National Aeronautics and Space Administration

Armstrong Flight Research Center

Flight Test Capabilities and Opportunities for the Applications of Wireless Data Acquisition Systems

PWST Workshop 2015

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Armstrong Mission

Advancing technology and science through flight

1. Perform flight research and technology integration to revolutionize aviation and pioneer aerospace technology
2. Validate space exploration concepts
3. Conduct airborne remote sensing and science observations

Ikhana MQ-9 Predator B
Unmanned Aircraft System

Stratospheric
Observatory for
Infrared Astronomy
(SOFIA)

X-56 Multi-Utility
Technology Testbed

Armstrong Vision

To separate the real from the imagined through flight




Armstrong Capabilities

Core Competencies

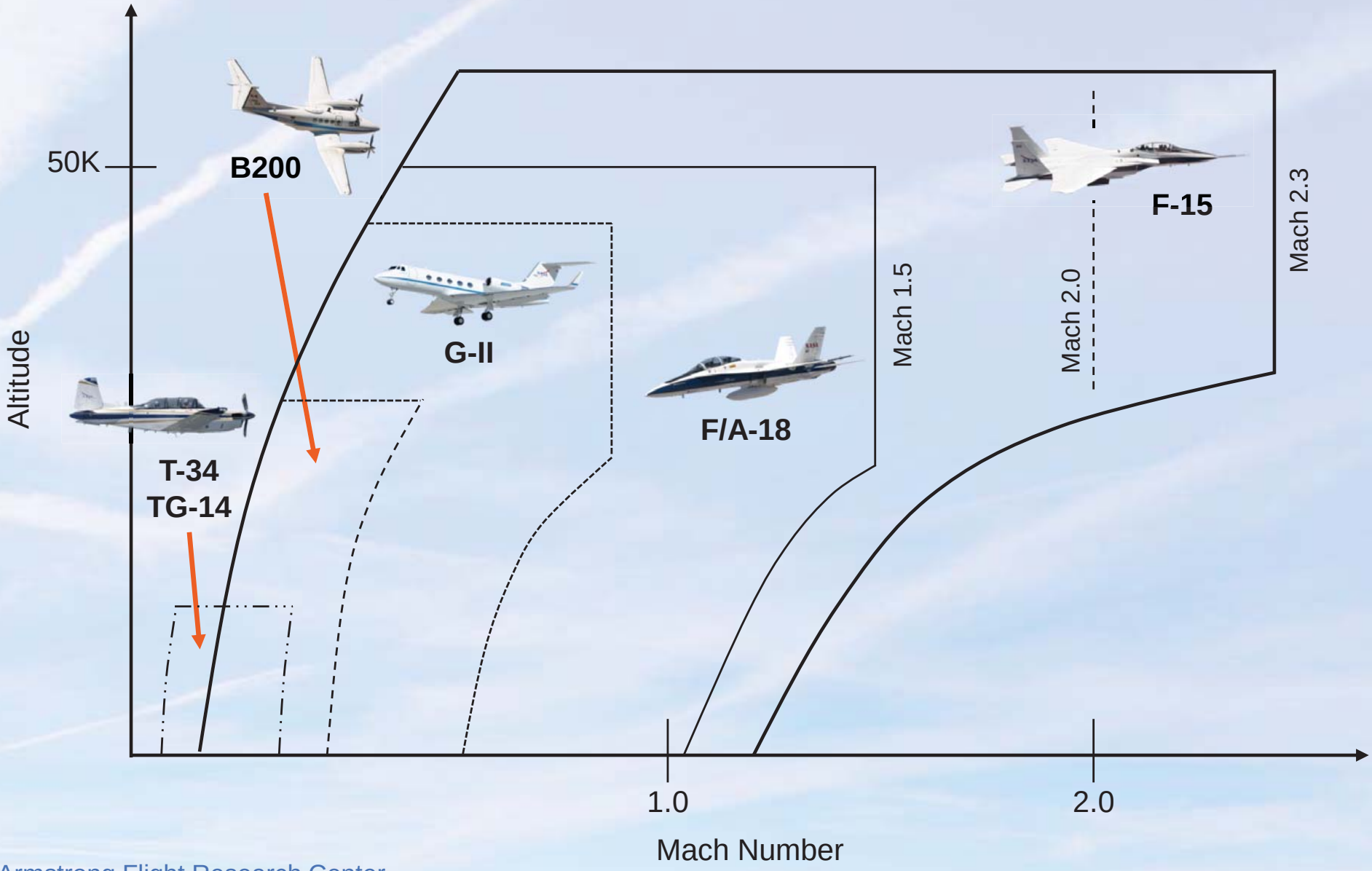
- Flight operations and engineering staff
  - Back shops
- Atmospheric flight research and test
  - Flight safety and risk management
  - Flight project and mission management
  - Flight research technology
  - Flight test operations
  - Experimental aircraft (piloted and unmanned)

Facility Capability

- Experimental/testbed aircraft
- Unmanned aircraft systems
  - Certificates of Authorization (COA)
  - Ground control stations
  - Full range of UAS sizes and capabilities – 40 years experience
- Airborne science platforms
- Range and aircraft test facilities
  - Western Aeronautical Test Range
  - Research Aircraft Integration Facility
  - Flight Loads Laboratory
  - Building 703

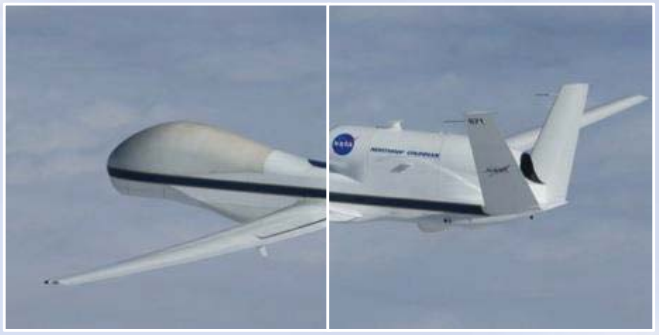
NASA AFRC Flight Research Envelope

Support Aircraft and Test Range Requirements



Testbed Aircraft

King Air
B200



Global Hawk
RQ-4

Ikhana
Predator B

Mentor
T-34

Dragon Lady
ER-2

Eagle
F-15

Hornet
F/A-18

Gulfstream
G-III

Dryden Aeronautical Test Range Capabilities





- Telemetry/uplink (fixed and mobile)
- Time-space-position information (radar, differential GPS)
- Video monitoring and recording
- Radio frequency (RF) communication
- Ground voice communication
- Real-time data monitoring and processing
- Data distribution
- Data archive
- Range safety (FTS, EFTS, RSO station)

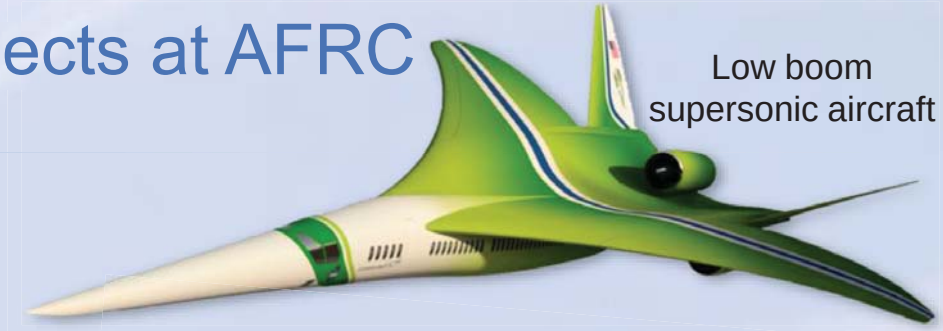
Fight Load Lab Capabilities

- Structural loading
  - Load frames, hydraulic actuators, and load cells
  - 84 channels of hydraulic load control
  - Ground vibration and structural mode interaction testing
- Thermal loading
  - Quartz lamp and graphite element heating
  - 264 channels of thermal control
  - Low- and high-temperature chambers
  - Liquid and gaseous nitrogen supply systems
- Instrumentation
  - Conventional and fiber optic instrumentation

Stiffness Characterization and Load Calibration

- Structural evaluation
  - Photogrammetry for full-field strain and spatial deformation
  - Transient infrared pulsed thermography for non-destructive evaluation
  - Acoustic emission sensing for damage detection
- Data acquisition
  - Approximately 2,000 channels of data acquisition

Some Current, Recent & Future Projects at AFRC



Low boom supersonic aircraft

Towed Glider Air-Launch System

X-48C Blended Wing Body

Flight research on the F-15 and F-18 aircrafts to understand sonic booms and how to over-land supersonic flight possible

X-56A Multi-Utility Technology Testbed

Quad rotor flying with Expandable Variable-Autonomy Architecture

Preliminary Research Aerodynamic Design to Lower Drag (PRANDTL-D)

Gulfstream III

ACTE research

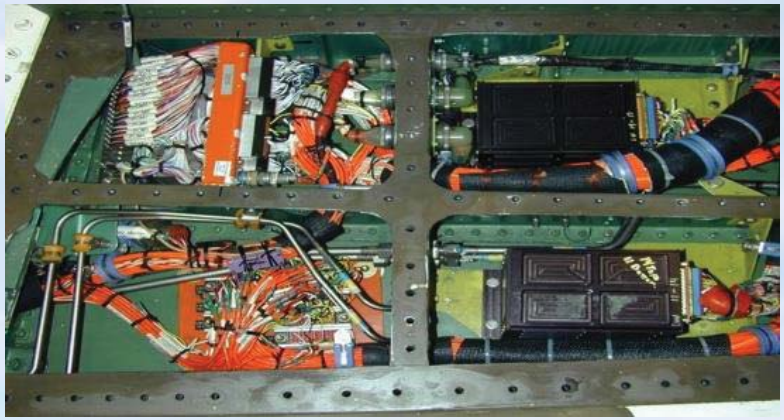
- A U.S. Air Force C-17 is used for Vehicle Integrated Propulsion Research (VIPR) testing.

Flight Instrumentation Capabilities

- Design Instrumentation Systems for Ground & Flight tests:
  - Data Acquisition Development
  - Custom Circuit Board Design
  - Sensor selection, installation and calibration
  - Fiber Optic Sensing System (FOSS)
  - Power Distribution Systems Design
  - Real-time embedded data processing systems
  - Satellite Communication Applications
  - Data Telemetry (PCM, IP-over-TM)
- Support Instrumentation-Related Activities On All Flight Platforms
- Support Flight Test Operations
- Process flight data using a variety of tools

Issues with Conventional Instrumentation

- Additional weight (wires, connectors brackets, mounting plates…)
- Must penetrate aircraft structure for wire routing
- Requires longer aircraft down time
- Requires extensive aircraft wiring labor
- Requires extensive, costly engineering
- Not convenient for quick add-ons



Wireless Solutions

- **NASA AFRC is studying wireless sensors/systems**
  - Benefits: reduced cost, integration schedule, aircraft weight and engineering time
  - Allows quick addition of sensors without extensive wiring modifications
  - Avoids additional penetrations of aircraft structure (bulkhead, firewall, etc.)
  - Can be used for moving parts (engines blades, landing gears, etc..)
  - Allows remote sensing/measurement in inaccessible or dangerous places

- **Wireless sensors/systems needed:**
  - Pressure
  - Temperature
  - Strain
  - Fuel flow
  - Acceleration (low and high frequency)
  - Acoustic
  - Video camera
  - Torque
  - Position
  - Others?

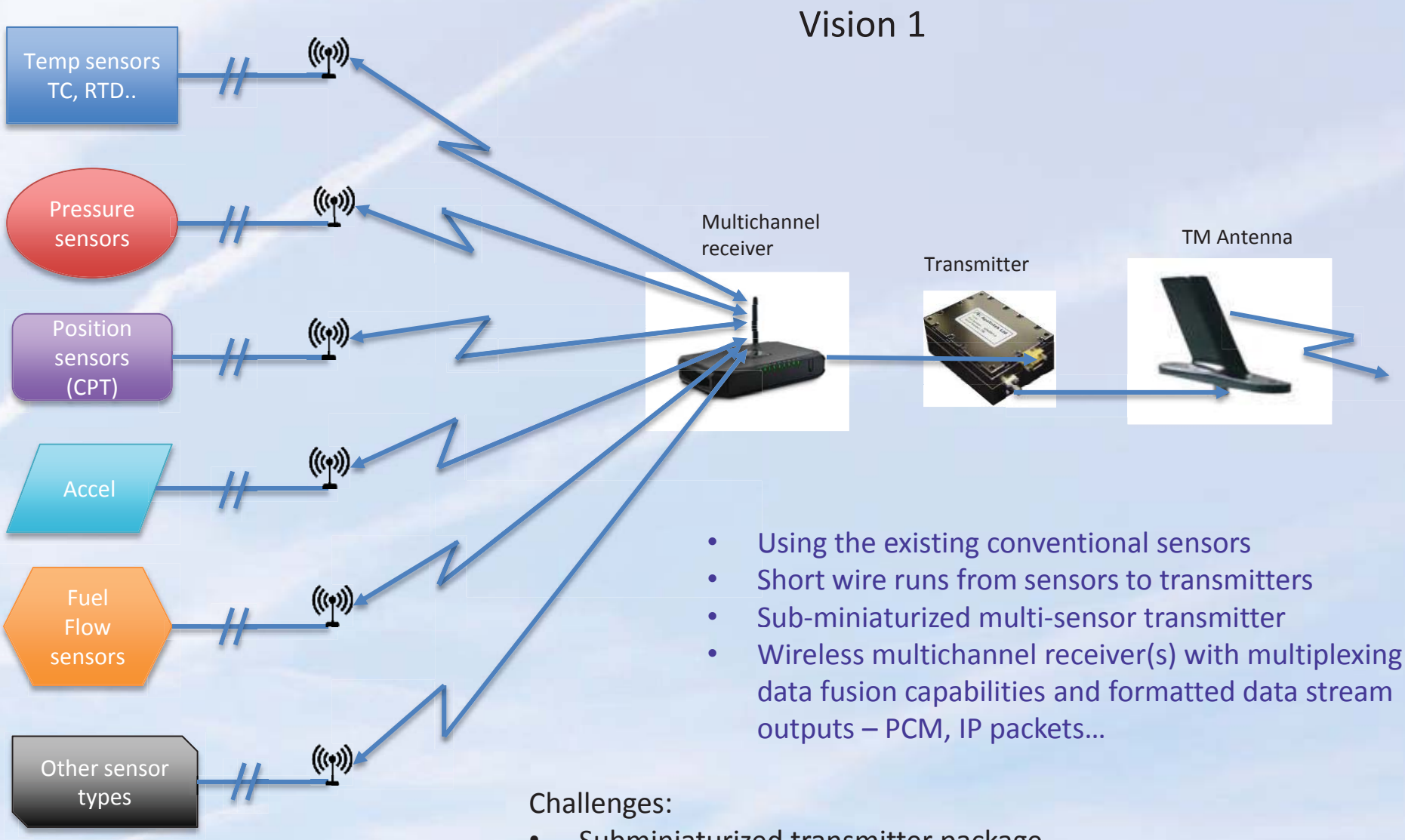
- **Environment Constraints/Requirements**
  - High altitude (50k feet)
  - Extreme temperature condition (-60 to 160 disagree F, operational)
  - High g vibration (depending on where the sensor is used it can be up to 22 g rms)

Wireless Solutions Cont'd

- **Other constraints/requirements**
  - Sensor power/excitation (batteries vs wireless powered)
  - Meeting defined EMI/EMC standards
  - Battery operation concerns
  - Spectrum (L, C bands, ISM band)
  - Data security – encryption protocols
  - Data rate capabilities
  - Number of channels per system
  - Low power requirement
  - Connection types (P2P or P2MP)
  - Miniaturization (as small as possible)
  - Multiplexing receivers with required outputs
  - Other?

- **Expectation to gain from this Workshop**
  - What passive wireless sensors/systems are currently available that can be used for AFRC flight test applications?
  - Learn more about wireless technologies to help my Branch's research/development
  - Learn about wireless data security protection methodologies
  - Partnership with Wireless Community in flight testing of wireless data acquisition systems or sensors.
  - An opportunity to make connection with Wireless Community for exchanging knowledge of wireless technologies and requirements

AFRC Vision of Active Wireless Systems for Flight Test



- Using the existing conventional sensors
- Short wire runs from sensors to transmitters
- Sub-miniaturized multi-sensor transmitter
- Wireless multichannel receiver(s) with multiplexing & data fusion capabilities and formatted data stream outputs – PCM, IP packets…

Challenges:

- Subminiaturized transmitter package
- Multi-sensor interface and serialization for transmitting
- Number of channels and data rate
- Passing environmental requirements

AFRC Vision of Active Wireless Systems for Flight Test

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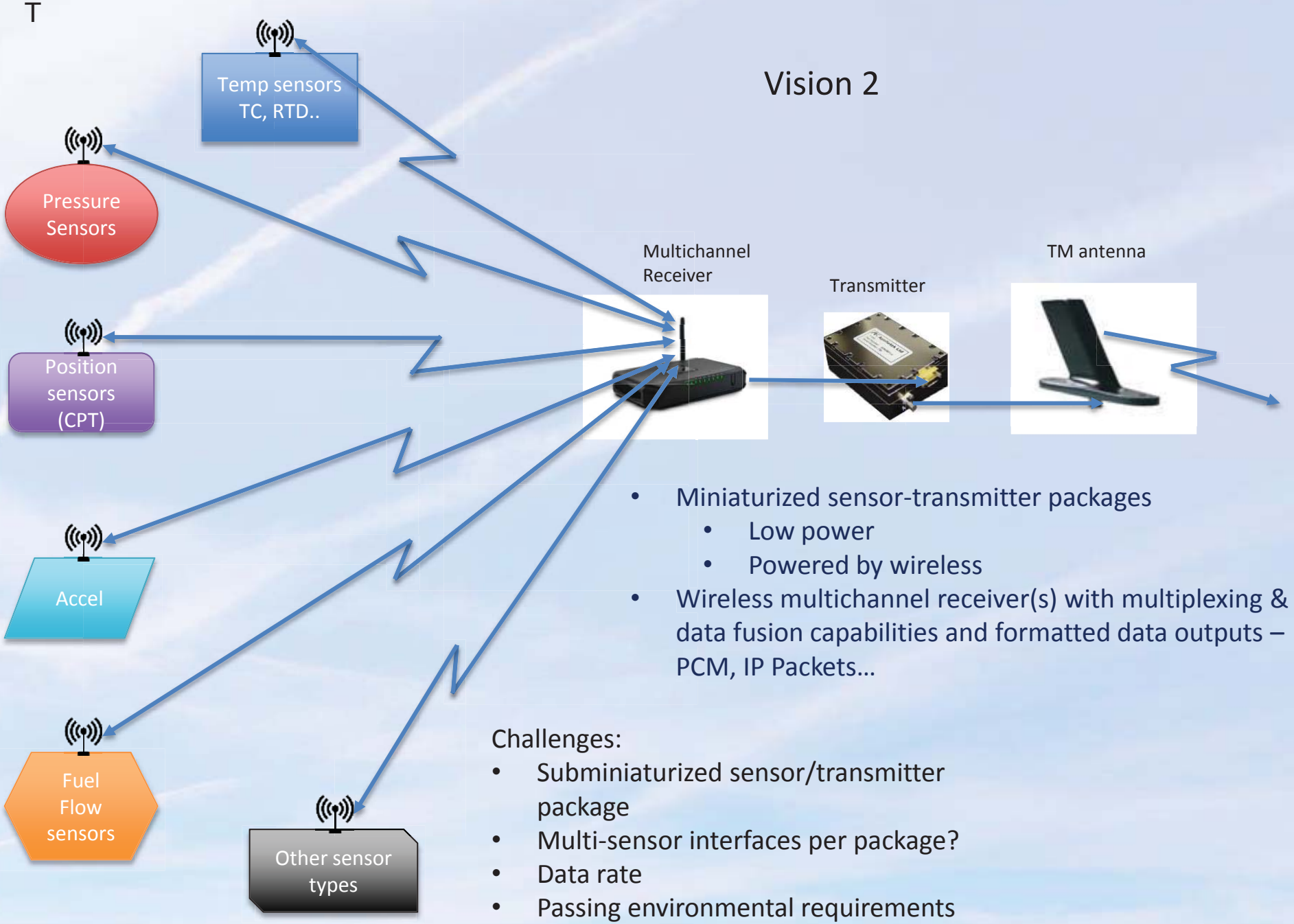
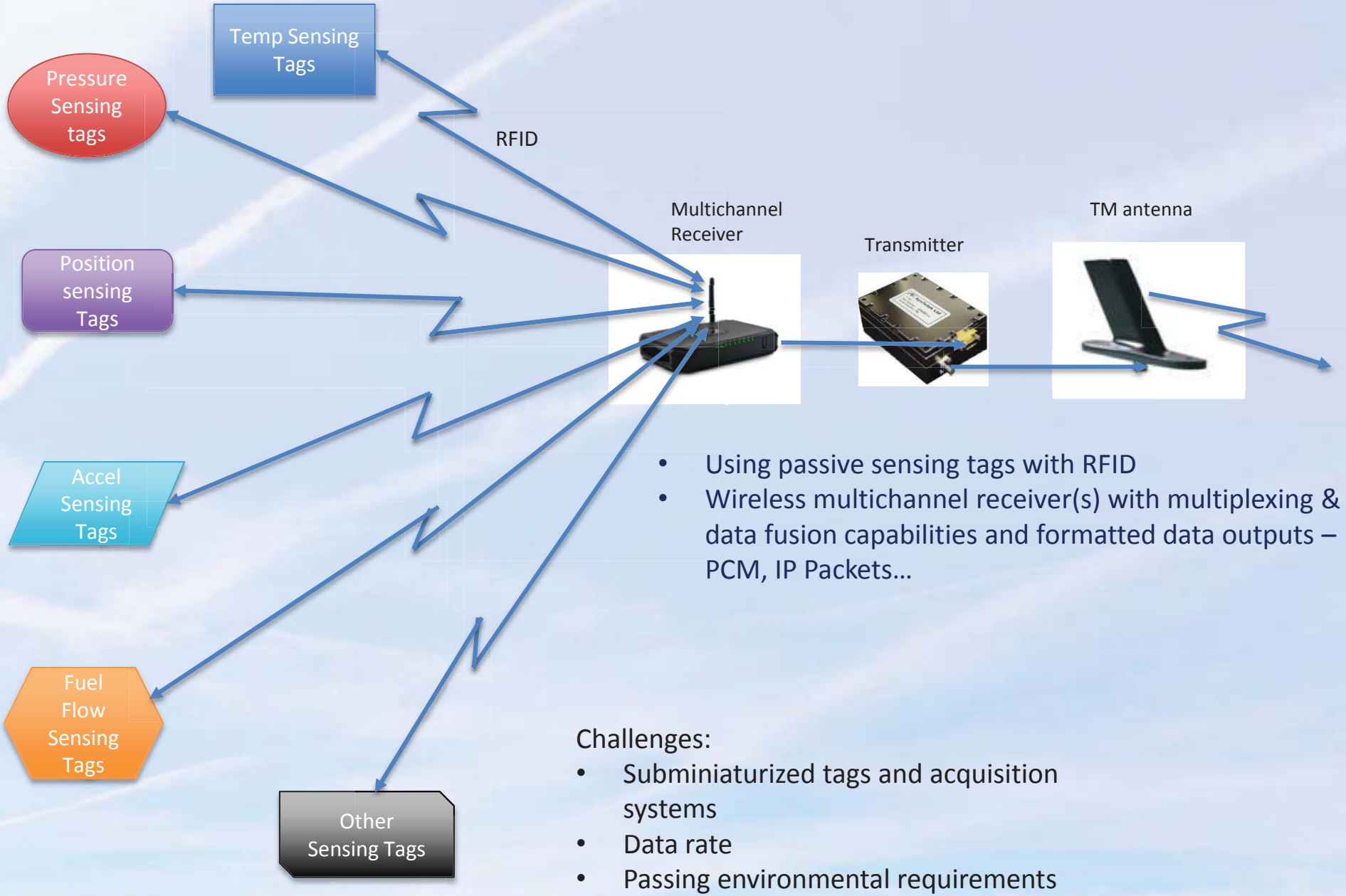


- Miniaturized sensor-transmitter packages
  - Low power
  - Powered by wireless
- Wireless multichannel receiver(s) with multiplexing & data fusion capabilities and formatted data outputs – PCM, IP Packets…

Challenges:

- Subminiaturized sensor/transmitter package
- Multi-sensor interfaces per package?
- Data rate
- Passing environmental requirements

Passive Wireless Sensors for Flight Test



- Using passive sensing tags with RFID
- Wireless multichannel receiver(s) with multiplexing & data fusion capabilities and formatted data outputs – PCM, IP Packets…

Challenges:

- Subminiaturized tags and acquisition systems
- Data rate
- Passing environmental requirements

Summary:

- AFRC has a broad flight test capability that is suitable for flight testing of any wireless sensor suite
- I am here to learn how **passive** wireless sensors might be used in flight testing at AFRC– please educate me on what you have!
- I want to learn about passive wireless sensor technologies under development or available
- I am looking for opportunity for partnerships in developing wireless sensor systems
- I am looking for other **active** wireless sensors on the market that are applicable to flight testing