

# Aerospace Engineering Master's Defense

## Takeoff Obstacle Clearance Procedures: The Feasibility of Extended Second Segment Climb

School for Engineering of Matter, Transport and Energy

**John Beard**

**Advisor:** Timothy Takahashi

### abstract

To ensure safety is not precluded in the event of an engine failure, the FAA has established climb gradient minimums enforced through Federal Regulations. Furthermore, to ensure aircraft do not accidentally impact an obstacle on takeoff due to insufficient climb performance, standard instrument departure procedures have their own set of climb gradient minimums which are typically more than those set by Federal Regulation. This inconsistency between climb gradient expectations creates an obstacle clearance problem: while the aircraft has enough climb gradient in the engine inoperative condition so that basic flight safety is not precluded, this climb gradient is often not strong enough to overfly real obstacles; this implies that the pilot must abort the takeoff flight path and reverse course back to the departure airport to perform an emergency landing. One solution to this is to reduce the dispatch weight to ensure that the aircraft retains enough climb performance in the engine inoperative condition, but this comes at the cost of reduced per-flight profits.

An alternative solution to this problem is the extended second segment (E2S) climb. Proposed by Bays & Halpin, they found that a C-130H gained additional obstacle clearance performance through this simple operational change. A thorough investigation into this technique was performed to see if this technique can be applied to commercial aviation by using a model A320 and simulating multiple takeoff flight paths in either a calm or constant wind condition. A comparison of takeoff flight profiles against real-world departure procedures shows that the E2S climb technique offers a clear obstacle clearance advantage which a scheduled four-segment flight profile cannot provide.