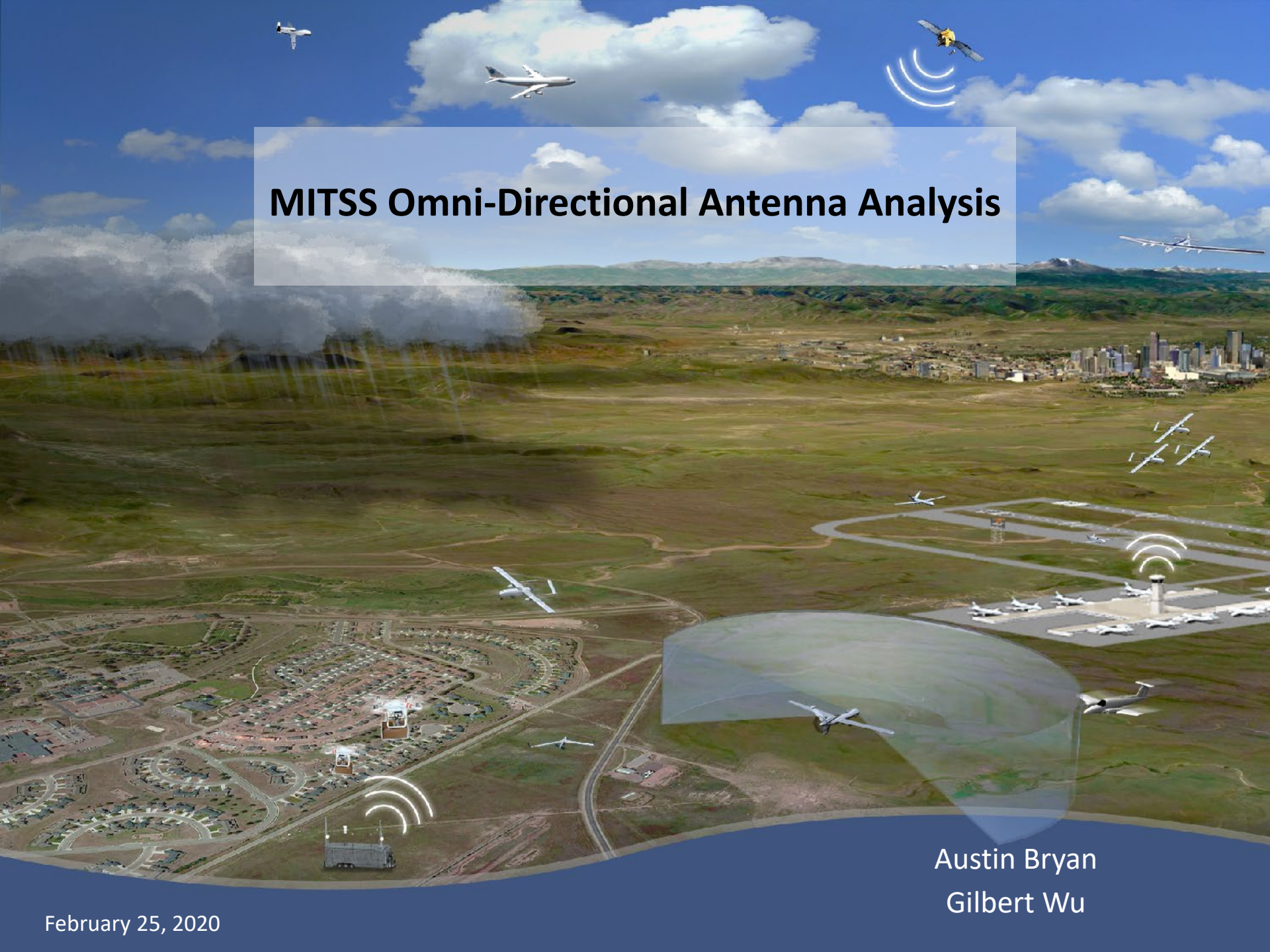


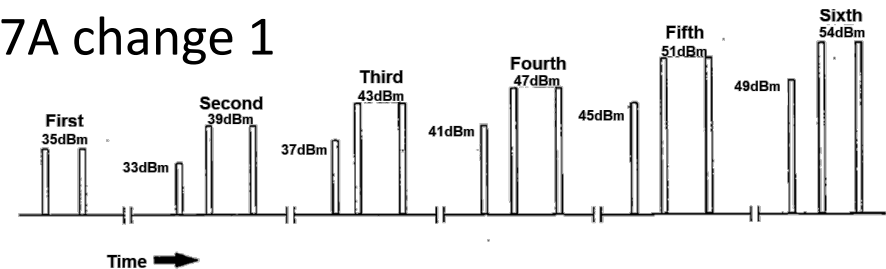
An aerial photograph of a landscape featuring a city, an airport, and various aircraft. In the foreground, there's a residential area with houses and a large antenna structure emitting radio waves. In the middle ground, an airport with several planes is visible. In the background, a city skyline is seen under a blue sky with clouds. Various aircraft are shown in flight, including a satellite in the upper right corner. A semi-transparent blue banner is overlaid on the top part of the image.

MITSS Omni-Directional Antenna Analysis

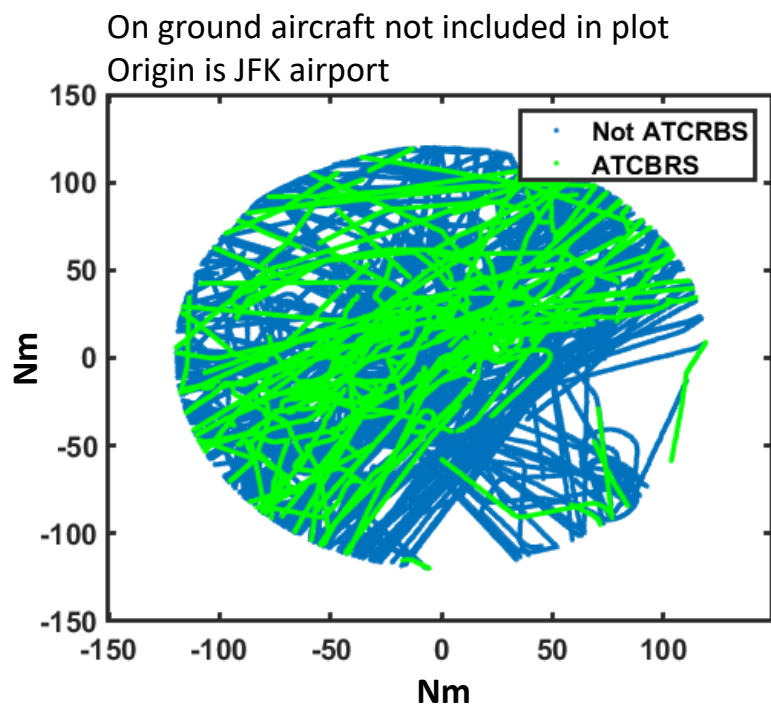
Austin Bryan
Gilbert Wu

February 25, 2020

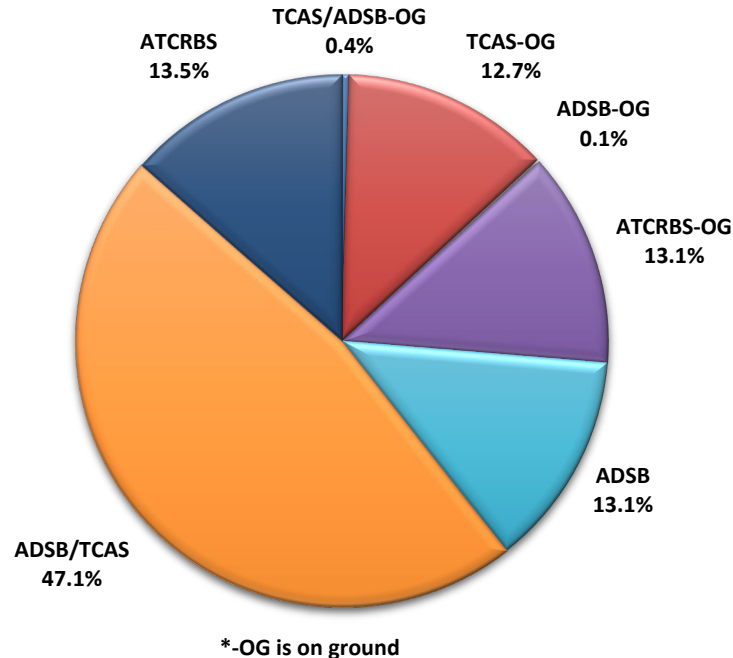
- Goal: Assess effect of omnidirectional TCAS antenna on spectrum environment and ownship Mode S and Mode C surveillance range
- MIT Surveillance Simulation (MITSS)
 - Used to inform DO-300A hybrid surveillance requirements
- Change equipage of existing aircraft in track data to Omni antennas
- Level 6 Whisper-shout from DO-197A change 1
 - DO-197A is TCAS I MOPS
- DO-185B Interference limiting



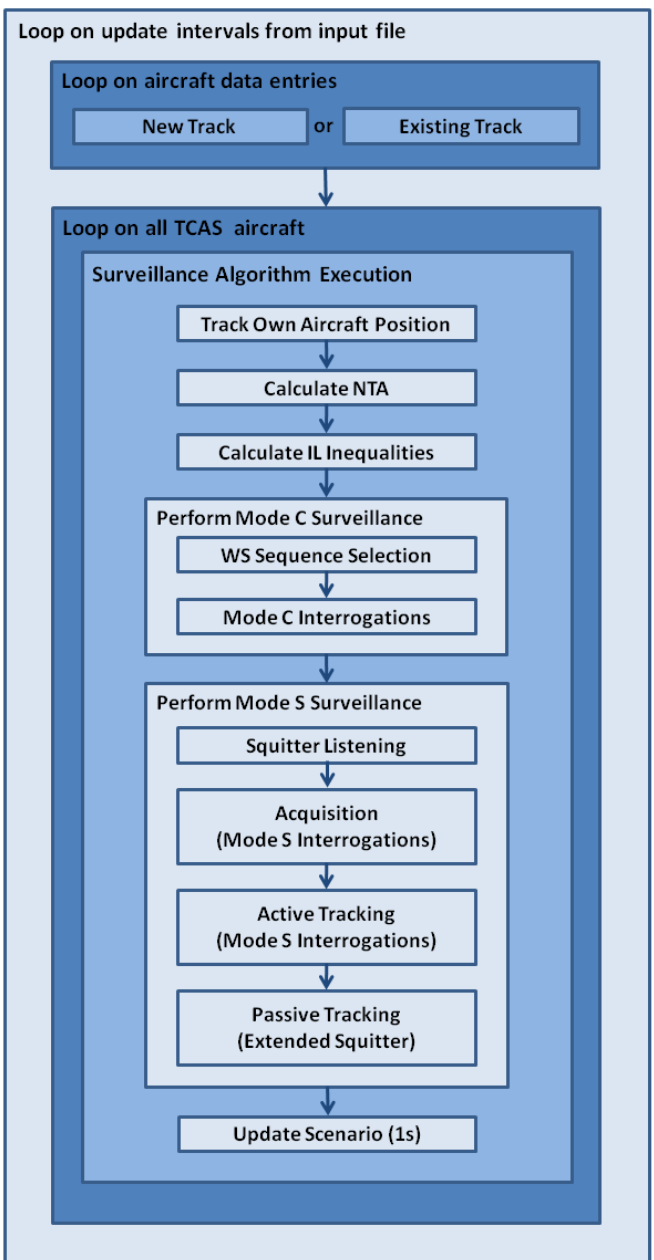
- Input file: Radar tracks centered at JFK from Sunday, November 29, 2009 between 17:00 and 18:00 EST because it was identified as worst case traffic density
 - Tracks taken from RADES and TRAMS and combined
 - Additional on ground aircraft added



Equipage



RADES Data
&
TRAMS Data



Outputs:

Transponder Utilization %
Surveillance Range
Interrogation/Reply Rates

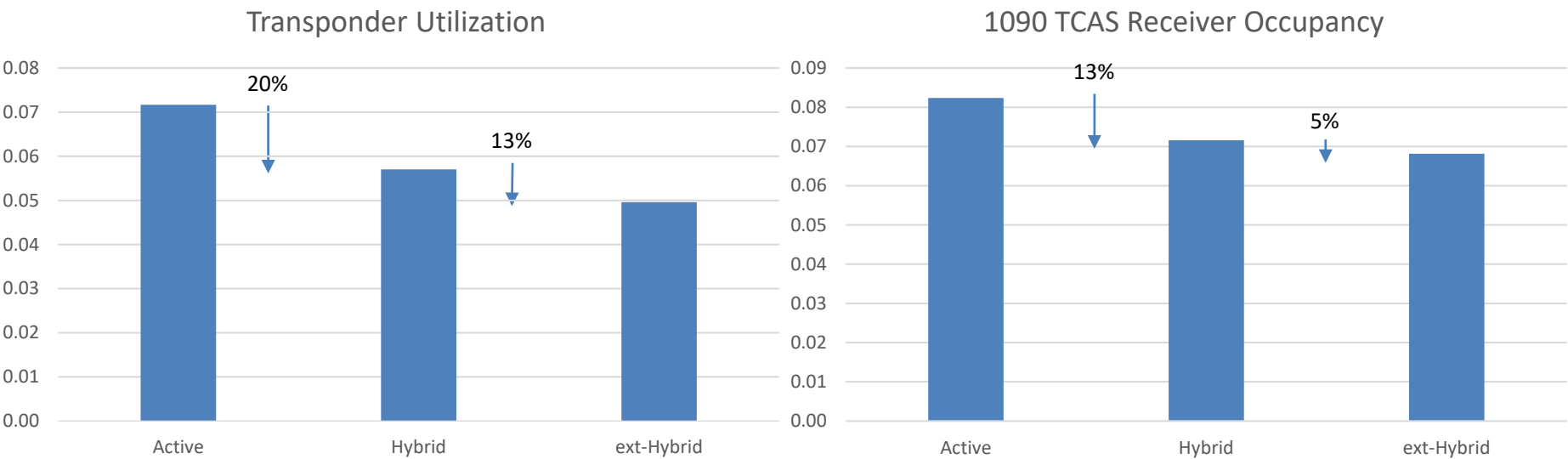
- Metrics are averaged over all TCAS equipped aircraft less than 30nm from JFK sensor
- Transponder Utilization
 - Percentage of time transponder is in use
 - Affected by the following
 - Sent long and short replies
 - Received Whisper Shout interrogations that cause suppression
 - Received Mode S interrogations that require a reply
 - Received Mode S interrogations that cause suppression
- TCAS receiver occupancy
 - Percentage of time receiver is in use
 - Affected by the following
 - Sent and heard long and short replies (1090)
- Reliable Surveillance Range (nmi)



Results: Comparison between Active only, Hybrid, and extended Hybrid Surveillance



- Goal: assess the effect of running only active surveillance against hybrid surveillance, and extended hybrid surveillance when equipped with a top and a bottom omni antenna
- No significant change in Reliable Surveillance Range

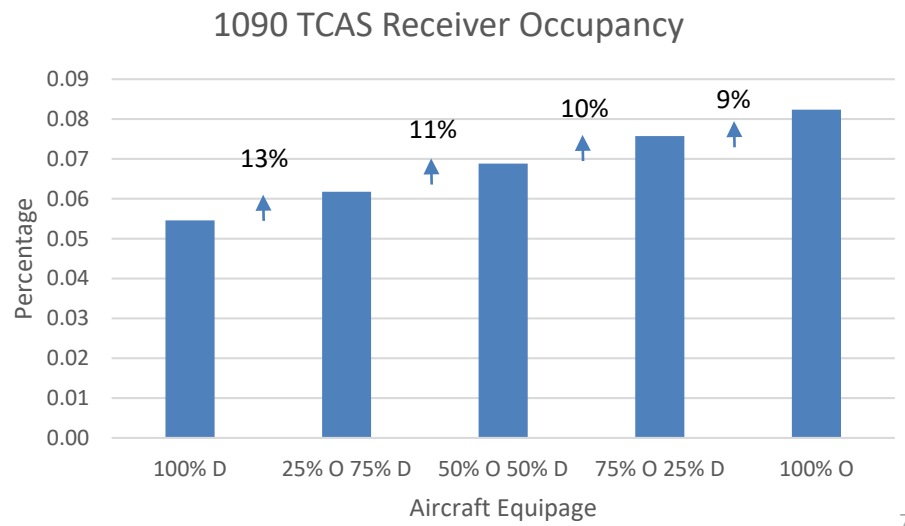
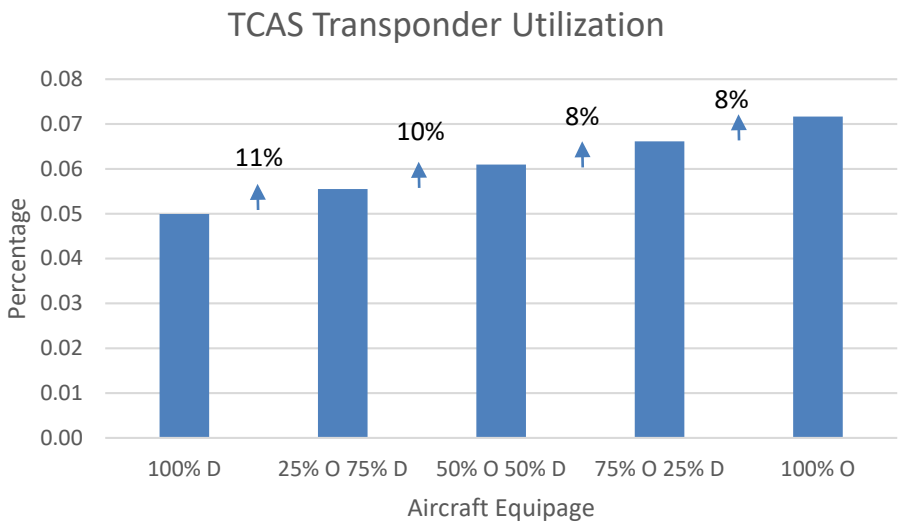




Results: Different Aircraft Equipage Percentages Active surveillance



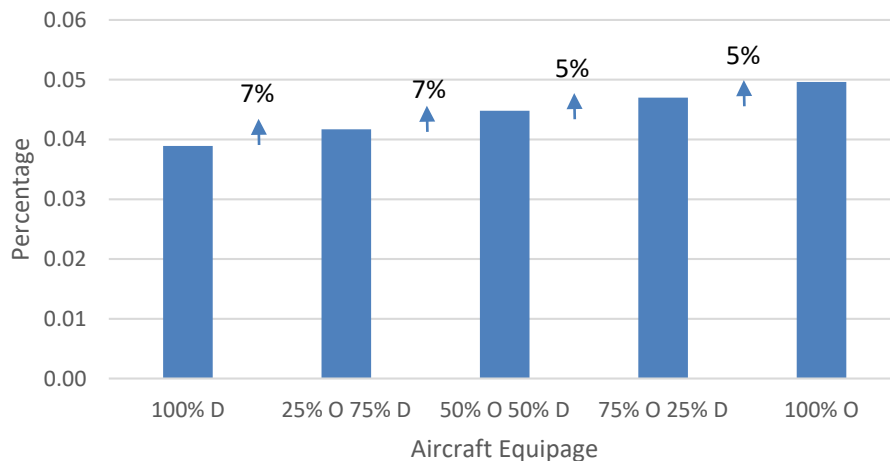
- Goal: assess the effect of different percentages of aircraft equipping with omnidirectional antenna using only active surveillance
- %O is the percentage of all the aircraft assigned Top omni antenna and Bottom omni antenna
- %D is the percentage of all the aircraft assigned Top directional antenna and Bottom omni antenna



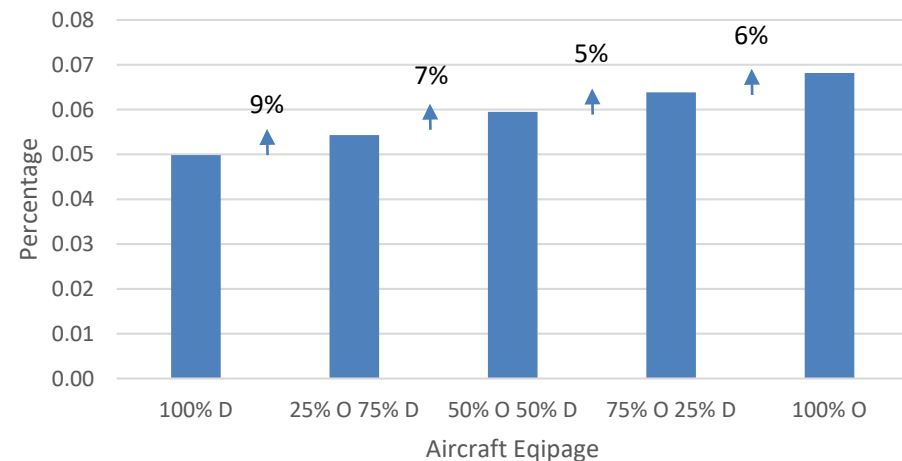


- Goal: assess the effect of different percentages of aircraft equipping with omnidirectional antenna while utilizing extended Hybrid Surveillance.
- No significant change in Reliable Surveillance Range

TCAS Transponder Utilization

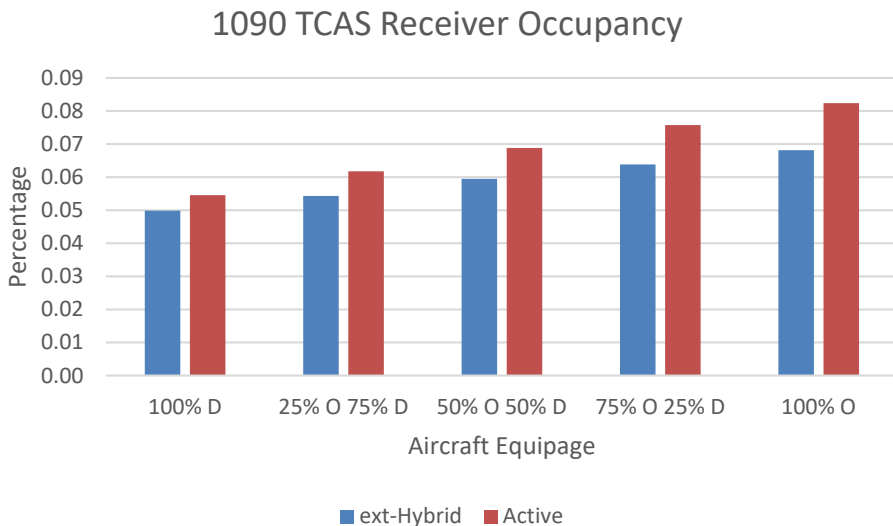
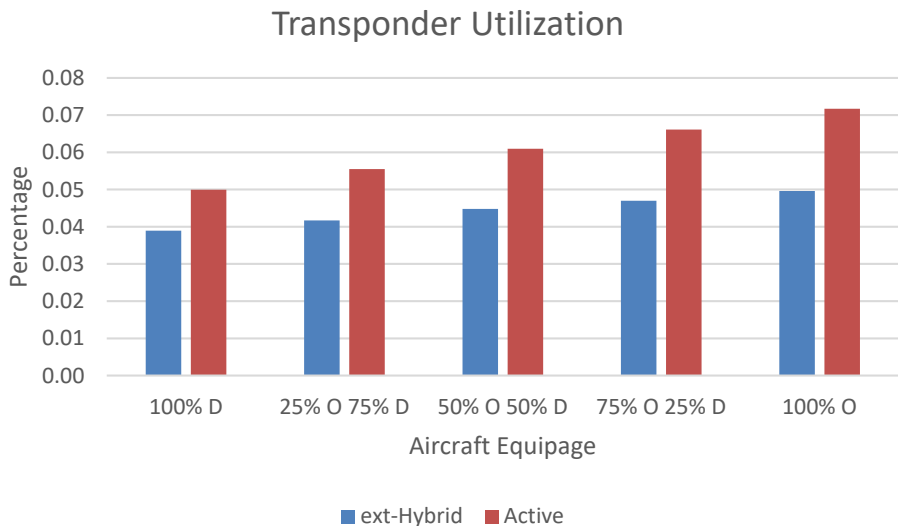


1090 TCAS Receiver Occupancy



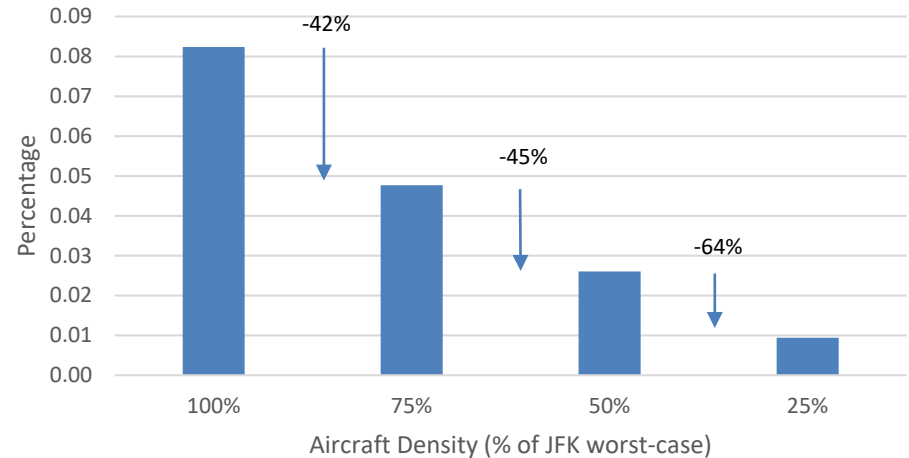


- Blue bars represent the runs with extended hybrid surveillance enabled
- Red Bars represent data using only active surveillance
- No significant change in Reliable Surveillance Range
- Omni antennas running extended hybrid surveillance is roughly equivalent to Directional antennas running just active surveillance in terms of transponder utilization

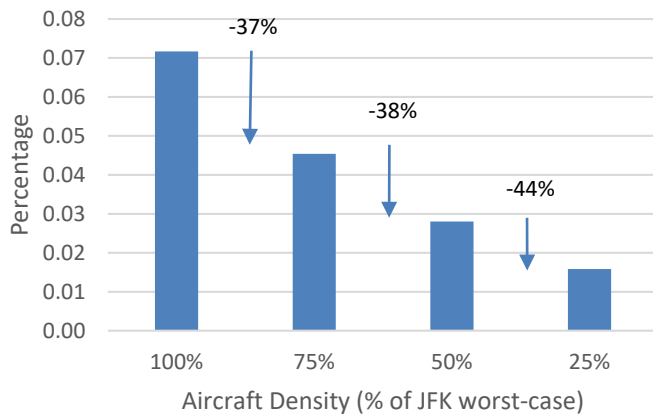


- Goal: assess omni-antenna performance in less dense airspace environments using active surveillance
- All aircraft have a Top Omni antenna and a Bottom Omni antenna
- A random selection of aircraft were removed from the JFK airspace.
 - E.g., 25% means 75% of the aircraft have been removed

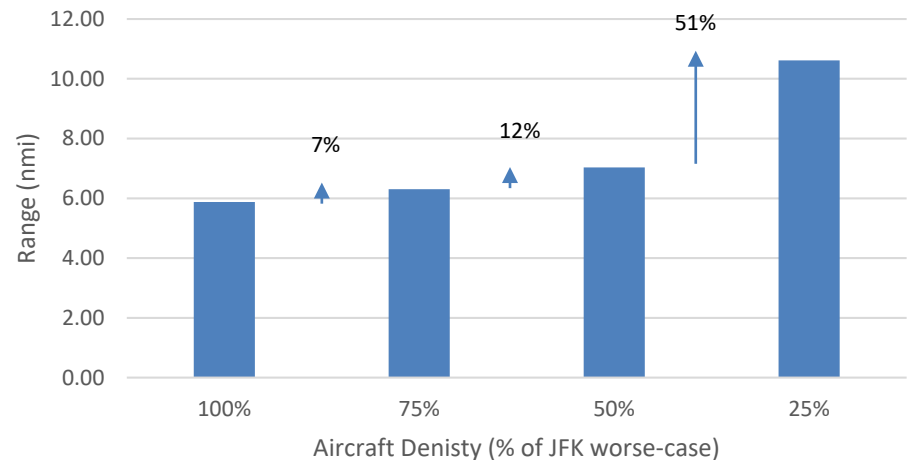
1090 TCAS receiver occupancy



TCAS Transponder Utilization

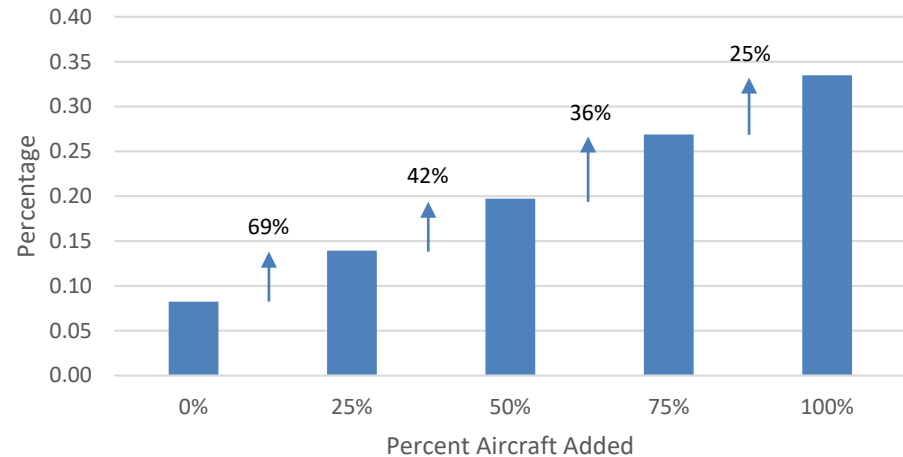


Reliable Surveillance Range

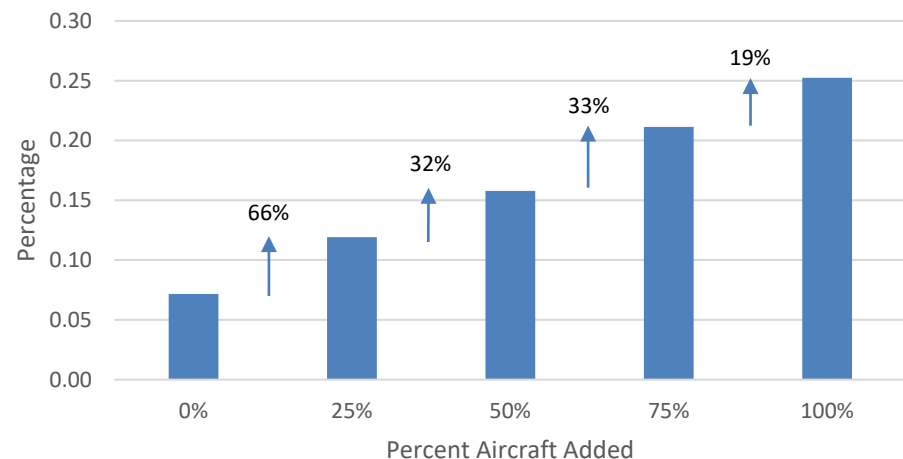


- Goal: assess omni-antenna performance in more dense airspace environments using active surveillance
- All aircraft have a Top Omni antenna and a Bottom Omni antenna
- A random selection of aircraft were added to the JFK airspace.
 - E.g., 100% means twice the number of aircraft in the original JFK dataset are simulated
- Reliable Surveillance range remained around 5.9nmi for all cases
 - Likely due to already being maximally limited

1090 TCAS Receiver Occupancy



TCAS Transponder Utilization





- New degarbling methods
- New Whisper Shout sequences
- Reduce update rate