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Denver Evaluation of Pulsed and Continuous Wave Lidar

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Introduction

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- In Fall of 2003 a wake vortex measurement campaign took place including SOCRATES, 2 phased microphone arrays, a continuous-wave lidar, and a pulsed lidar.
- Presence of two lidars, measuring the same area, allows a study to check the quality of lidar wake tracking and quantify track performance.
- 249 cases are available in which both lidars were operating and provided tracks, including a variety of aircraft:

50 Airbus 319

29 Boeing 757-200

36 Airbus 320

12 Boeing 767 (mostly -300)

67 Boeing 737 (several series)

16 MD-80 (several series)

12 regional jets (various manufacturers)

Heaviest: Boeing 777-200

Lightest: Fairchild Metroliner SW4



Previous Work

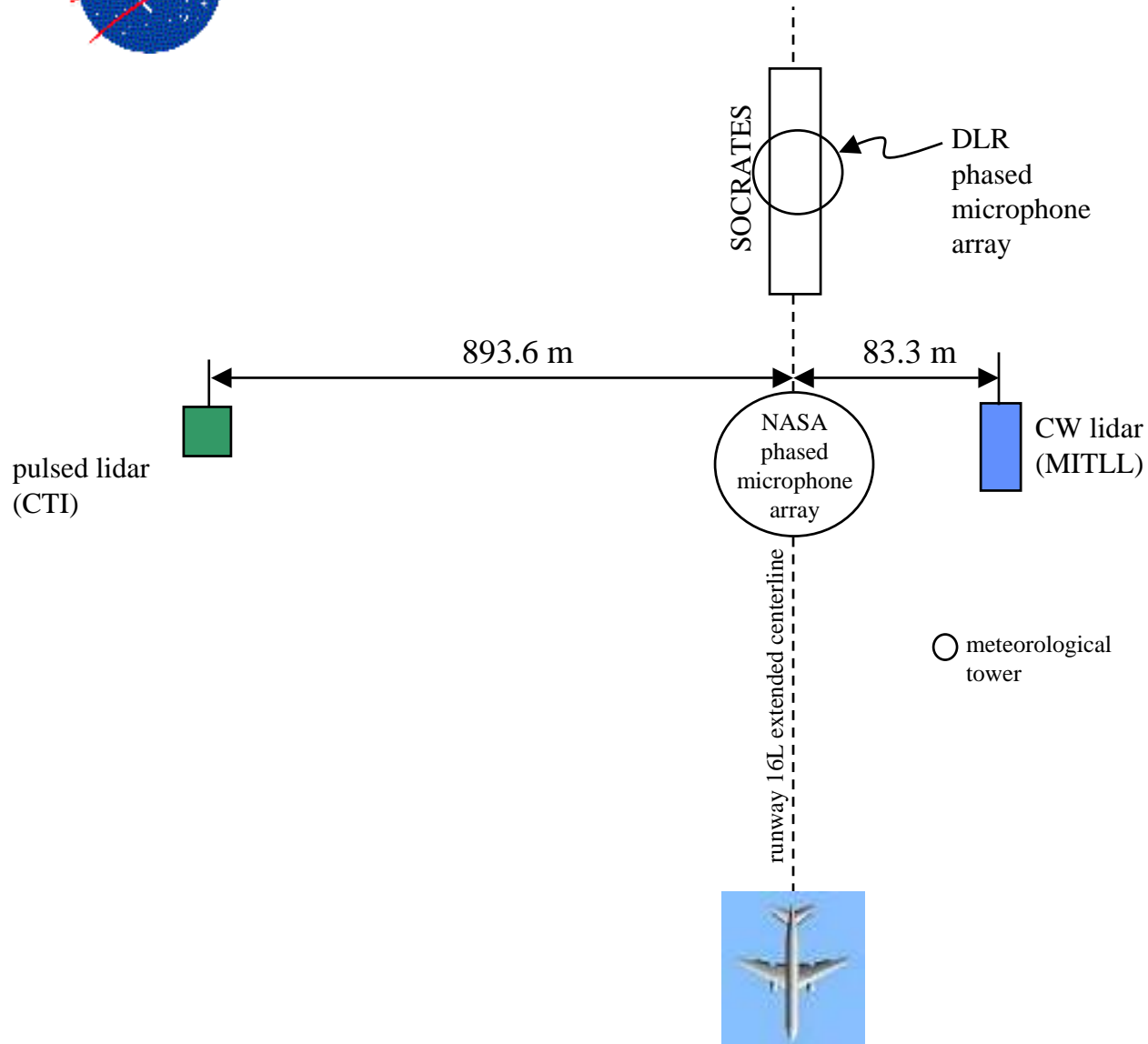
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- NASA Aircraft Vortex Spacing System (AVOSS) Project made pulsed lidar/CW lidar/windline comparison at JFK in Spring 1997.
 - Aircraft altitude approximately 55 m.
 - 27 aircraft cases.
 - Pulsed lidar processing algorithms relatively immature.
 - Standard deviation of vertical tracks about 20% of mean.
 - Lateral tracks: “. . . most cases the data provided by each sensor were within the aircraft’s wingspan.”
 - Wide range of values of circulation.
- DLR/ONERA/Qinetiq C-Wake Project made dual CW lidar and pulsed lidar comparison at Tarbes in 2002
 - Aircraft altitude approximately 283 m.
 - Multiple CW lidars used to enhance tracking capability.
 - Results soon to be published (Journal of Aircraft)?



Test Layout

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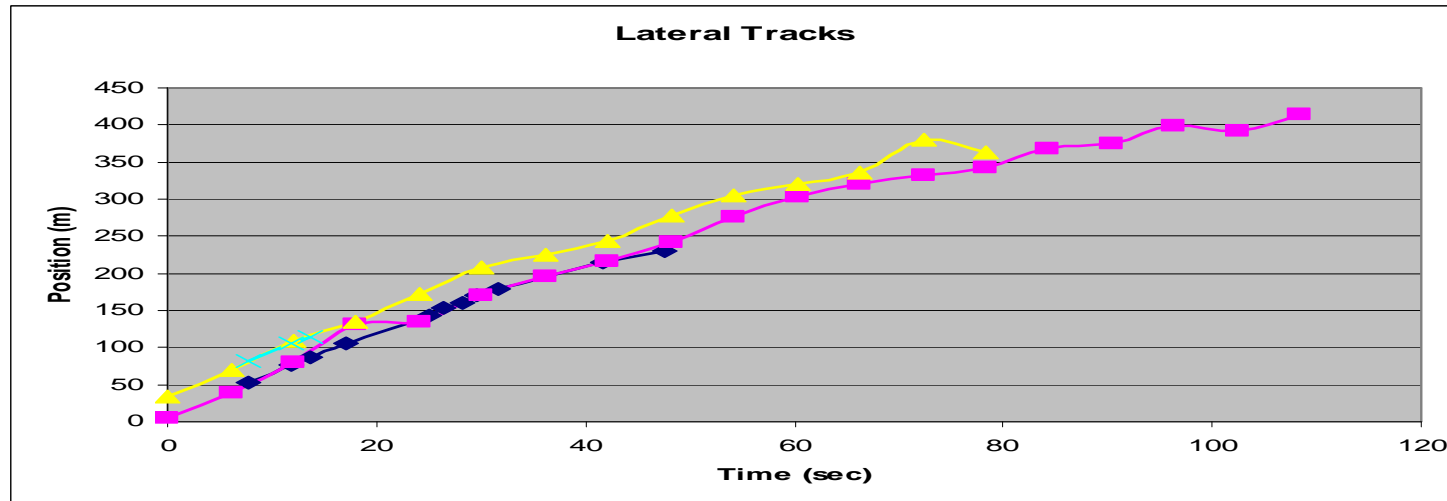
aircraft altitude
approximately 213 m



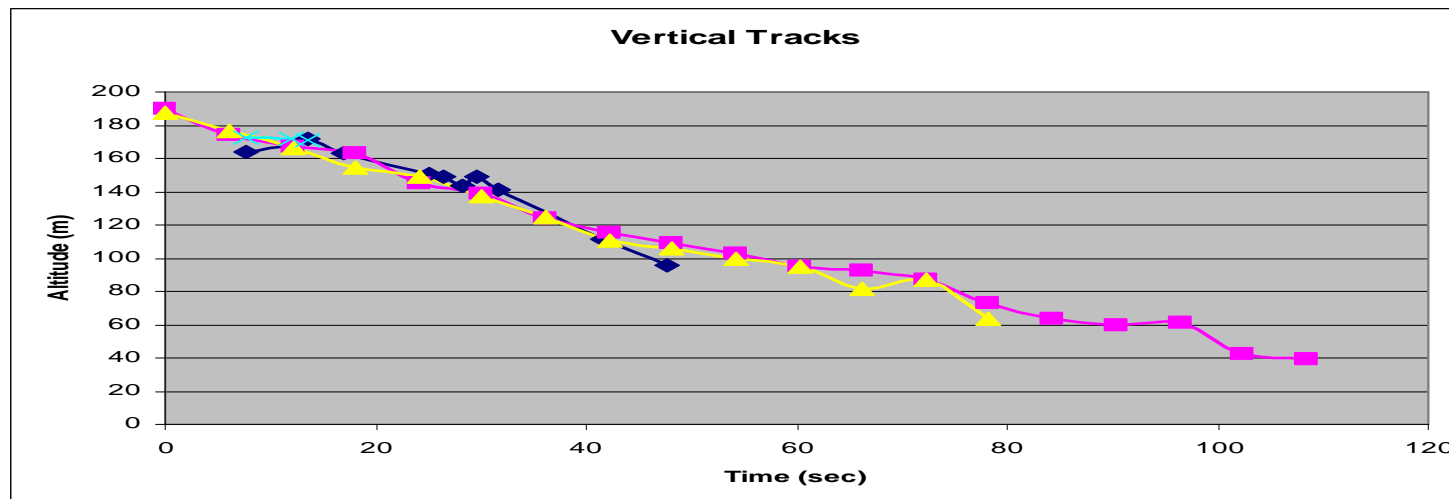
Sample Track I

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A319



◆ CW starboard
■ pulsed starboard



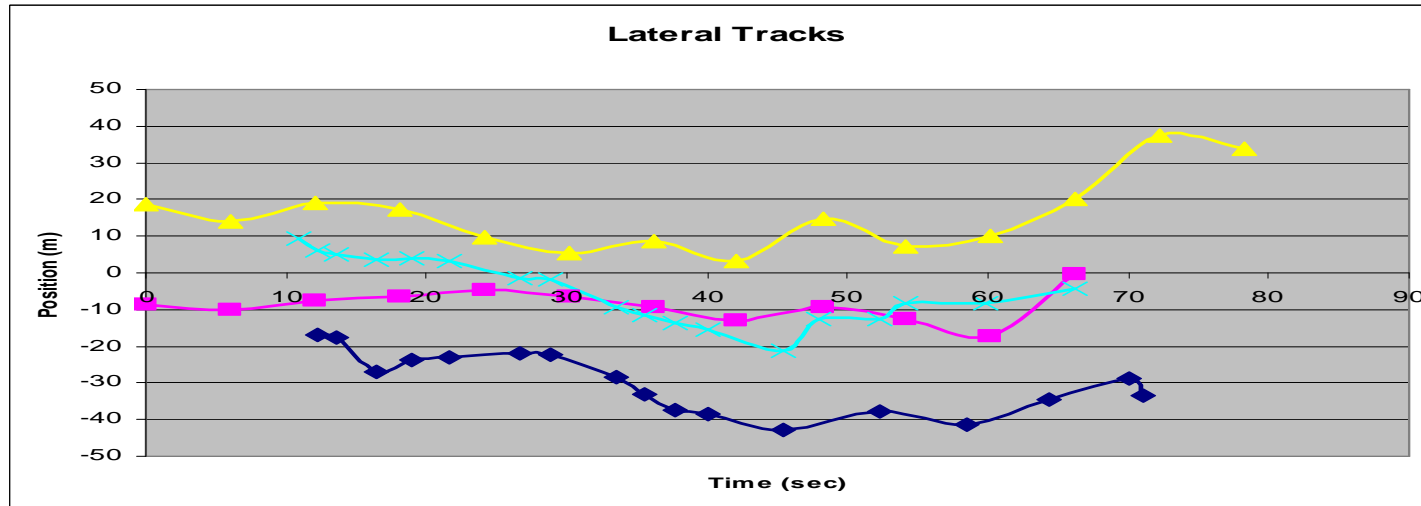
× CW port
▲ pulsed port



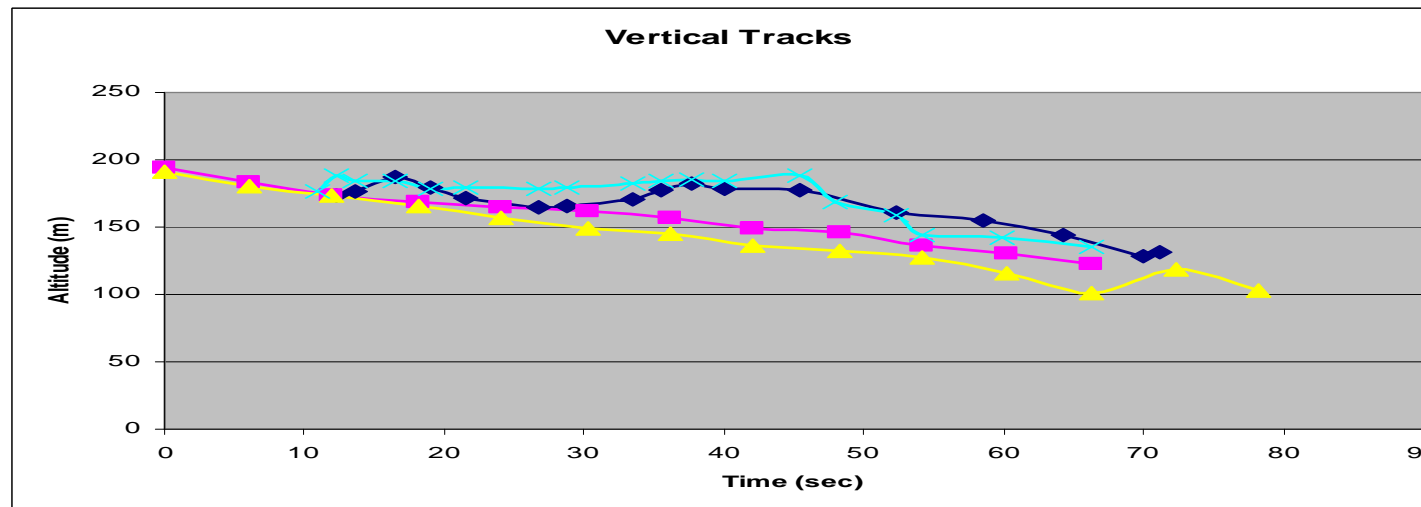
Sample Track II

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A 319



- ◆ CW starboard
- pulsed starboard
- × CW port
- ▲ pulsed port

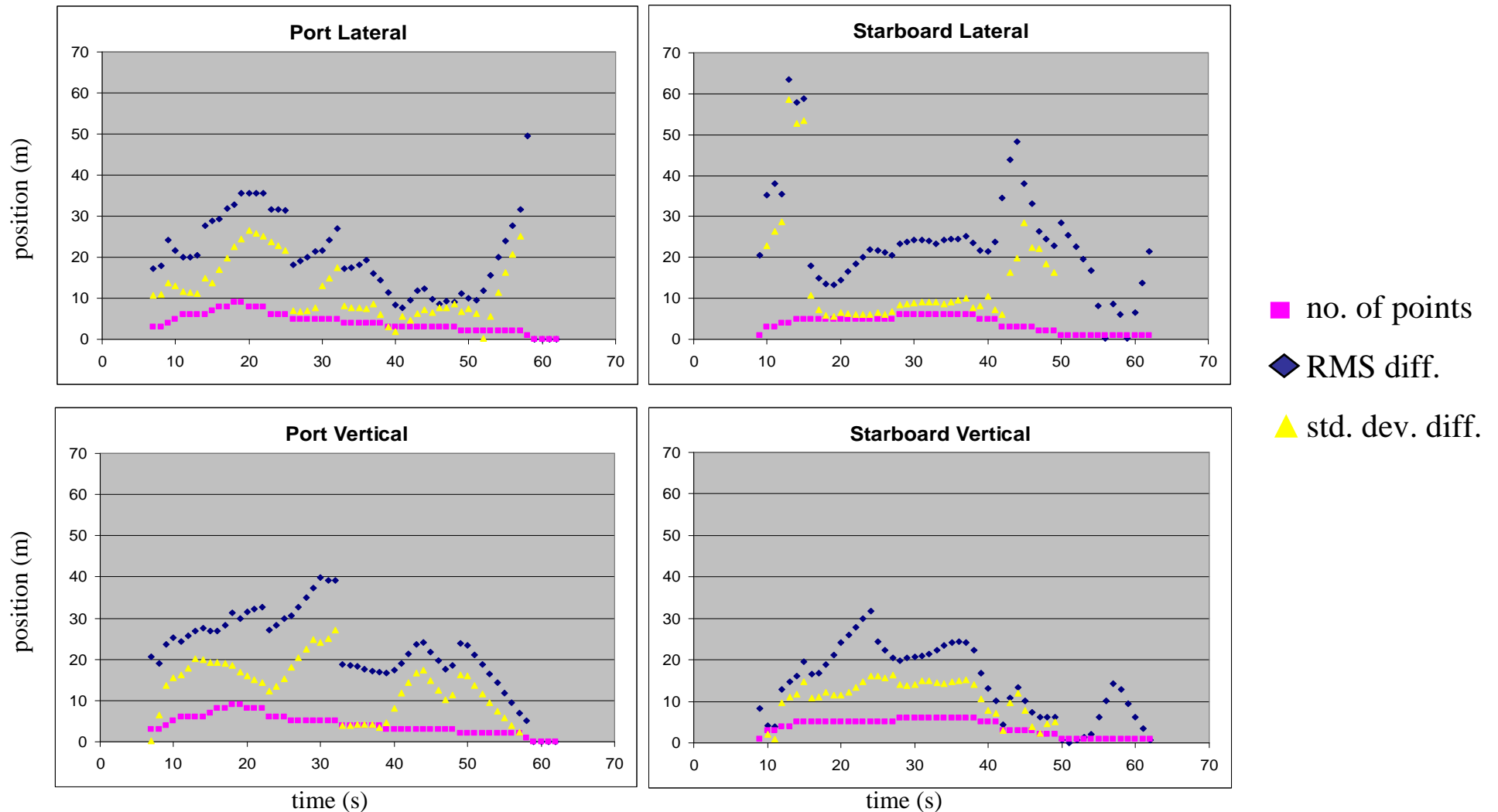


Statistics on Position Track



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MD-80 (including 81, 82, 87)

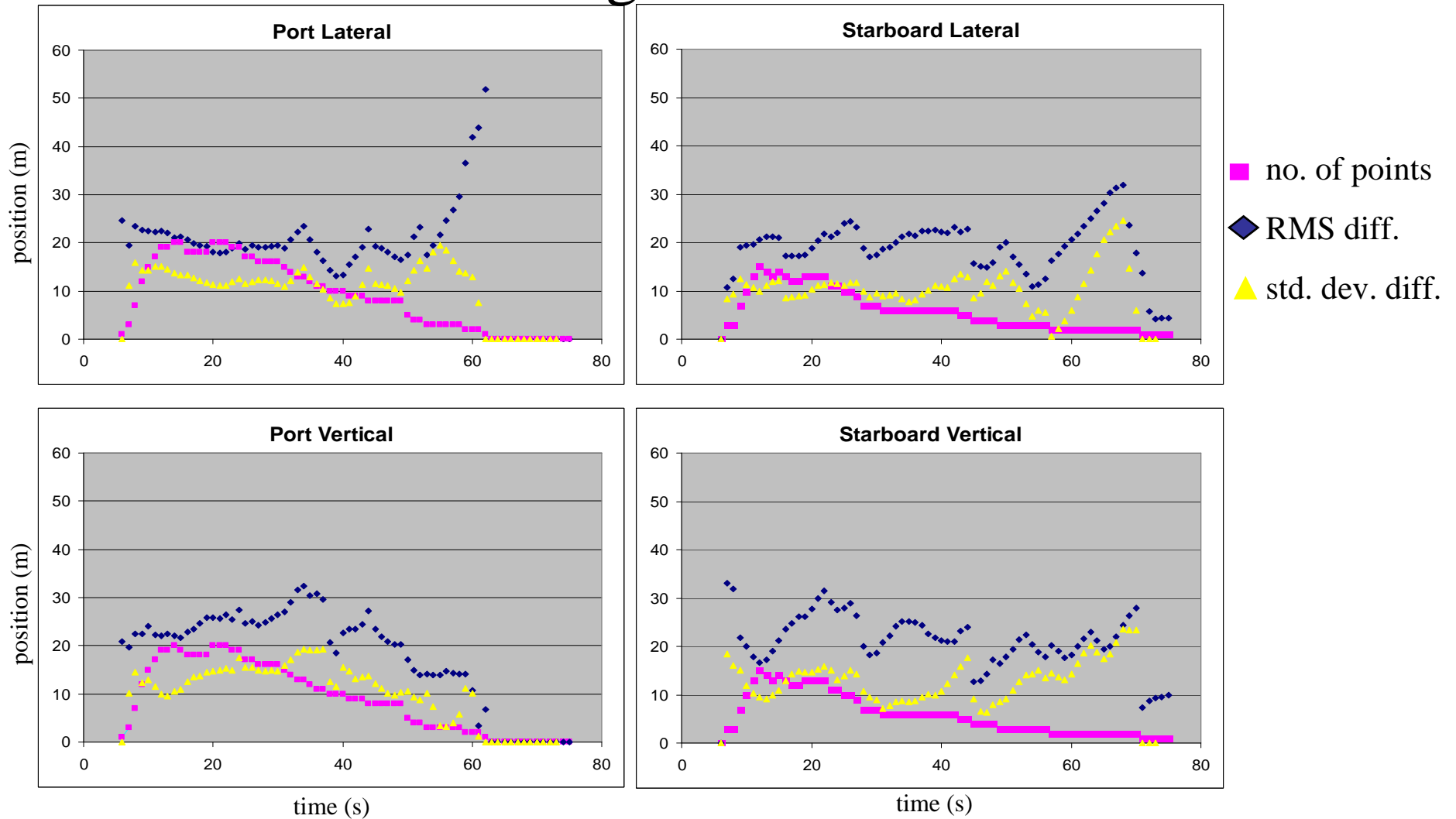


Statistics on Position Track II



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Boeing 757-200

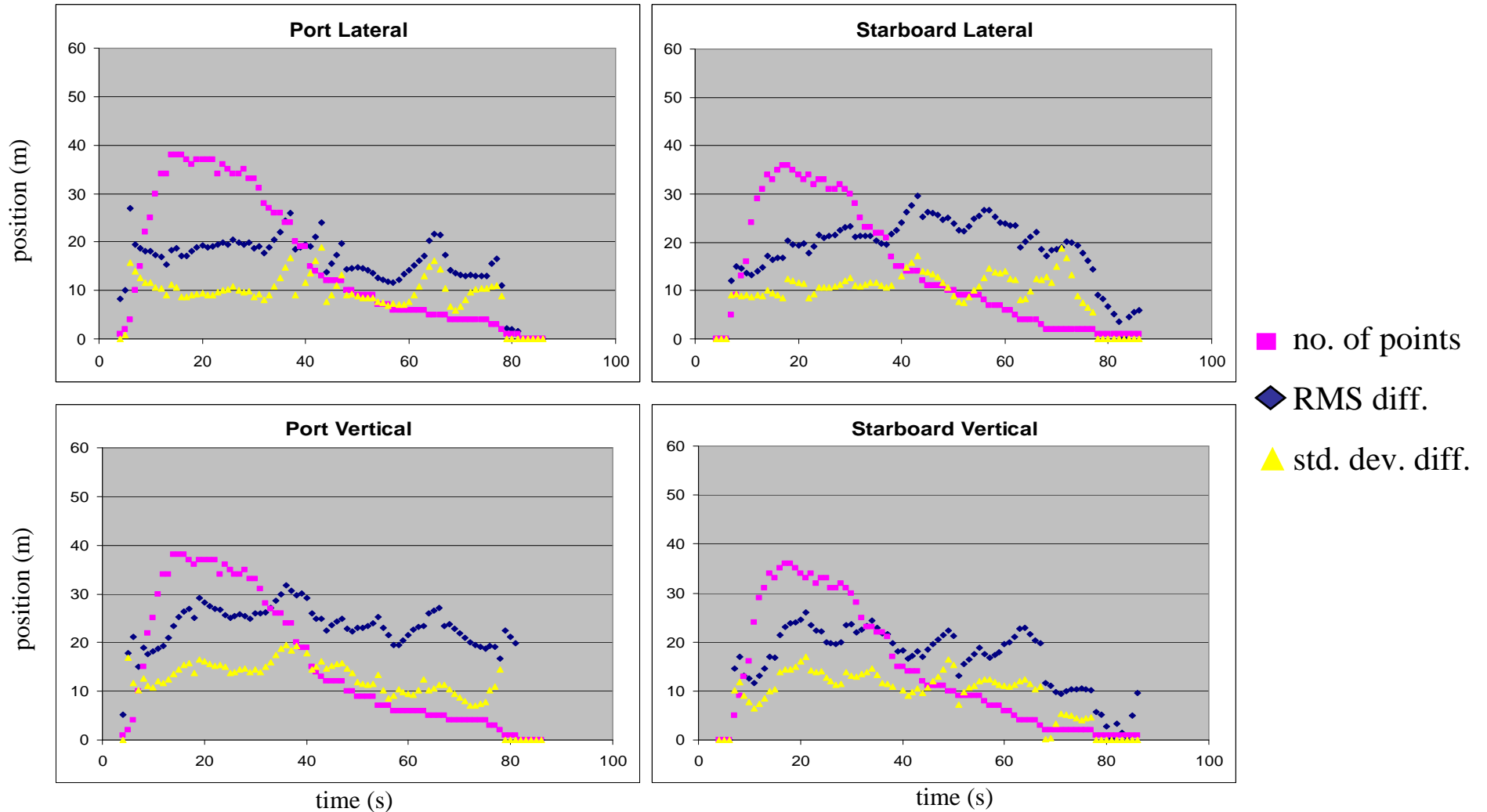


Statistics on Position Track III



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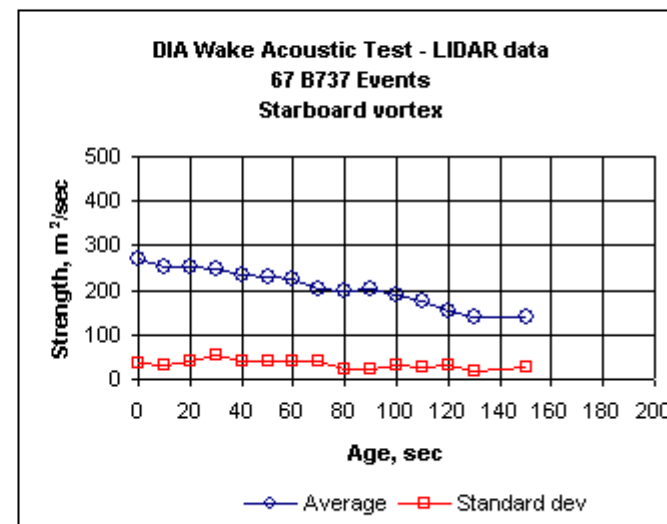
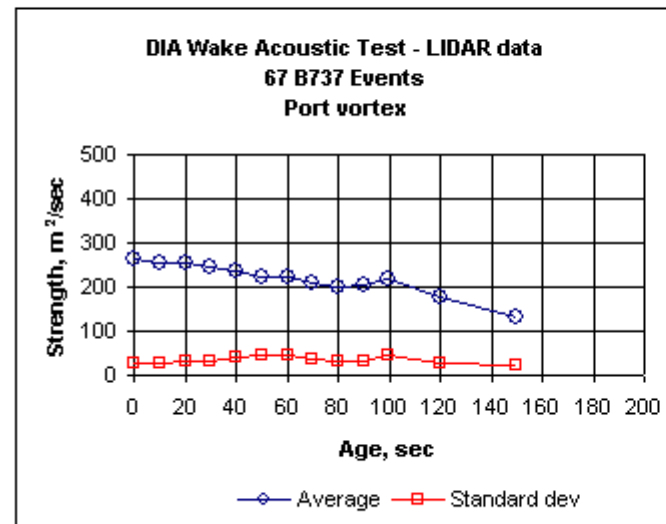
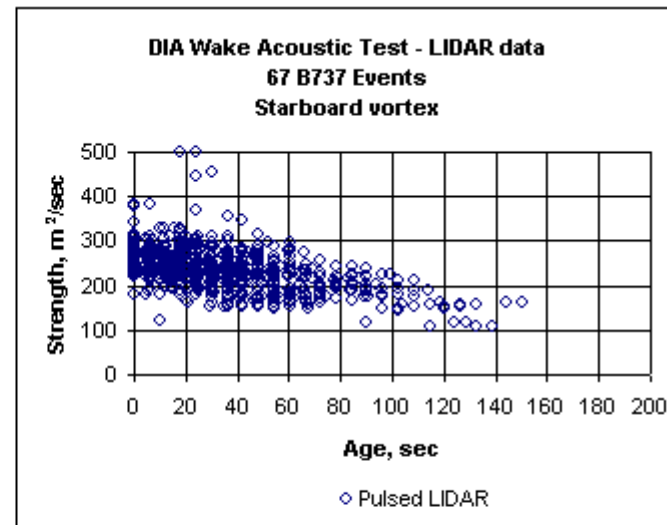
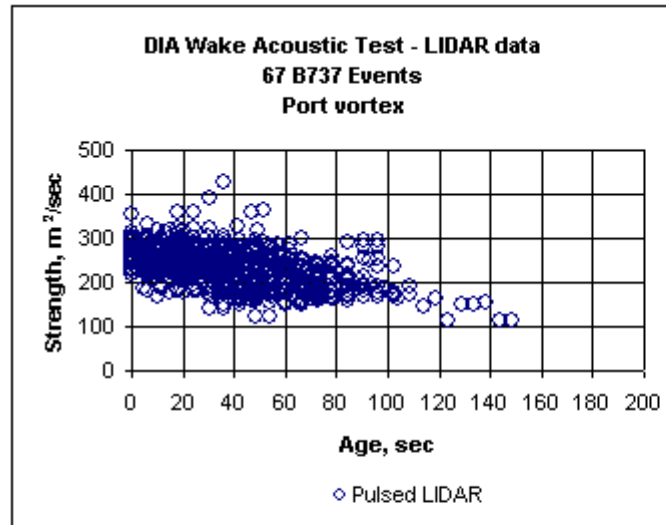
Airbus 319 and 320





Circulation Data Sample

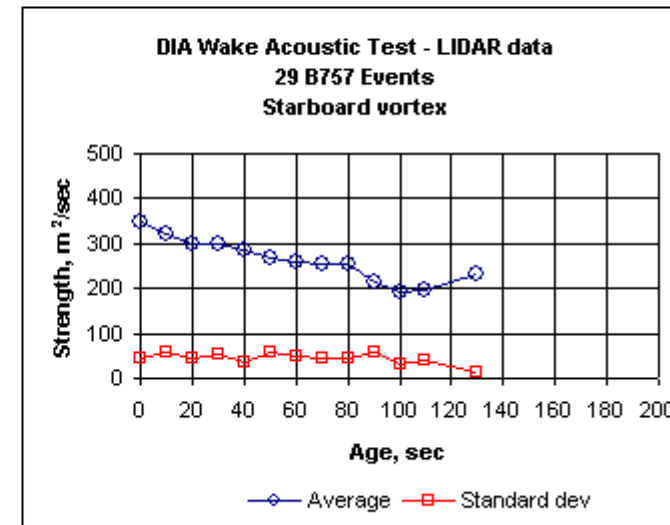
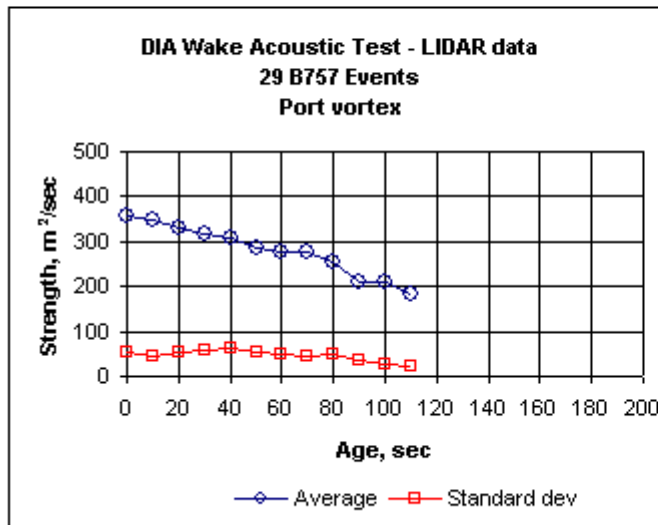
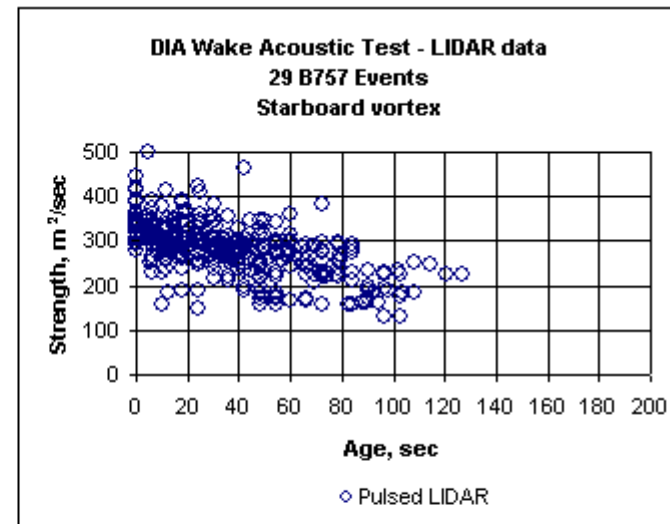
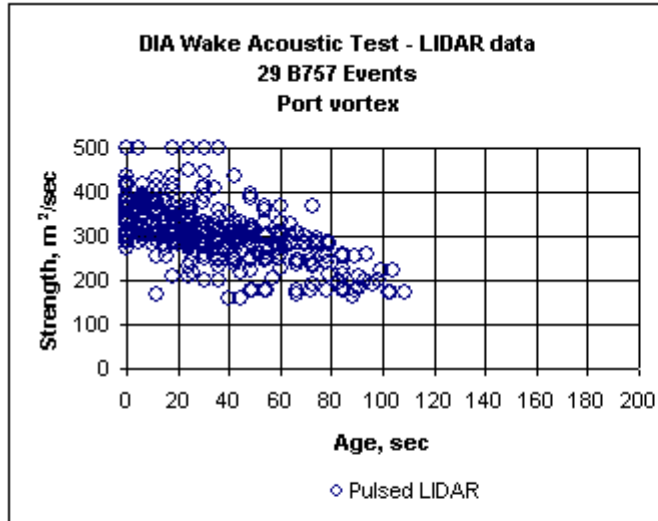
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Circulation Data Sample II

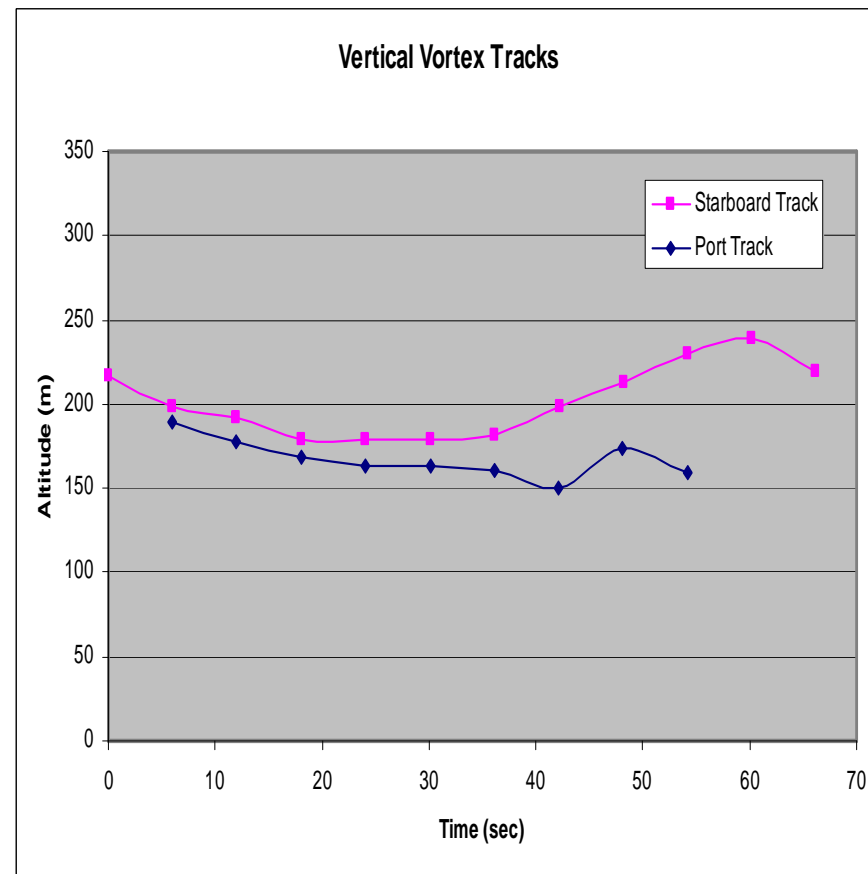
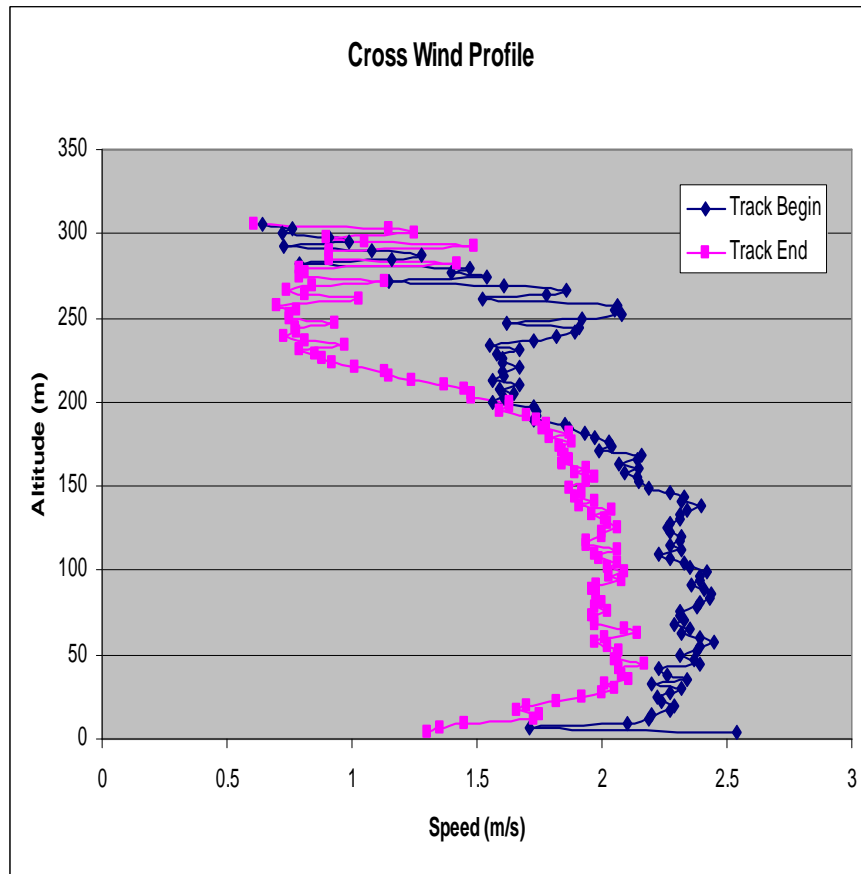
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Crosswind Effects

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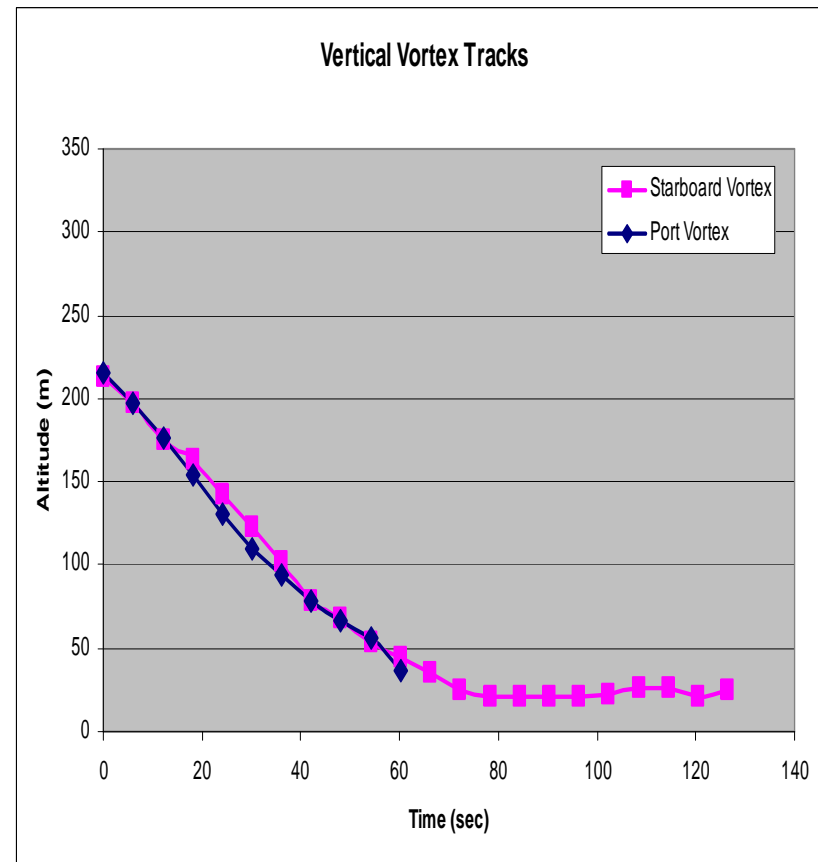
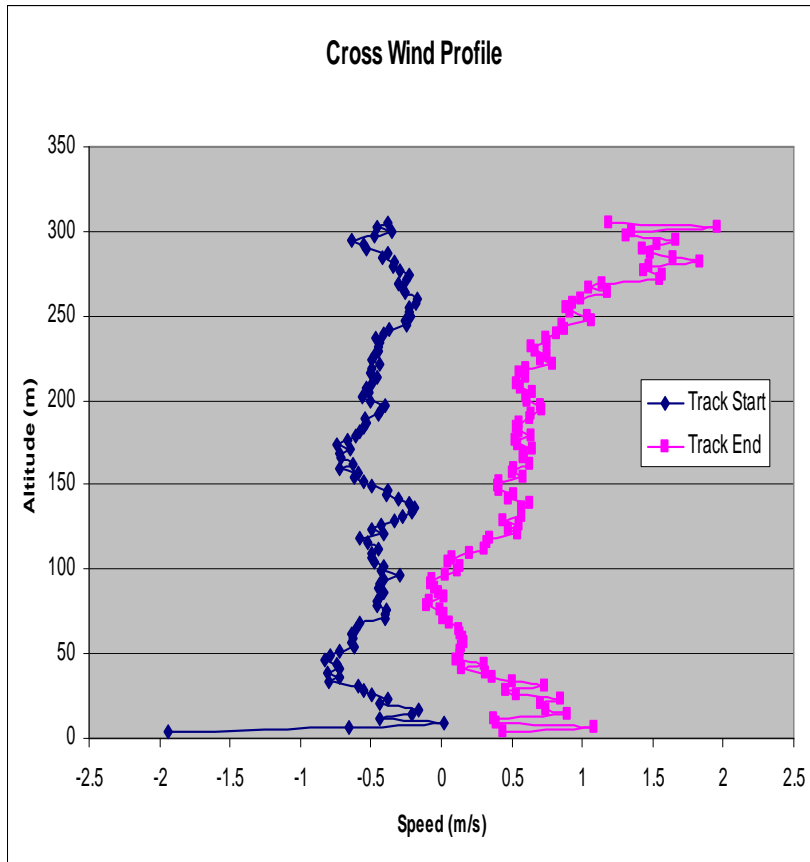


A319



Crosswind Effects, continued

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B757-200



Conclusions

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- Work in Progress. Over next few months:
 - Complete analysis on location tracks per aircraft type and for all aircraft.
 - Reduce CW lidar circulation data and make comparison to pulsed lidar.
 - Create report of comparison results and provide lidar data in a format for a database.
- Results so far:
 - Denver experiment has proven to be a good case for lidar comparison with a large number of aircraft and out-of-ground effect condition.
 - RMS difference in position tracks approximately 20-m for both lateral and vertical dimensions.
 - Pulsed lidar tracks are of longer duration than CW lidar.
 - Circulations measured by pulsed lidar are reasonable in strength and decay.