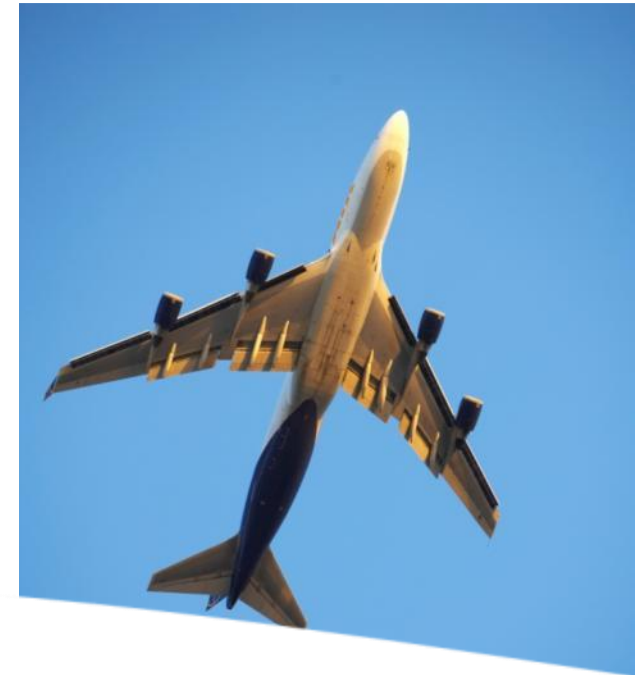
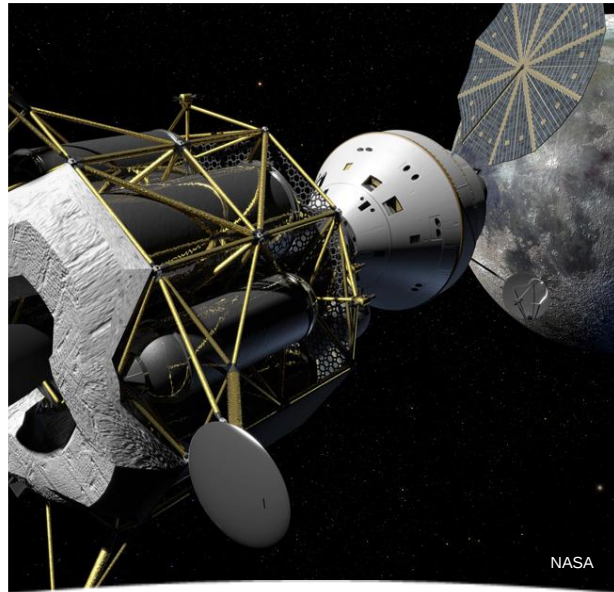
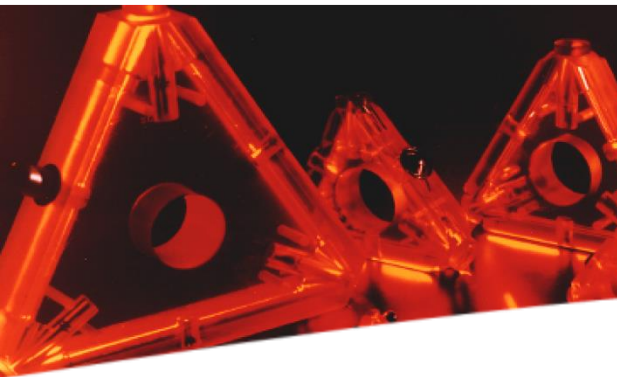
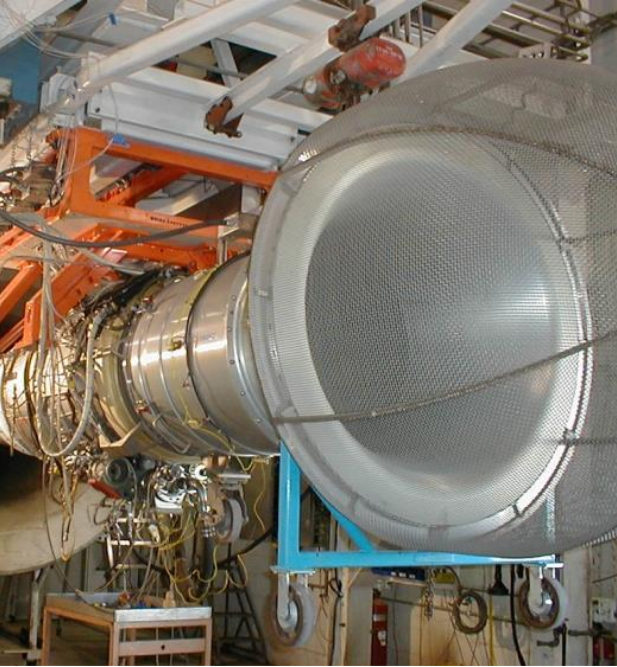




Aircraft Safety R&D Directions

Jeff Radke – Honeywell Aerospace Advanced Technology
September 2017

Honeywell Aerospace Product Portfolio

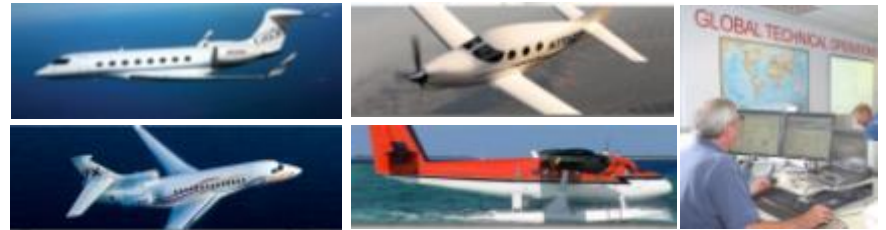
Honeywell



Air Transport and Regional



Business and General Aviation



Defense and Space



Broad Portfolio Across Diverse Aerospace Applications

V. P. Advanced Technology
Mike Stewart

**Advanced Sensors
& Microsystems**

Earl Benser

**Connected
Components,
Power & Controls**

Torey Davis

**Crew Interface &
Platform Systems**

Rakesh Jha

**European
AT**

George Papageorgiou

**Communications,
Navigation &
Surveillance Systems**

Jeff Radke

**Engines &
Air Management**

Eric Blumer

**Technology
Strategy**

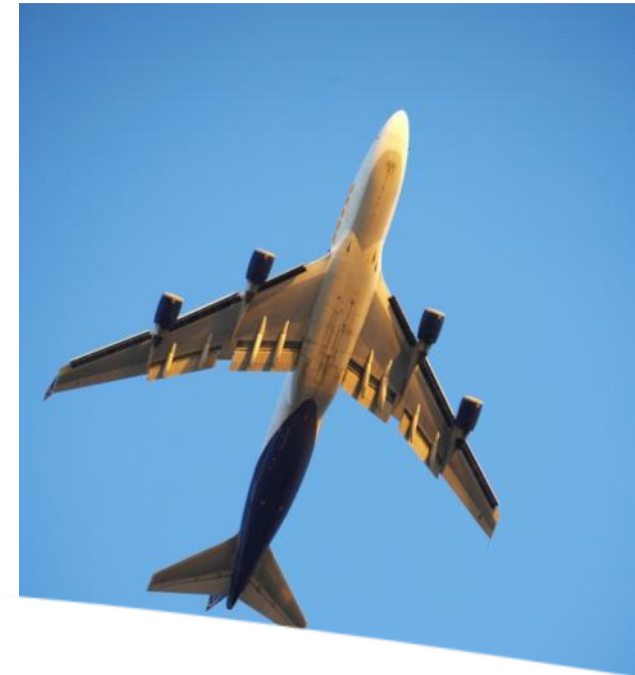
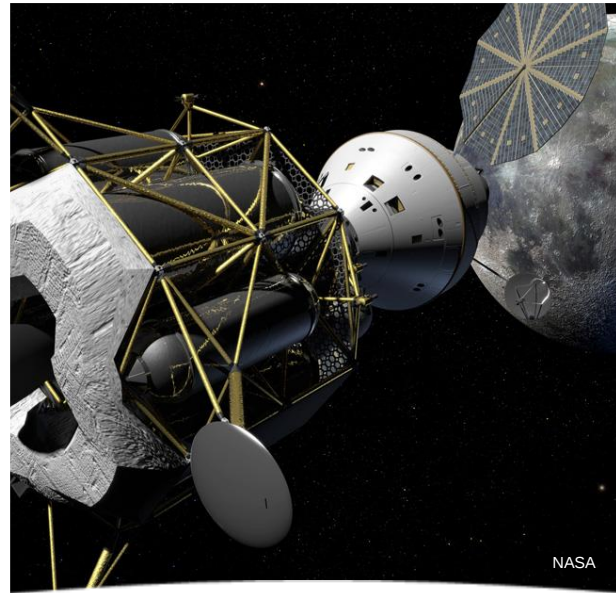
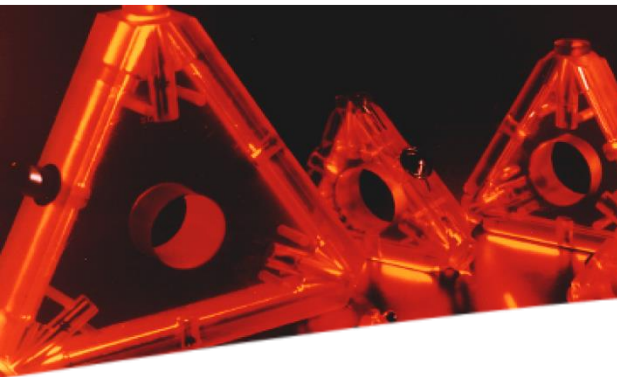
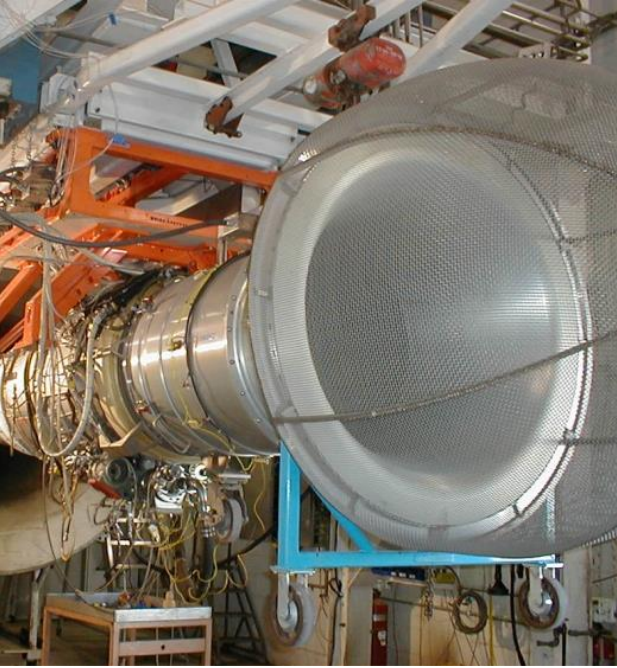
Bob Rasmussen

View the [Advanced Technology web site](#).

Aerospace Advanced Technology Global Footprint

Honeywell



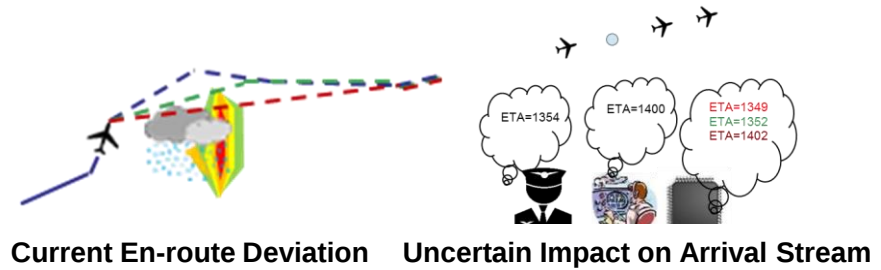


Aircraft Safety-Related R&D Examples

Air Traffic Management Modernization – US NextGen

Trajectory Based Operations

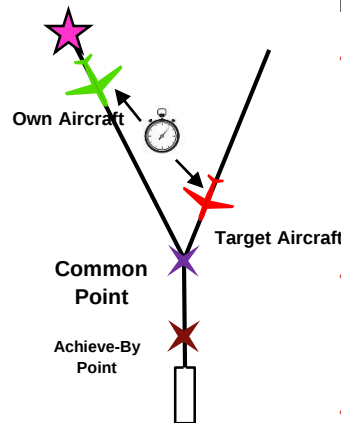
Current research focused on closed loop trajectory operations with use of Air-Ground System Wide Information (SWIM) to exchange trajectory predictions between pilots and controllers



Example Programs:

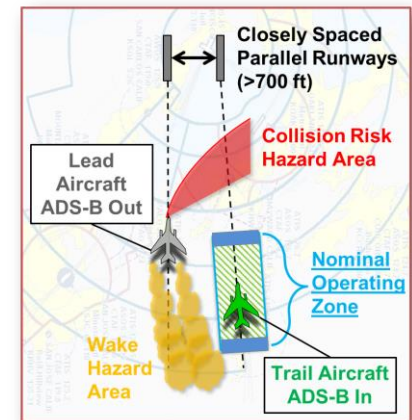
NASA/Boeing Flight Deck Interval Management:

- Flight Deck avionics automation that enables the Flight Crew to fly an approach with an assigned time-based spacing goal behind another aircraft
- Reduces variability in arrival rates and facilitates reduced average separation between arriving aircraft
- Increases airport runway arrival rates and capacity during high demand periods and facilitates aircraft Optimized Profile Descents (minimizes fuel burn during Arrival and Approach). Capacity increases may lead to additional landing slots benefiting operators
- Automatic Dependent Surveillance – Broadcast (ADS-B) information (GPS-based position data) is used by the FIM application to determine time and distance to the leading aircraft



FAA Paired Approach:

- Flight Deck avionics automation that enables the Crew to fly an approach with an assigned time-based spacing goal behind another aircraft on a closely spaced (<2500 feet) parallel runway
- Allows additional landing capacity in IMC where one of the parallel runways cannot be used at the same capacity as in VMC.
- Automatic Dependent Surveillance – Broadcast information is used by the FIM / A-IM application to determine time and distance to the leading aircraft. Flight crew are provided with speed commands that will keep them spaced in compliance with the Paired Approach Assigned Spacing Goal.



Air Traffic Management Modernization - SESAR

Single European Sky Air Traffic Management Research

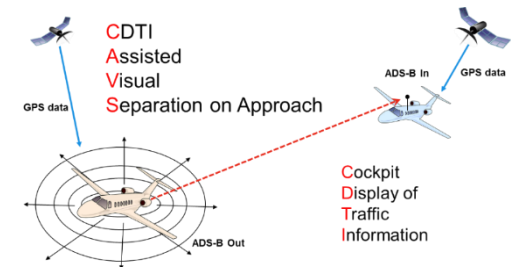
Follow-up of a successful SESAR 1 program (2009-2016)

Goal: modernization of Europe's Air Traffic Management System by coordinating and concentrating all relevant research and development efforts in the European Union

- *Triple capacity of the system*
- *Increase safety by a factor of 10*
- *Reduce environmental factor by 10%*
- *Reduce the overall cost of the system by 50%*

Total HON budget: 38.5M\$ (~50% cost-share)

- Unique public-private partnership of European Commission, ANSPs, Aircraft Operators, Airports and Manufacturers



Multiple Constellation Global Navigation Satellite System



Runway and taxi way alerting



Air Traffic Management Modernization – Clean Sky 2



Clean Sky 2 Main Goals

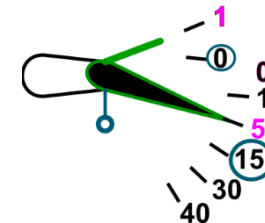
- Fuel consumption and CO2 emissions reduced by 20% to 30% (2025 / 2035)
- NOX emissions reduced by 20% to 40% (2025 / 2035)
- Noise footprint impact reduced by up to 75% (2035)

Total HON budget: 38.5M\$ (~50% cost-share)

Honeywell Programs as a Core Partner

Disruptive European Cockpit: Mature cockpit functions and technologies, demonstrate & validate technologies for Large Aircraft and Business Jet cockpit concepts

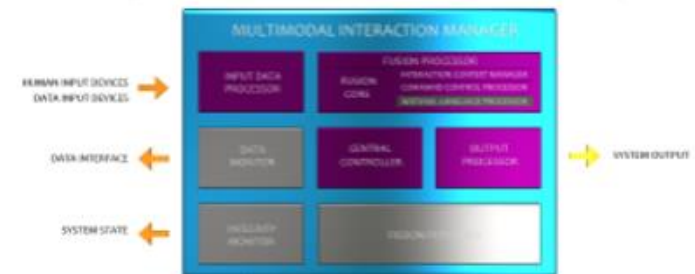
Cost Optimized Avionics System: Deliver key technology enablers for affordable cockpit and avionics with a focus on commuter category aircraft



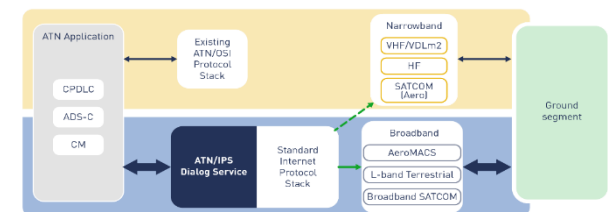
Approach stabilization assistant



GPS Attitude Heading Reference System



Multi-modal Interaction Manager



ATN/IPS Router

Air Traffic Management Modernization – Honeywell China ATM Lab

- **China ATM Lab**

- Established in 2010; Beijing and Shanghai
- **Mission:** Help define and deploy China's ATM strategy through partnerships with CAAC, universities and the Chinese aviation industry



- **China AT Growth Areas**

- Advanced Mechanical Components/Actuators
- Connected Aircraft/IoT – Brakes, ECS, Lights
- Autonomous system and Machine Learning

- **Accomplishments / Technology Capabilities**

- NextGen ATM Datalink / Communication
- Beidou GNSS & SatCom
- Air Traffic Surveillance / ADS-B In
- Future Flight Trajectory and Performance Management
- Air Traffic Management ConOps Studies, Modelling and Simulation
- RF Antenna/Radar Concept & Design
- Cross Cultural Flight Deck & Human Factor
- Flight-deck Speech Recognition
- Future Avionics/Offboard Systems & Apps
- Data Science and Analytics
- Strengthened Airline Engagement



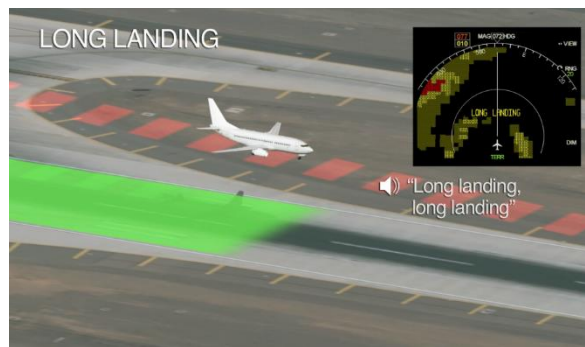
Honeywell Enhanced Ground Proximity Warning Systems

Runway Awareness & Advisory System, SmartRunway/SmartLanding

- S/W Applications hosted in the EGPWS
- Provide advisories and warnings to help prevent runway incursions and excursions
- Reduces the risk of taking off from, or landing on, the wrong runway or taxiway
- Alerts pilots to unstable approaches and long landings
- Reinforces the need to Go-Around when a potentially unsafe condition exists

Runway Overrun Awareness & Alerting System – EUROCAE WG 101 MOPS

- Provides the pilot easy to understand visual & aural alerts based on real-time comparison of remaining runway length & predicted stopping distance.



Honeywell Enhanced/Synthetic Vision Systems

Gulfstream SEVS 450 Flight Test

In cooperation with NASA and Gulfstream, evaluated the use of EFVS and SVS during a series of flight tests on G450 at CAT1 airports (no centerline or touchdown zone lights)



- Honeywell SVS Head Down flown to a 150ft decision height and transition to visual segment to land in conditions as low as $\frac{1}{4}$ mile visibility
- All Landing Touch and Gos met desired performance and workload objectives
- SVS demonstrated equivalent performance to HUD with EFVS in both instrument and visual segment



Honeywell SmartView Display

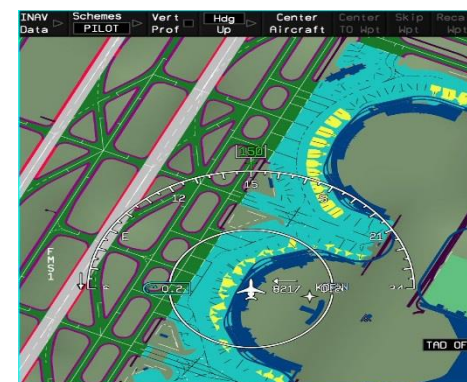


Embraer E2 E1 Regional Jets

SVS Part 25 Cert Expected: 2017



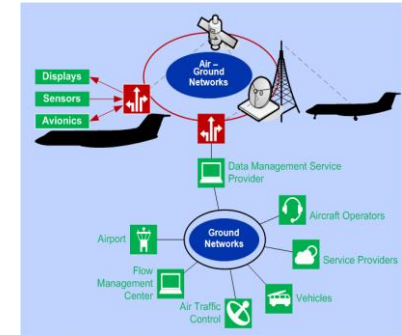
SVS Display with E-GPWS Warning



Taxiway/Runway Moving Map

Honeywell Cyber Security Research

- **Security Risk Assessment**
 - Airworthiness Security Threat Risk Assessment toolset
 - FMECA Security Assessment Instrument for Legacy Products
- **Airworthiness Security Certification Standards**
 - Streamline certifications
 - Participation on DO-326A, DO-356A, DO-355, DO-200B
 - **ARAC/ASISP Voting Member, Draft Reports**
- **Security Testing**
 - Standardized Test Plans for 100% Test Point Coverage
 - Testing Tools (Commercial, Custom Aero, ACARS Virtual)
- **Cooperative Research: Idaho National Laboratories**
- **Network Intrusion Detection Technologies**
 - Adaptive Cyber Security
 - Deep Learning for Network Intrusion Detection
- **Communication Security for Critical ATC Infrastructure**
 - Secure ACARS
 - Secure ATN Communications
 - NextGen, SESAR



Aviation Rulemaking Advisory Committee (ARAC) - Aircraft System Information Security / Protection (ASISP) WG

Final Report (8/22/16) Recommendation Research R1:

The ASISP recommends that the FAA consider the following topics as part of future agency research to address cybersecurity (Section 5.3):

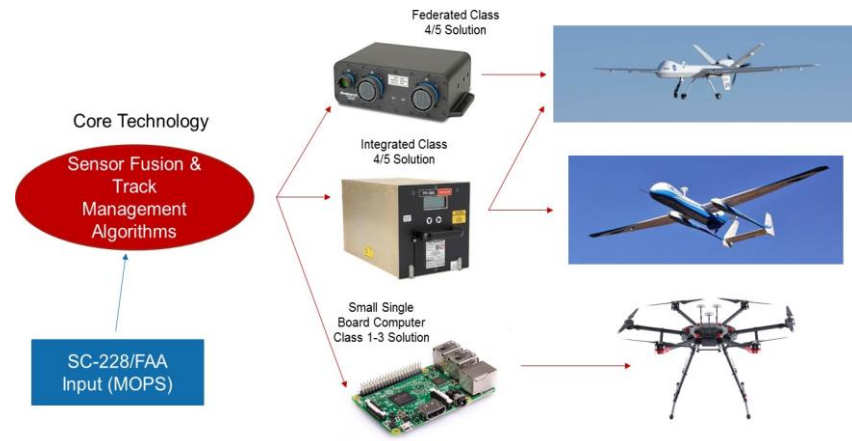
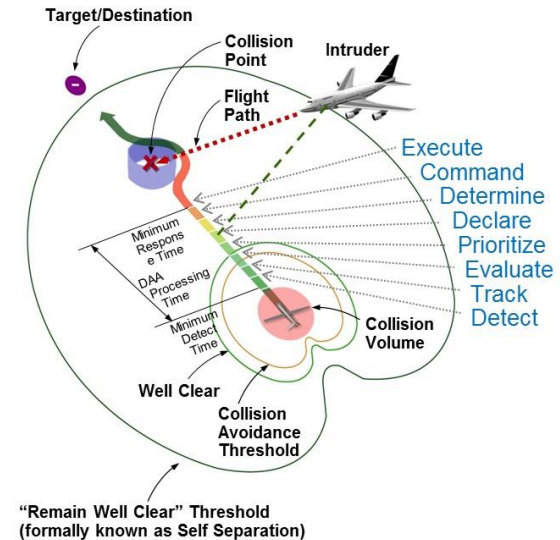
- The FAA should undertake research to determine how threat and vulnerability sharing can be most effectively done for ASISP including in coordination with international partners and regulators.
- The FAA should fund the development of tools that can facilitate event log analysis.
- Study means of detecting and preventing vulnerabilities from PED's connectivity to Avionic Interface Devices.
- Study means of detecting vulnerabilities in receiving transponder and ADS-B Data in aircraft.

Honeywell Detect & Avoid Technologies

- Core technology developed in coordination with SC-228 and FAA
- Developing scalable Detect and Avoid (DAA) technologies
 - Large and small aircraft
 - Integrated or federated architectures
 - “Plug & Play” surveillance
- Flight testing DAA technologies since 2013
 - Predator B Aircraft (2013-Present)
 - DAA & ACAS-Xu
 - MANTA UAS
 - HON Kingair
 - DJI Matrice
 - IAI Herron (Future)
- Supporting NASA & AFRL to develop and analyze standards
- Internal programs demonstrating Group 1 applications.
- Recent award from NASA for Group 3, integrates Cooperative DAA Algorithms with Radar to detect Non-Cooperative



NASA Sierra - Group 3 UAV



Engine Icing Research

Super-Cooled Large Droplets (SLD):

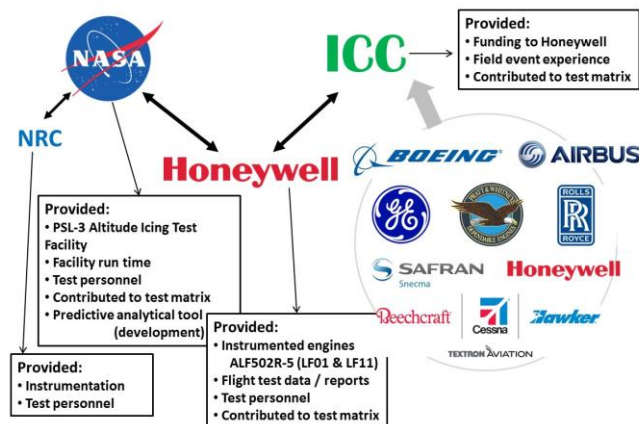
- Honeywell completed a 2 engine (HON ALF502) collaborative test effort in 2015 with NASA and the ICC to investigate the physics of ice crystal accretion under altitude conditions in NASA's PSL facility
- Helped NASA begin cell validation, and results are being used to develop analytical tools and identify additional research needed and streamline the methods of compliance for the new SLD regulations.

Ice Crystal/Mixed Phase:

- Currently involved with 3 different Engine Icing Working Group committees to identify recommendations for upcoming revision of AC20-147 that will help applicants meet new requirements, including Chair of Simulated Altitude Engine Test WG.



Ice crystal icing in ALF502 engine core flow path



NASA Propulsion Systems Lab Altitude Facility

Honeywell IntuVue Radar High Altitude Ice Crystal Detecting Prototype



NASA flight trials utilized IntuVue with special algorithms to detect vertical winds in cells conducive to producing ice crystals



Airbus selected Honeywell IntuVue as exclusive data collection platform to complete flight trials in January 2016.



European Union Framework 7 Consortium



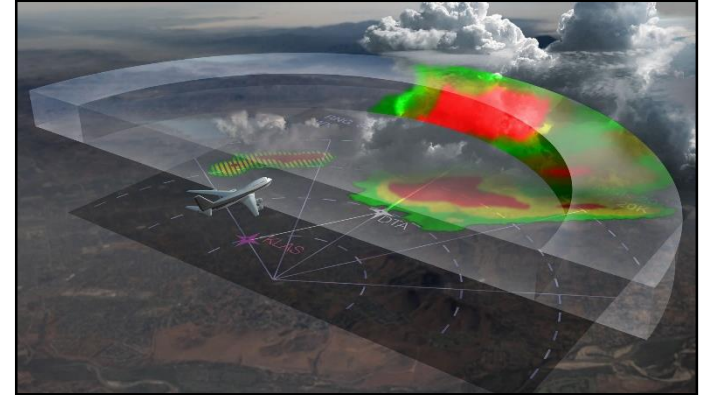
IntuVue RDR-4000 HAIC Prototype



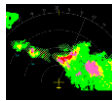
Honeywell IntuVue Hazard Display & Connected Weather

Weather Hazard Displays: Honeywell completed the investigation into the technical feasibility and certification considerations for weather radar features that provide weather hazard assessment and corresponding display

Algorithm Development: using, as a minimum, volumetric reflectivity data and wind to track weather cell growth, decay and motion. Incorporate integration with flight plan to identify cells that will intersect flight path. Vertical display of Hazard features, and vertical display available on EFB displays.



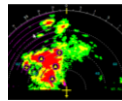
Legacy Products



IntuVue Automatic 3D Weather Radar

- 3D Scanning & Modeling
- Pulse Compression
- Earth's Curvature Correction
- Ground Clutter Extraction
- On-Path & Off-Path Weather
- Vertical Cell Analysis Mode
- Simultaneous Dual Controls
- Enhanced Turbulence
- Natural Global Weather Coverage
- Natural Over-flight Awareness
- Dual Redundant Antenna Drive
- Vertical Profile (A380)

Current Products



Hazard v2.0

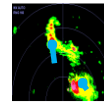
- Attenuation Awareness
- 60nm Turbulence Detection
- Predictive Hail
- Predictive Lightning
- Convective Weather Discrimination
- Weather Ahead Alerting



Connected Radar v1.0

- Initial Data Set
- A429 Connection to CMU
- Data Link communication

Future Products



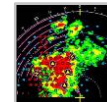
Hazard v3.0

- Long Range Convective Turbulence
- Cell growth and position tracking
- Two Level Turbulence



Connected Radar v2.0

- Full Data Set
- Broadband Connected
- Various communication channels



Hazard v4.0

- High Altitude Ice Detection
- Connected Radar Downlink
- Vertical Display on EFB
- Connected Wx Up/Dn Ink
- Flight Planning
- Runway Incursion Det.

2017

2018

2019

2020

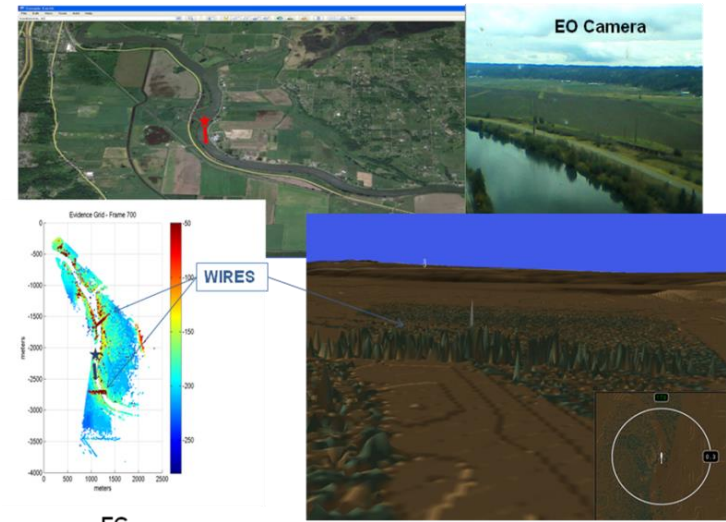
2021

2022

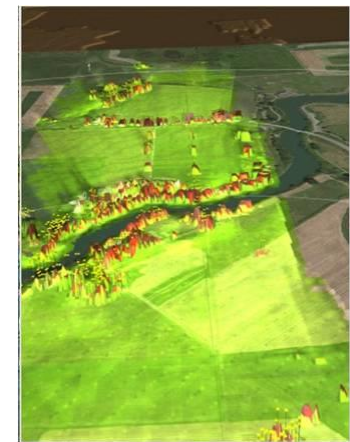
Honeywell 94 GHz Cable Warning & Obstacle Avoidance Prototype

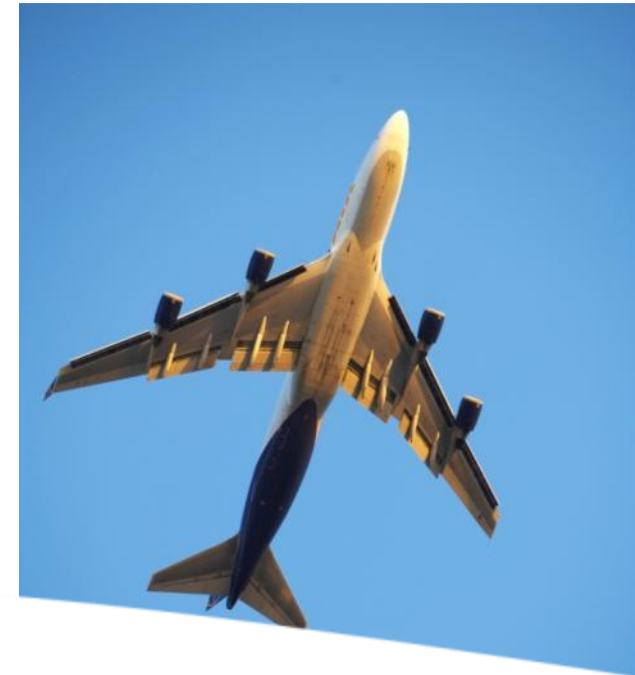
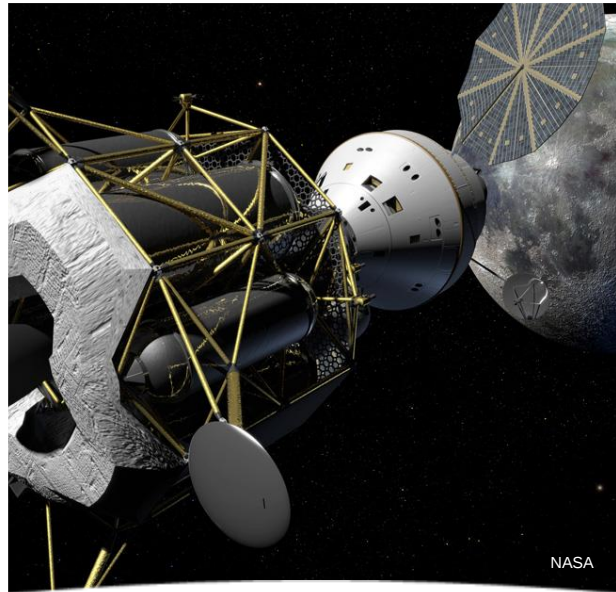
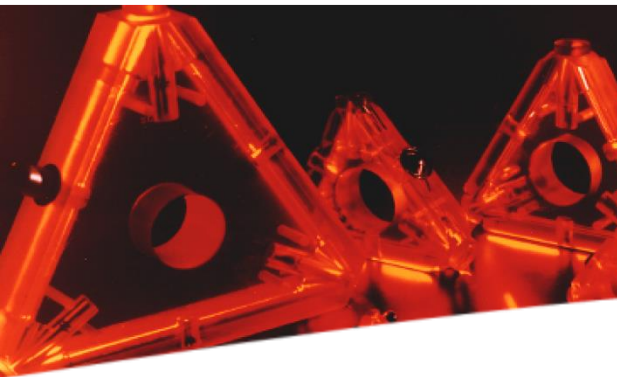
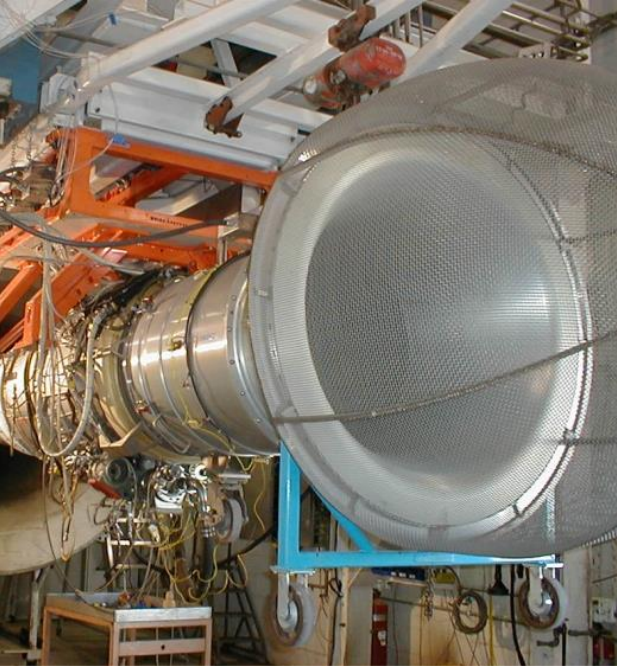
Multiple flight test campaigns in Degraded Visual Environment

- Yuma, AZ: Brownout testing incl. Wire detection
- Ft. AP Hill, VA (rain)
- Los Alamitos Joint Forces Base, CA (fog)
- Deployed on HH-60M
- W-band FMCW Imaging Radar Data processed through SVAB with LIDAR and IR data
- Data collection for multi-sensor fusion application



Honeywell 94 GHz MMW Sensor & A-Star Testbed





Thank You!