Weather in the Connected Cockpit

What if the Cockpit is on the Ground?

The Weather Story for UAS

Friends and Partners of Aviation Weather
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Outline

• Mosaic ATM Role in Aviation Weather
• UAS Research Involvement
• Weather Needs of UAS
• High Bandwidth Air-Ground Connection
Weather Integration: GPSM

- GPSM is a decision support tool designed to provide guidance to decision makers in selecting traffic management programs at SFO when low ceilings are expected to reduce airport capacity.

- Provides recommendations based on probabilistic forecast of the clearing of stratus, bridging the gap between the forecast product and the tool used to issue GDPs.

- Provides relative indication of risk and benefit of the recommendations vs. alternative options given the uncertainty in the forecast.

- GPSM is one of the first decision support links between weather forecasts and actual decisions, which can improve the prediction of actions and result in better planning.
Weather Integration: START

• Purpose:
  • To aid the ZMA TMU in the strategic planning of arriving traffic during convective weather events.

• Motivation:
  • Empower the TMU to proactively manage traffic in anticipation of convective events.
  • Reduce reliance on tactical (reactive) management.
  • Minimize diversions and safety concerns.

• Approach:
  – Utilize probabilistic convective weather forecast products to create probabilistic airspace capacity estimates for key ZMA/ZJX routes.
  – Use the probabilistic capacity estimates to help drive strategic traffic management decision making.
Mosaic’s Role in UAS R&D

Advanced Technologies

• Safety
  – Flight Risk Analysis - NASA
  – Contingency Planning & Management - NASA
  – File and Fly Visualization Tools - IR&D
  – Non-GPS Navigation in the Terminal Area - Air Force
  – Threat Tracking - Navy, Boeing
  – 4D Trajectory Prediction - Navy

• Command & Control
  – Automatic Speech Recognition (ASR) of Air Traffic Control (ATC) - Air Force
  – Adaptive Task Planning Under Uncertainty - Air Force

• Capability
  – Optimized Optical Sensing of Complex Terrain - Army
  – Biologically-Inspired Navigation - Army
  – UAV Ground Segment & Mission Planning Functionality - Air Force / Global Hawk
Rapid Automated Mission Planning System (RAMPS) – *Information Integration*

**RAMPS Considers a Spectrum of Factors in Its Decision-Making**

- **Population Density**
- **Geospatial / Urban Dev**
- **Air Traffic Density**

**Safety Thresholds**

**Aircraft Performance Model**

**Define Risk**

**Compute Risk**

**Minimize Risk**

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SBIR Data Rights apply
Algorithm Architecture

Ownership Measurements

Threat Measurements

Multiple-Model Threat State Estimator (TSE)

Rapid Decision Logic

Most Likely Threat State

Adaptation(s)

Possible Tracks

Trajectory Conformance Monitoring

Predicted 4D Threat Trajectory

UAV Ownership Trajectory Predictor (OTP)

Probability of Joint Occupancy

Vehicle Safety Manager
UAS Weather Needs

Small UAS are More Susceptible to Weather Impact:
• Lower Aircraft Speed and Mass
• High Winds and Turbulence and Greater Impact on Speed, Range, and Severity of Disturbance

Weather Data Required by UAS for Flight Planning and Real-Time Control:
• Surface Wind Dir & Speed
• Winds Aloft
• Convection & Turbulence

Minimize Weight by Offloading Sensors and Systems
• Obtain Weather Data via Uplink, Not Additional Sensors

• High-Bandwidth, Low-Latency Data Pipe Needed!
UAS Weather Needs

- UAS Operational Requirements and Procedures Specify Flight Must be **Within Line of Sight** of Operator
- Visual Contact with the UA Enables Collision Avoidance via
  - Visual Detection of Threat Aircraft, and
- Maneuvering to Avoid the Threat

But is That All?
UAS Weather Needs

- UAS Operational Requirements and Procedures Specify Flight Must be *Within Line of Sight* of Operator
- Visual Contact with the UA Enables Collision Avoidance via
  - **Visual Detection of Clouds, and**
  - **Avoidance of Clouds,**
  - **So Other Aircraft Can See and Avoid Ownship**

Cloud Detection and Localization
- Downlink UAS Video Feed
- Image Processing to Find Clouds and Geolocate Them
- High-Bandwidth, Low-Latency Data Pipe Needed!
UAS as Weather Sensors

- Each UAS Senses Atmospheric Information
  - Wind via Difference of Motion through Air and Motion over Ground
  - Temperature, Pressure

- UAS Will Predominantly Fly at Low Altitude
  - Low Altitude Weather Will be the Predominant Product

- Most Useful for:
  - Other UAS
  - Surface Wind/Weather Observation and Forecasts

Rapid, Micro-Scale Weather Updates

- High-Bandwidth Air-Ground Datalink to Obtain Frequent Weather Updates from UA
- Fast Weather Model Update Conducted on Ground
- Uplink New Weather Observation and Forecast
- Hypothesis: Dense Airborne Sensor Network Reduces Complexity of Modeling Required