SENSURION

AEROSPACE

Minneapolis - Denver - Washington, D.C.

Weather needs and Shortfall for UAS

Joe Burns

Sensurion Company Highlights

- Uniquely positioned as a vertically integrated sUAV platform and services provider
  - FAA-certified UAVs, avionics and sensor platforms
  - Drones as-a-service (“DaaS”)
  - UAV-enabled data management solutions
- Seasoned management team from major airlines, aerospace companies and the US military with deep relationships with the FAA and NASA
- Designed and engineered two distinct UAV airframes
  - Magpie: Fixed wing aircraft
  - Sentinel: Commercial grade drone with unlimited persistence capability from tethered operations
- Partnerships with IBM Bluemix and Watson and Amazon Web Services
- History of providing security and safety professional services to commercial and governmental agencies and successfully transitioned to being a provider of products and software/data services
- Extensive weather operational experience

How is "Weather" Relevant to sUAS Operations?

- Regulatory Requirement for certain 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
  - Managing challenging or near-limit conditions
  - Reacting to changing conditions
- Contributing Data Back Into the Weather System
  - Alert other operators of changing conditions
  - AMDAR-type observation input to forecast models

Weather Impacts on Practical sUAS Operations

- Most UAS are not intended for flight into IMC
  - Icing, precip, loss of Vis/CAVU all potential issues
  - Ability to maintain VLOS is key to planning and executing many missions
  - How do we characterize ground-to-air "visibility"
- Lower boundary layer atmospherics hard to measure, much less model
- Dramatic wind shifts/shear from surface to 500' for small UAS
- Effects of weather on ground-based (versus aircraft-based) operator

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
  - Cruise speeds top out about where Part 23 begins
- 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

- Temperature susceptibility of Li-Ion battery packs
- Effects of turbulence & winds on mission duration
  - Deviation limits can significantly vary impacts on mission duration
- Increasing levels of sUAS autonomy will require reduced weather uncertainty
- Tethered UAS Systems Present Additional Considerations, Including Lightning and Static Buildup
- A briefing is required – but where do the pilots get one?
  - FSS is not yet equipped to handle UAS briefing request
  - Typical sUAS operator will have limited weather training – will need simple, intuitive tools in the field

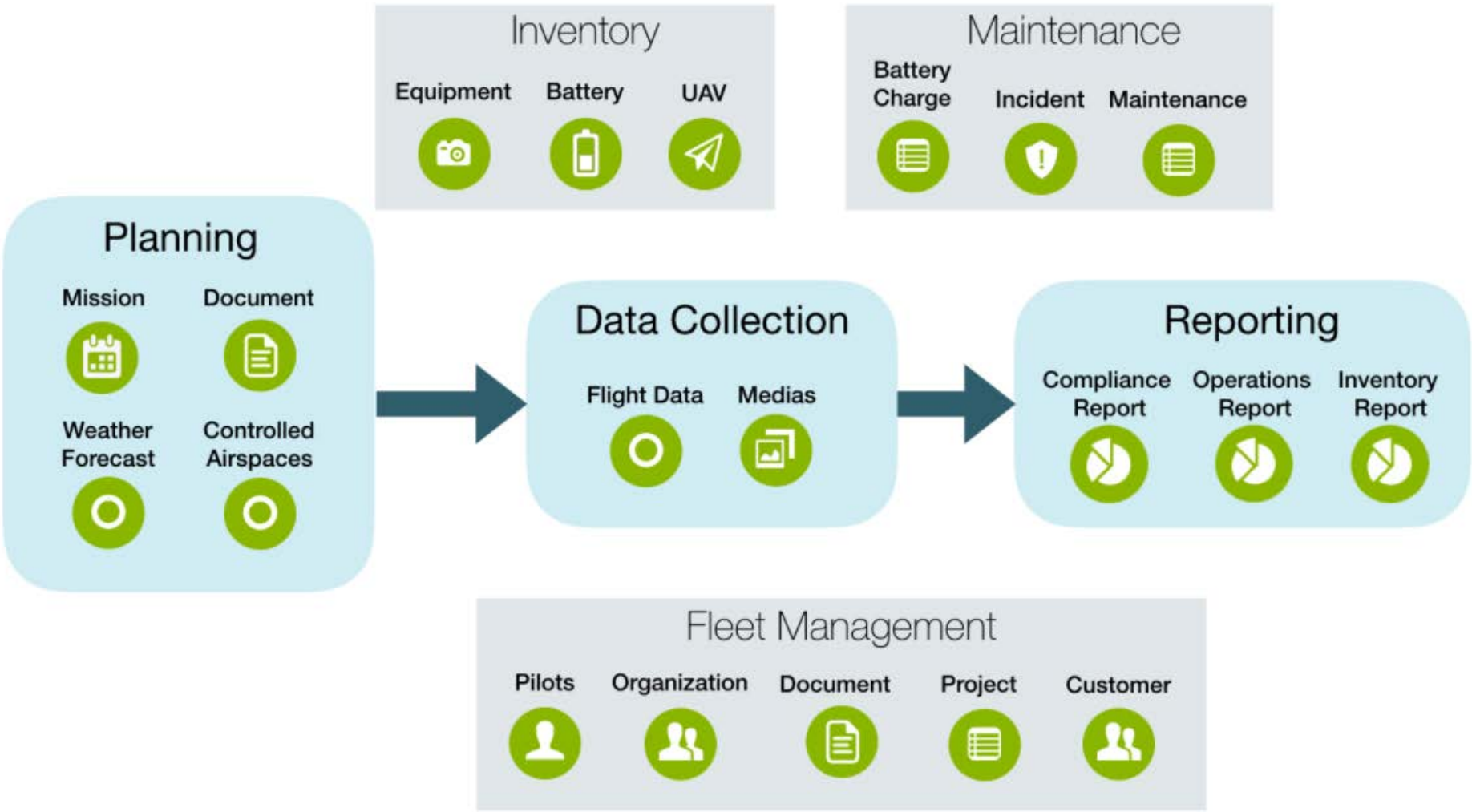
What Weather is available for sUAS Operations

- “EyeDAR”
- METAR, TAF – useful? How to access?
- Winds – 3000 AGL + - not useful
- PIREPS – scale, altitudes, no boundary
- RADAR – planning only
- Datacomm – good news, 4G/LTE
- FSS?
- DUATS?

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
  - Probability of exceeding specific limit factors:
    - 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
  - IFR Briefing system for BVLOS ops

FAA Certified Mission Planning, Management and Reporting



FAA 107 Certified Operations and Reporting

Sensurion Mission Planning

Goal

Obtain high resolution images, orthomosaics and possibly 3D model of assets throughout the East and West Customer Plant Sites in Savage, MN. Images acquired will be used to feed IBM Watson and for review by Customer for (1) Safe Operation, (2) Intelligent enterprise connectivity.

Deliverables

Inspection: Straight / Oblique / NADIR images of each asset from 20-30 ft

- ❑ **Goal:** Part of Customer's "LifeSaver Risks" initiative is to reduce expose to risks that can cause injury or worse. One such initiative is "Working at Height" - which is certainly the case when inspections are being done...whether its the routine facility inspection or in the case of a problematic component or high-value asset, more frequent inspections.

Asset Tracking: Straight / Oblique / NADIR im

- ❑ **Goal:** Incorporating Artificial Intelligen tagging, tracking and cross-utilization

TFRA - Traffic Flow Risk Assessment: 1-2 mi

- ❑ **Goal:** TFRA - Traffic Flow Risk Asses Interaction". This includes everything like, to pedestrians (visitors, contractor they must navigate. Drones can help assess the not only individual intersec

Orthomosaic of site: (area TBD, max 30 acre

- ❑ **Goal:** The output of this effort is a hig measure, give detailed orientation, and

Equipment Needed

- ❑ DJI M600 Pro Hexacopter
  - ❑ Payload A: Sony A6000
  - ❑ LiPo: (6) 5700 mAh batteries
  - ❑ GeoSnap Express - GPS/photo
  - ❑ *Total Estimated Equipment Co lens) + extra LiPo set ($900) +*
- ❑ DJI Transmitter Controller, Charger
- ❑ PPE: Hardhats, steel toe boots (no sn
- ❑ Apple iPad, charging cable
- ❑ PC / Mac Laptop for image review, cha

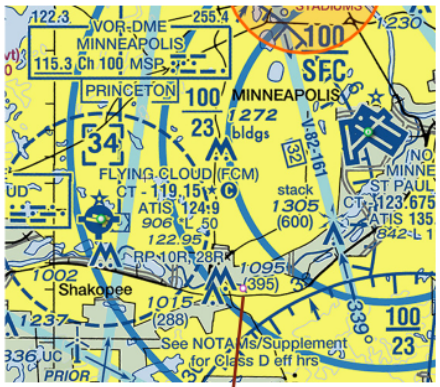
Client: Customer (Savage, MN)

Sensurion Mission Planning

Airspace Verification:

- ❑ Lat 44°47'02.1"N Lon 93°19'57.8"W
- ❑ Class G YES NO

Waiver Info (if required) N/A



Customer plant sites are within Class G airspace, under Class B floor @ 2300 ft AGL. Operation will not exceed 400 ft per FAA Part 107 Regulations

Client: Customer (Savage, MN)

Sensurion Mission Planning

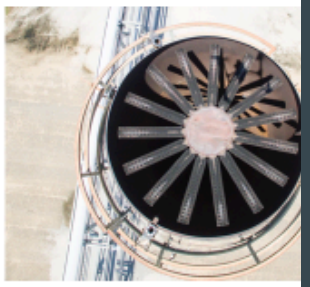
Mission Outline:

Straight on images of each asset from:

- ❑ 20-30 ft from structure
- ❑ Specific infrastructure not reachable by climbing, or safe access
- ❑ Specific assets that are susceptible to wear, decay or breakage

3D Model Images of East and West Site:

- ❑ NADIR, Straight and Oblique
- ❑ Autonomous and Manual overlap



NADIR Images above each asset from:

- ❑ 20-30 ft from structure
- ❑ Specific infrastructure not reachable
- ❑ Specific assets that are susceptible to
- ❑ Provides accurate georeferencing of

Orthomosaic of site (area TBD, max 30 acres

- ❑ 400 ft
- ❑ Overlap 80/50
- ❑ East site and West site

Client: Customer (Savage, MN)

Sensurion Pre-flight Checklist

Weather:

- ❑ Winds (max 12mph surface) _____
- ❑ Visibility (min. 3 statute mi) _____
- ❑ Aerial and Ground Hazards

_____

Equipment Check:

- ❑ DJI M600 Pro UAS System
  - ❑ FAA Registration sticker affixed
  - ❑ Ronin MX gimbal balanced and calibrated
  - ❑ A6000 Payload secure, lens clean, memory card formatted, cabling attached
  - ❑ LiPo(s) charged
  - ❑ Transmitter Controller charged
- ❑ Apple iPad charged
- ❑ PC/Mac Laptop for image review, Charger
- ❑ PPE: Hardhats, steel toe (or at least boots, no sneakers), High visibility vest

Personnel:

- ❑ Define PIC and Define VO(s) along with their positions during flight for each asset location
- ❑ Ensure PIC and VO are clearly ok to fly
  - ❑ No alcohol for at least 8 hours prior
  - ❑ No drowsiness from prescriptions
  - ❑ Not tired or stressed to a point where flying would be hazardous or unclear
- ❑ Flight Operation
  - ❑ SAFETY is the utmost goal at all times, not Image Capture or other Flight operations
  - ❑ Define Area of Operation, Takeoff and Landing Zones
  - ❑ Mission Plan in-hand
  - ❑ Documentation available within AOI (Insurance, Licenses, etc)

Location: _____ **Contact:** _____

Date: _____ **Time:** _____ [____] zone

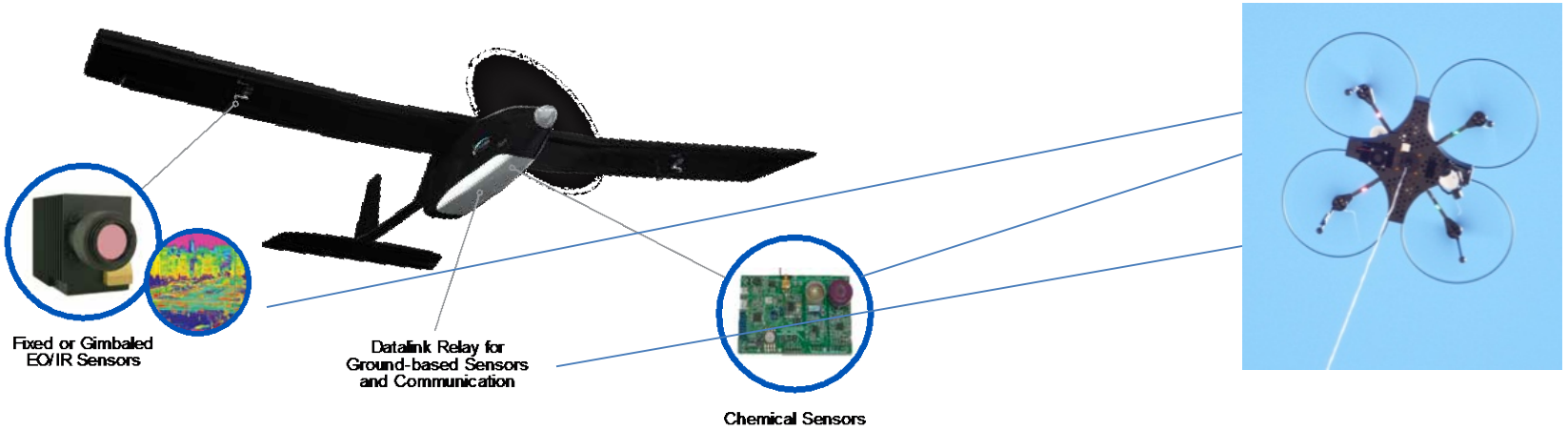
Phone: _____ **Email:** _____

Client: Customer (Savage, MN)

Additional Weather from UAVs?

- **Leverage the UAS platforms themselves as a key part of the solution**
  - **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**

sUAV-Based IoT Sensors & Data Management



Sensors

- Airborne, fixed-point, & mobile sensors
- Optical / High-Definition optical imaging / Infrared (IR) / Enhanced IR
- Chemical / Radiological / Toxicity
- Atmospheric - Temperature / Pressure / Humidity / Wind direction / speed
- Turbulence / Ride Quality
- Lighting Systems
- RF detection / Radio Relay

Data Management

- Cloud-based data management
- Atmospheric plotting
- Winds aloft profiling
- Plume modeling
- Carbon output monitoring
- Traffic monitoring
- Emergency communication provision

UAV-Enabled Data Solutions

Sensurion 4G/LTE IoT data module

Sentinel or Magpie aircraft

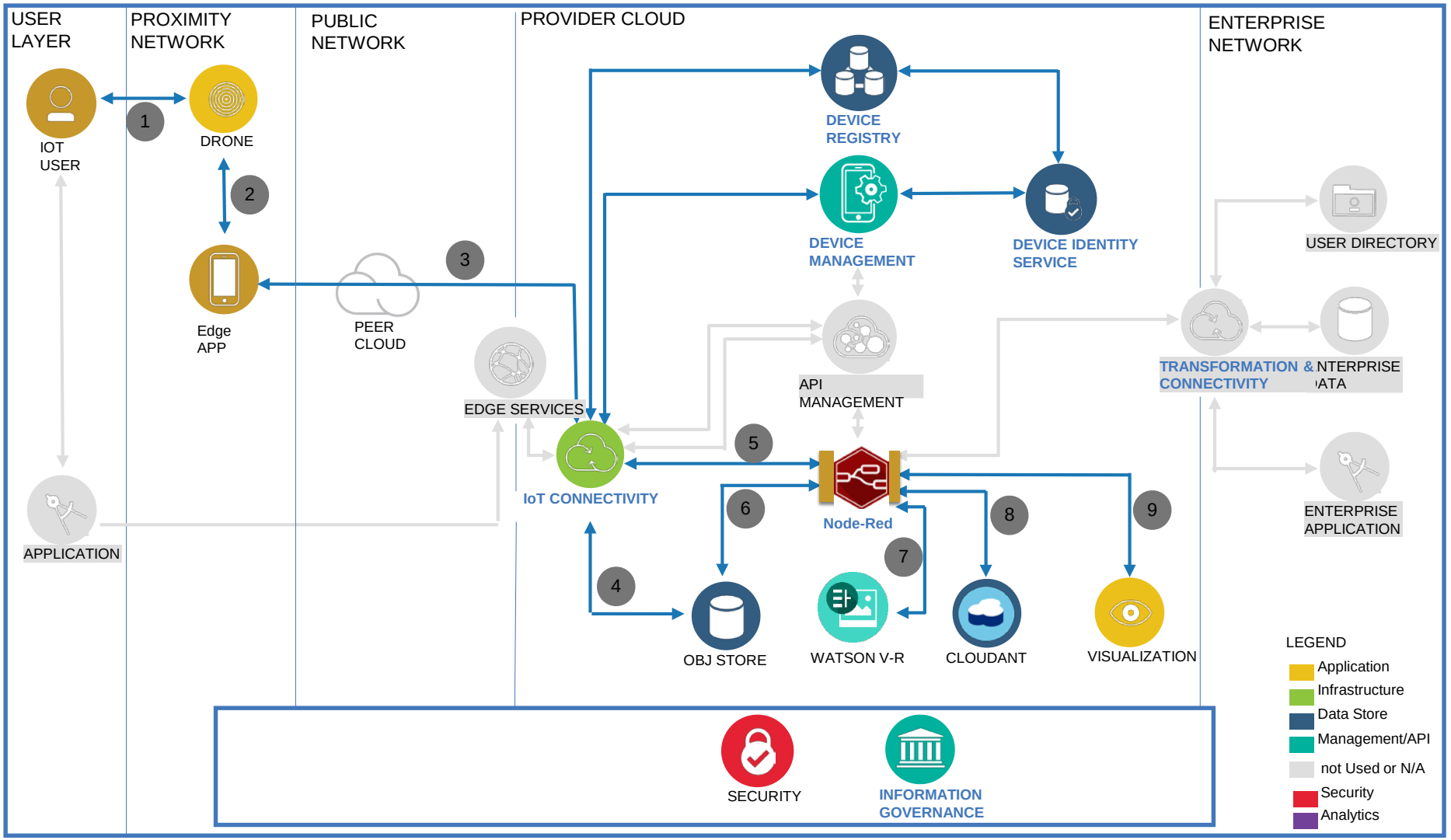
The “cloud” - IBM Bluemix and Watson, AWS and Azure

Mobile apps

Security

Asset Management

Sensurion Communications and Watson IoT Architecture



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Thank you!

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