SENSURION

AEROSPACE

Minneapolis - Denver - Washington, D.C.

Weather Needs for UAS Operations

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November 2016

UAS Weather Needs – *Sensurion Perspective*

Sensurion Background:

- 10-year company history
- Extensive manned aircraft experience
- Extensive weather experience
- Worked with NASA and NCAR in many areas, for many years
- Extensive UAS Experience

We understand how hard it is to operate aircraft safely and reliably – and yet profitably –

…and what it takes to do that, and how the manned aviation industry achieved those goals.

The UAS industry still has a long way to go in all three of those areas, and can learn a lot from the manned aviation industry – but also has specialized needs that are very different.

UAS Weather Needs – *Sensurion Perspective*

Sensurion Background:

- Airline weather requirements, systems, & solutions
- GA weather & flight planning systems
  - R&D, deployment and long-term ops of national systems
  - Preflight & in-flight
  - Dissemination and Collection Systems
- R&D
  - TAMDAR, MDCARS, etc.
  - Weather Radar Systems
  - Weather uplink, downlink, and cockpit displays
  - Turbulence, Icing, Winds, Deicing

We can take advantage of experience in "traditional" weather & aviation, but must also avoid "default thinking"

Typical sUAS Aircraft

TYPICAL Fixed-Wing sUAS:

- Conventional Fixed Wing Design
- Hand, rail, or gear takeoff
- Flight durations 60-120 mins
- Multiple Payload options
- Working toward BLOS
- 0-60 kts, stall speeds 10 kts
- 20 kt max l/d
- Full autoflight avionics
- Variety of recovery systems

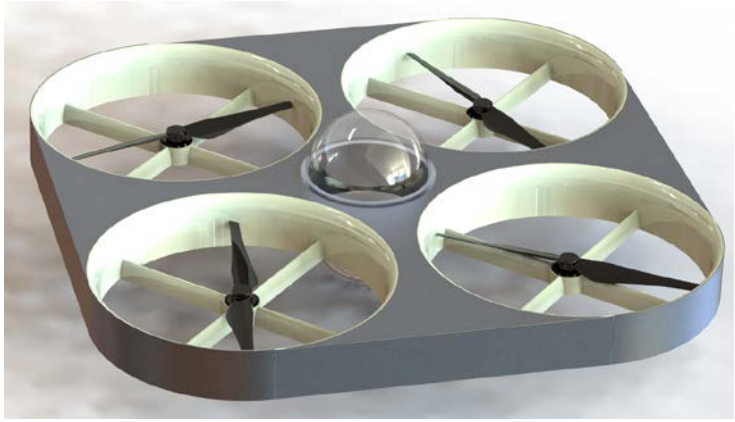
TYPICAL Multirotor sUAS

- Ease of launch and flight
- Flight duration <15-45 min
- Visual/EO sensors
- 0-20 kts speed
- Strong reliance on GPS
- Manual & Limited Autoflight

- Sensurion Sentinel also has tethered configuration

Sensurion Magpie MP-1

Sensurion MP-4



How is “Weather” Relevant to sUAS Operations?

- Planning
  - Can I successfully conduct the mission? Safely?
  - Can I stay within required altitude, geofencing, and other limits for entire mission?
  - Can I successfully recover aircraft at the end of the mission period?
  - What impact will weather have on my mission duration capability?
- Direct Operational Impacts
  - Scheduling jobs, personnel, and logistics
  - Managing challenging or near-limit conditions
  - Reacting to changing conditions
- Contributing Data Back Into the Weather System
  - Alert other operators of changing conditions
  - TAMDAR-type observation input to forecast models

Weather Impacts on Practical sUAS Operations

- Scale Factors of sUAS vs Part 23 Aircraft Make Them Much More Susceptible to Turbulence and Wind Shear:
  - Wing loading is much lower
  - Mass is much lower
  - Wing/Rotor Spans are Much Shorter
- Stall and cruise speeds much lower than Part 23 and Part 25 – winds have a dramatically increased impact
  - Very compressed range of “V Speeds”
  - Cruise speeds top out about where Part 23 begins
  - Approach speeds 8-10 Kts
- Many lower boundary wind speeds can exceed forward flight speeds – thus creating a no-return scenario
- Many sUAS have Precipitation Restrictions

Weather Impacts on Practical sUAS Operations

- Most sUAS are not intended for flight into IMC
  - Icing, precip, loss of Vis/CAVOK all potential issues
  - Ability to maintain VLOS is key to planning and executing many missions
  - How do we characterize ground-to-air “visibility”
- Effects of weather on ground-based (versus aircraft-based) operators themselves
- Temperature effects on Li-Ion battery packs
- Effects of turbulence & winds on mission duration
  - Deviation limits and stabilization energy cost can significantly impact mission duration
- Increasing levels of sUAS autonomy will require reduced weather uncertainty

So… What Weather Information Will Be Needed - *Specifically?*

- **Currently available WX information, tailored for sUAS users**
- **New products that provide much higher spatial and temporal resolution in the boundary layer area, including:**
  - Winds, Turbulence and “Gustiness Factors”
    - We need to look at “Gusts” differently than classical turbulence in low-altitude, sUAS Ops contexts
    - Indexing Gusts/Turbulence to a radically different scale of airframe/limits
  - Visibility – referenced to VLOS-type operations
  - Envelope Protection: Probability of exceeding specific limit factors including:
    - Max Winds versus aircraft return speeds
    - Gusts, Turbulence, Shear – Controllability AND Battery Life
    - Temperature & Density Altitude
    - Visibility variations
    - Precipitation / Icing
    - Variations in altimeter setting during a mission
    - Lightning/Static Buildup

So… What Weather Information Will Be Needed - *Specifically?*

- BLOS Weather Needs
  - Downrange landing and diversion site forecasts / nowcasts
  - Long-duration operation forecasts / nowcasts
  - Corridor-oriented products
- Tethered operations
  - Very long duration operations
  - Electrical considerations – e.g., static and lightning

Weather Sources for sUAS

Will there be a single authoritative source for weather data and translated data for operators?

o Yes and No…

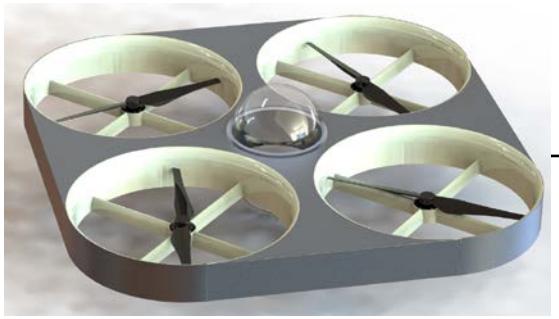
- FAA Will always be a source of regulatory requirements
- Sheer volume of operations & pace of industry/technology growth/change – and low per-ops capital value – will make it very hard for government to take on "primary source" role
- Government is more likely to define trade space, and pedigree/reporting requirements
- Industry may be better positioned to fill the high-volume, low-cost, rapidly evolving direct service needs
- INSURERS may be a critical part of defining and approving WX and other safety-assurance components of this industry

Weather Sources for sUAS

- **Leverage the UAS platforms themselves as a key part of the solution**
  - **Flight stabilization / control systems inherently have turbulence and other atmospheric data**
  - **Real-time observations of boundary layer conditions**
    - **Nowcasting**
    - **Research & modeling**
    - **Calibrate model metrics for individual aircraft types**
  - **Interaction between turbulence, deviation limits/range, and vehicle performance**
  - **Terrain and vegetation database updates**

UAVs as a Weather-Collection Platform – “Micro” AMDAR/TAMDAR/MDCRS

Sensurion MP-1 or MP-4



Thank you!

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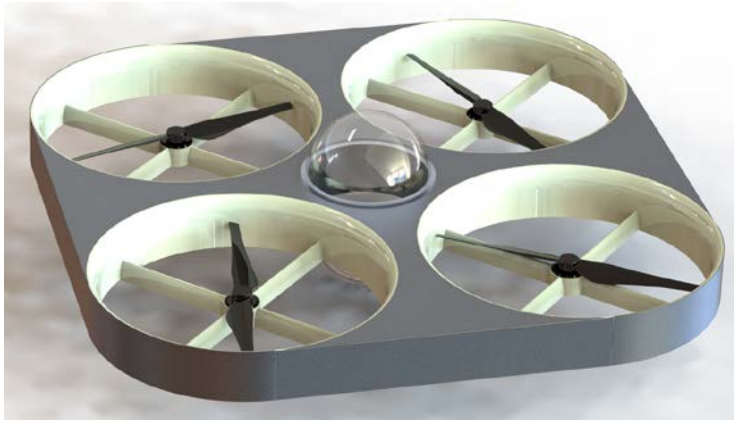

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