Iron Stomachs and White Knuckles: Navigation Flight Testing at the Ohio University Avionics Engineering Center

Institute of Navigation
Southern California Section

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One Small Plane – One Big Research Tool
PA-32 Piper Saratoga
40 Years of Flight Testing in 40 Minutes

- DC-3: Hauling the first commercial GPS receiver; Attitude and Heading Determination
- NASA 737: First autoland with RTK
- King Air: Synthetic Vision in Alaska
- Fly-by-light: LADAR mapping in reverse
- Loran: A system that works great except when a pilot needs it the most?
- Learjet hunting: ADS-B in south Florida
- Ohio U joins the jet age
Real-Time Attitude and Heading Determination

Angular accuracies better than 1 mrad (0.06 degrees)

1991
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NASA Langley 737 Autoland

Static Calibration of GPS, Laser, and Plumb Bob

Aircraft Installation

In-flight accuracies of better than 10 cm
Kinematic GPS vs. Laser Tracker

![Graph showing error in feet vs. distance to runway threshold in feet. The mean + 2*sigma for the data is 9.6 cm (0.32 ft) and 42 cm (1.39 ft).]
FAA/UPS/OU DGPS Autoland Demonstration

UPS Boeing 757 Cargo Aircraft

110 Autolands to Demonstrate Feasibility
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Synthetic Vision Systems
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Scanning Laser (LiDAR)

From RIEGL, Laser Measurement Systems
Meter-Level Positioning in 0.1 Second

Position, Orientation and LiDAR Scan Angle at $t_i$

Terrain DB

LiDAR Range

Ray Trace to Find Range to Terrain Pierce Point

$r_{db}(t_i)$

$\mathbf{p}_{\text{disparity}}(t_i)$

Example of a Horizontal Position Search Space Plot

Time = 315280.0883 (GPS sec)
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Loran-C

Loop and Wire Antennas
Atmospheric Noise and P-Static

Static Charging
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Automatic Dependent Surveillance - Broadcast
Before
After
40 Years of Flight Testing in 40 Minutes

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AeroVodochody L-29 Delfin
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- Eastern block fighter-trainer: 1964 – 1975
- Built by AeroVodochody in what was then Czechoslovakia (now the Czech Republic)
- Approximately 3500 built; over 100 operating in the U.S. today
- Fully Aerobatic: +8 g’s and -4 g’s
- Max Ceiling: 36,000 feet
- Max speed: 440 knots
Taxi Test

Note intentional offset between GPS and INS;
Also note the low resolution of the INS data
Valuable Lessons Learned

- Working with the local FAA reps to secure operational and maintenance approval
- Turning a COTS INS into a research INS
- Intestinal fortitude of the flight test engineer
- High dynamic hardware ‘issues’
  - Push-to-talk switch
  - Data collection exit sequence
Industrial Keyboard
Altitude vs. Time

Runtime (seconds)

Altitude (Feet)

GPS

INS
Acknowledgements

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