Experimental study of aircraft wake vortices in ground effect

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Aircraft wake vortices pose a great threat in airport terminal areas, where heavy transport vehicles operate along the same flight paths as lighter aircraft. Flying an aircraft into a vortical wake can cause large changes in altitude and bank angle. These changes in attitude are most dangerous when an aircraft is flying low and slow, either after takeoff or before landing. In addition, vortex strength is proportional to the aircraft weight and inversely proportional to flight speed. Therefore, the strength of the vortices is greatest for heavy aircraft flying at slow speeds. Thus, a good understanding of aircraft wake vortex motion close to the ground is needed. The purpose of this research is to investigate the behavior of aircraft wake vortices near the ground. The experiments are performed in the water tunnel located in the National Institute for Aviation Research (NIAR) on the campus of Wichita State University. In the course of this research, investigations are made of the motion of a pair of counter-rotating vortices, simulating the wake from the two wingtips of an aircraft, and a pair of co-rotating vortices, simulating the wake from the wingtip and the edge of the flap on one side of an airplane. For both vortex pairs, the motion is studied both with and without the presence of the ground plane. A unique data acquisition method is used that allows for quantitative measurement of the temporal and spatial behavior of the wake vortices. The water tunnel measurements taken with counter-rotating vortices are shown to be consistent with Lidar data recorded from actual flights near airports and with numerical models tuned with the Lidar measurements. No experimental or computational data is available for comparison for co-rotating vortex pairs.