are in the 45-63 age range as of 2009. They were born during the dramatic increase of births between the end of WWII and 1964. The Boomers value individualization, self-expression, optimism, and “Be Here Now.” [4, 10] In terms of their characteristics, lifestyles, and attitudes, Boomers have defined themselves by their careers and many are workaholics. [18] Boomers have increased discretionary income and time. [19] Family responsibilities are important to Boomers. [6] This generation is more tech savvy than previous generations. [20] Health, energy, and wellness are major goals for them. [22, 23] As a generation, they are considered more self-centered and suspicious of authority. [16, 5, 17, 15]

Generation X. Generation X was born during 1965-1977 and are in the 33-44 age range as of 2009. They reached adulthood during difficult economic times. These latch-key children grew up quickly, experiencing rising divorce rates and violence. [6, 4, 15] To the

less-traditional X Generation, nothing is permanent. With Generation X, multiculturalism and thinking globally have become the norm. They have experienced the increasing impact of personal computers and produced the 1990’s dot-com stars. The characteristics, lifestyles, and attitudes of Generation X include balancing family, life, and work. [24] They are skeptical and disillusioned with almost everything. They do not believe in sacrificing time, energy, and relationships for advancement like the Boomers did. Xers are free agents, not team players. [5, 25, 26, 27]

Generation Y. Generation Y was born during 1977-1994 and are in the 15-32 age range as of 2009. They are children of the original Baby Boomers and their numbers rival that of the Baby Boomers. They grew up in a time of immense and fast-paced change including virtually full-employment opportunities for women, dual-income households as the standard, wide array of family types seen as normal, significant respect for ethnic and cultural diversity, and computers in the home and schools. They were born into a technological, electronic, and wireless society. [4, 6] The characteristics, lifestyles, and attitudes of Gen Y include older teens and young adults. They are self-absorbed and self-reliant with a strong sense of independence and autonomy. Gen Yers are image-driven and make personal statements with their image. [15] They have a greater need for peer acceptance, connecting with their peers, fitting in, and social networking. [30, 31] Gen Yers are goal oriented and highly motivated toward their perceptions of success. [18, 25, 5, 28, 33, 34]

Generation Z. Generation Z was born after 1994 and are less than 15 years old as of 2009. Generation Z is the newest generation and these individuals are in their early formative years. They face global terrorism, the aftermath of 9/11, school violence, economic uncertainty, recession, and the mortgage crisis. They continue to experience the spread of "tweendom" including commercial exploitation of young girls (and to a lesser extent boys). [35, 36, 4, 6, 37] In terms of characteristics, lifestyles, and attitudes, Generation Z individuals are the new conservatives. They are accustomed to high-tech and multiple

information sources, with messages bombarding them from all sides. [40, 41, 42] Gen Z values authenticity and “realness.” Peer acceptance is very important to Generation Z, they need to belong. [43] They are a global and diverse generation who come from a wider mix of backgrounds with different experiences and ideas. [38, 39] Gen Z values security more than ever. [44, 45]

### **General Tips for Multi-Generational Marketing**

Eight general tips are offered for bringing about more effective and efficient multi-generational marketing [46, 47]. For example, marketers need to understand the backgrounds, morals, values, characteristics, institutions, lifestyle preferences, and priorities of each generation. [49, 50] These different and unique behaviors can be used as the basis for targeted marketing approaches. In addition, one can market to the consistent characteristics among generations. Also, it is important to remember that people cycle in and out of different life-stage events based on their interests rather than their age. [48, 54]

### **Specific Tips for Multi-Generational Marketing**

Marketers may want to consider building relationships with each specific generation represented in their targeted audience or community. For example, each generation has preferred methods of communication and trusted sources of information that the marketer should understand and be using. It is the marketers’ responsibility to know and understand their specific markets. As such, ten specific tips are offered for improving multi-generational marketing. [48, 49, 46, 40, 18, 55, 48]

### **Summary**

Multi-generational marketing is appealing to the unique needs of individuals within more than one specific generational group. Marketers will need to respond to the trend of multi-generational marketing and branding by adjusting their marketing mixes and strategies

accordingly. This means that marketers must understand the six U.S. generations: Pre-Depression Generation, Depression Generation, Baby Boomers, Generation X, Generation Y, and Generation Z. Each of these generations was defined and described in terms of the times in which the generation grew up and the characteristics, lifestyles, and attitudes of each generation. Then, general as well as specific tips were offered for improving the implementation of multi-generational marketing.

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