

National Aeronautics and Space Administration



## **Armstrong Flight Research Center (AFRC)**

# **Wireless Instrumentation System for Flight Research/Testing at NASA AFRC**

**PWST Workshop 2017  
Montreal, Canada  
Presenter: Richard Hang**

**Presenter:** Richard Hang, Chief of the Sensors and Systems Development Branch.

**Company:** NASA Armstrong Flight Research Center (AFRC)

**Location:** Edwards Air Force Base, California, USA

## Agenda:

- **Overview AFRC's flight test Capabilities**
- **Issues with Conventional Instrumentation Methodology**
- **Wireless solutions with Issues and/or challenges**
- **AFRC's Vision of Wireless systems for flight test applications**
- **AFRC's effort in developing wireless system**
- **Partnership with AFRC on wireless development and/or flight testing.**



## Armstrong's Capabilities in Atmospheric Flight Research and tests

- Flight Test Operations
  - *Back shops (Fabrication, sensors calibration and environmental)*
  - *Control room*
- Engineering Expertise
  - *Various aircraft types*
  - *Avionics systems*
  - *Instrumentation systems*
  - *Sensing Techniques*
- Flight Safety and Risk Management
- Flight Project and Mission Planning/Management
- Variety of experimental manned aircraft fleet to choose from, including airborne Science platforms
- Various Sizes of UAS (Ikhana, Global Hawk, others)
- Aeronautical Test Range Capabilities (Telemetry, Communication, Radar, Video, Flight Termination System)
- Aircraft Test Facilities
  - Flight Load Lab
  - Flight Simulations

# Current AFRC Aircraft Fleet



**Remote Piloted  
PTERA**



**King Air  
B200**



**Global Hawk  
RQ-4**



**Ikhana  
Predator B**



**RC Model  
DROID 2**



**TG-14**



**Mentor  
T-34**



**Dragon Lady  
ER-2**



**Eagle  
F-15**



**Hornet  
F/A-18**



**X-56 Multi-Utility  
Technology Testbed**



**Science Platform DC-8**



**Gulfstream G-III**



**SOFIA 747SP**



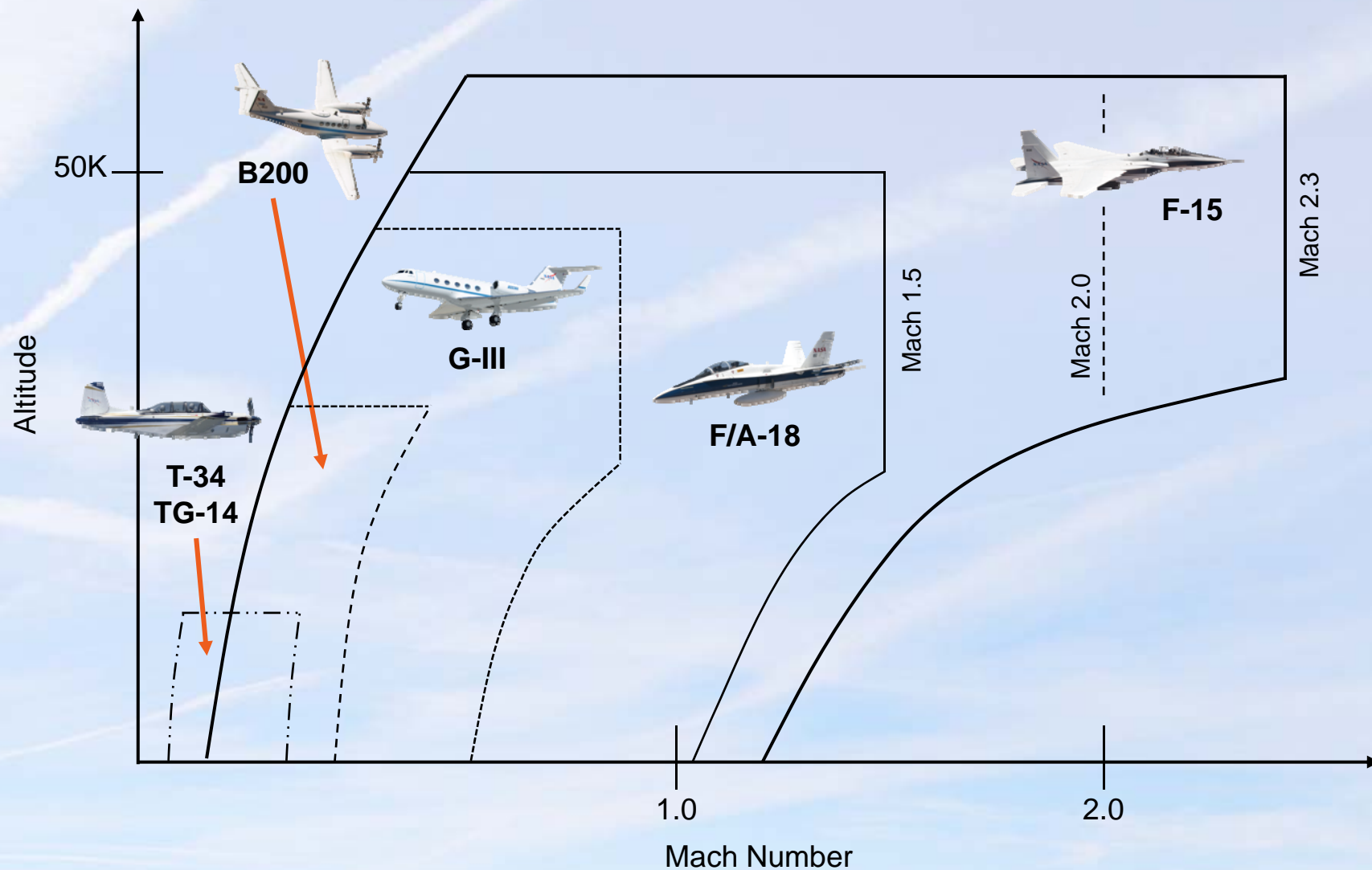
**X-57 electric  
Airplane**



**Prandtl  
Model airplane**

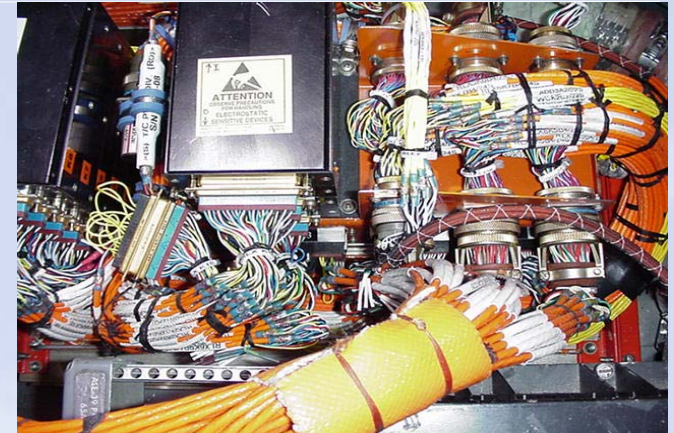
# NASA AFRC Flight Research Envelope

*Support Aircraft and Test Range Requirements*



# Conventional Flight Instrumentation Capabilities (Wired)

- Data Acquisition Systems
- Custom Signal Conditioning
- Sensor selection, installation and calibration
- Power Distribution Systems
- Real-time data processing & Distribution systems
- Satellite Communication, GPS acquisition
- Data Telemetry (PCM, EVTM)
- Aircraft's project wiring and V&V process
- Process and publish post flight data
- Address all requirement changes for different projects or within one project



# Issues with Conventional Instrumentation

- Additional weight (wires, connectors brackets, mounting plates...)
- May not access to hard to reach structure areas for wiring
- Must penetrate aircraft structure for wire routing
- Requires longer aircraft down time
- Requires extensive aircraft wiring labor
- Requires extensive and costly engineering for each flight project
- Not convenient for quick add-ons

*Most of these issues could be solved if we have the right kind of wireless instrumentation systems!*



# Wireless Solutions

## ▪ **Benefits:**

- › Reduced cost, integration schedule, aircraft weight, and engineering time
- › Allows quick addition of sensors without extensive wiring modifications and long aircraft downtime
- › Avoids penetrations of aircraft structure
- › Can be used for sensing moving parts (engines blades, landing gears, etc..)
- › Allows remote sensing/measurement in inaccessible or dangerous places
- › Quick turn around time for different projects

## ▪ **Issues/challenges for flight test applications:**

1. There will be many different brands/types of wireless sensors/systems that use different protocols for data communication – need a wireless system that accepts different communication protocols and frequencies.
2. The wireless data receiving systems currently can handle one frequency band and/or one communication protocol at a time. Which will lead to only use sensors with the same communication protocol and frequency. This will limit sensor selection and/or need multiple different receivers.
3. Very few providers of COTS wireless sensor technology designed to meet the need of flight systems
4. Instrumentation system for flight test requires interfaces to different sensor types (pressure, temperature, accelerator, strain, etc...) and large numbers of each sensor type in each flight.
5. Flight test will interface to both passive and active wireless sensors. How would be the effective way to deliver power to the remote sensors wirelessly?

# Wireless Solutions (continue)

- **Issues/challenges (continue):**

6. Must meet EMC/EMI technical standards to avoid interference problem to avionic system operations.
7. Flight test at AFRC requires compliance to the government's spectrum management/allocation. This would affect the channel bandwidth and in turn affects the data throughput.
8. Majority of available COTS wireless sensors/systems operate within Industrial-Scientific-Medical frequency band (ISM band) which could be susceptible to interference from other devices operating in the same band.
9. Simultaneous sampling of multiple sensors would require an effective degree of time synchronization. What would be the best way to synchronize time for all sensors and receivers?
10. Flight qualification (temperature, vibration and altitude)
11. Miniaturized sizes

# Vision of Wireless Instrumentation Systems for AFRC

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- Immediate focus

- › Using Radio Frequency as data communication method.
- › Develop a system that can supplement the conventional instrumentation
- › A system that would address the needs of spectrum compliance and technical standards, while being able to rapidly accommodate a dynamic range of operating frequencies and protocols
- › A system that would implement a network wide time synchronization
- › A system that can serve as an adaptable platform to rapidly advance the TRL of emerging wireless sensor technology through flight test.

- Future studies/enhancements:

- › Using Visual Light (LiFi) and/or laser as data communication medium to mitigate RF interference issue and enhancing the data throughput
- › Wireless power distribution to sensor nodes -- magnetic field radiation, etc.

# What we are developing...

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- **Software Defined Radio based Wireless Instrumentation System**
  - › To provide an efficient and comparatively inexpensive solution to the high costs and minimal flexibility in the traditional hardware based radio devices
    - All system configuration changes are modified through software instead of physical hardware.
  - › SDR provides the RF communication front end to communicate with various sensor node technology
  - › Allows multi-modes, multi-bands and/or multi-functionalities
    - Reprogrammable to accommodate a wide variety of current and future protocols
    - Can be modified to operate on wide suite of frequencies
    - Interfaces with the IP-based instrumentation network
  - › Streamline the process of integrating new wireless systems on to the AFRC aircraft
    - Reduce partnership cost
    - Simplify partnership process
    - Advance the TRL of your wireless technology faster

# What we are developing (continued)

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## **Up-to-date progress:**

- Preliminary custom system software, to work with the SDR, is being developed
- COTS SDR hardware was purchased and bench tested
- Verified communication with COTS transceivers that operate on dissimilar protocols and frequencies without hardware modification
  - » XBEE protocol, 2.4 GHz
  - » LoRa protocol, 900 MHz
- A basic prototype system is close to completion

## **Forward plan:**

- Complete the prototype system and perform a complete lab testing with COTS non-airworthy system hardware and sensors
- Finalize system development plan
- Partner with wireless communities for collaboration or system hardware and software development contract
- Finalize the custom system software development
- Identify flight qualified hardware and build the flight system
- Port the prototype software to the flight system
- Perform airworthy qualification process, aircraft integration, and flight testing

# SBIR Proposals

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- NASA has Small Business Innovation Research (SBIR) and Technology Transfer (STTR) solicitation annually
  - › Visit SBIR website: [www.sbir.nasa.gov](http://www.sbir.nasa.gov) for more information
  - › AFRC SBIR POC: Mark Davis, (661) 276-2241, [mark.c.davis@nasa.gov](mailto:mark.c.davis@nasa.gov)
  - › For Wireless Instrumentation ideas, refer to the A2.01 Subtopic (Flight Test and Measurements Technology). We are looking for innovative ideas for flight test and measurement techniques including the following ideas for wireless systems:
    - » Power and data transmitting
    - » Wireless data communication technologies using RF, laser, light, etc
    - » Wireless power distribution

# Information on Partnership and Collaboration with AFRC

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- NASA AFRC's assets, facilities and staff are available in certain circumstances to support external organizations.
- NASA missions have priority, but all Centers are encouraged to support on an as available basis if the proposed activity is in alignment with NASA's core competencies
- Wireless flight instrumentation has been and continues to be of interest to the NASA Armstrong Flight Research Center.
- The Partnership/collaboration process includes the following :
  - Solidify the requirements for the overall activity
  - Estimate the resources required to complete the activity
  - Capture the requirements at a top level and the cost estimate for the agreement between NASA AFRC and the customer organization. [uses the authority granted to NASA in the Space Act of 1958]. It is organized into two parts: those parts that are the responsibilities of AFRC and those responsibilities of the customer.
  - Negotiate the final terms of the agreement to be signed by both parties.

# Information on Partnership and Collaboration with AFRC

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- The agreement process would be handled by NASA Armstrong's Advanced Planning and Partnerships Office.
- There are two types of documents that are generated:
  - › One is a Memorandum of Agreement (executed under NASA's Space Act Authority) that captures at a high level the scope of the activity, who will be responsible for what, a cost estimate, POC's intellectual property, liability, etc. Armstrong's Advanced Planning and Partnerships Office could take the lead in developing this document.
  - › The other types of documents are project specific documents that are typically put in place for an efficient, safe and timely flight experiment such as: Project Plans, Schedules, Objective and Requirements Document (ORD), etc. Usually the Project Office that will be responsible for managing the execution of the activity would lead in the development of these documents.
- NASA Armstrong resources to carry out the activity are estimated and a cost associated with that is developed.
- As part of the negotiation, often the scope is increased or decreased to fit what is financially possible for the customer.

# Information on Partnership and Collaboration with AFRC

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- On a Reimbursable basis, NASA AFRC can provide the full spectrum of involvement. Our participation could range from support for a simple flight experiment/test with minimal involvement or full involvement to include collaboration on the technical development of wireless technology.
- By Reimbursable we mean that the customer would shoulder the entire cost of the effort to includes all AFRC labor and non-labor costs.
- NASA Armstrong's Advanced Planning and Partnerships is Armstrong's principal POC for external partnerships and collaboration.
- Here is the POC info:
  - › Mr. John Del Frate
  - › Director, Advanced Planning and Partnerships Office
  - › 661-276-3704
  - › [John.h.delfrate@nasa.gov](mailto:John.h.delfrate@nasa.gov)

## Information on Partnership and Collaboration with AFRC

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- There are two Center approvals for taking on Reimbursable work.
  - › The Tactical Management Board (TMB) determines if this is the sort of work that is a good match for AFRC competencies and strategic plan.
  - › The Project Management Board (PMB) determines if the Center has the right resources in the right time frame to carry out the activity. The PMB also determines what the final cost estimate will be. After this approval, we have the green light to sign the Space Act Agreement (the MOU).
- All Reimbursable work is done on a “cost” basis. It is not performed on a “fixed price” basis. If it costs less, funds would be returned. If it costs more, then more funds would have to be collected before the effort can continue.

# Conclusion:

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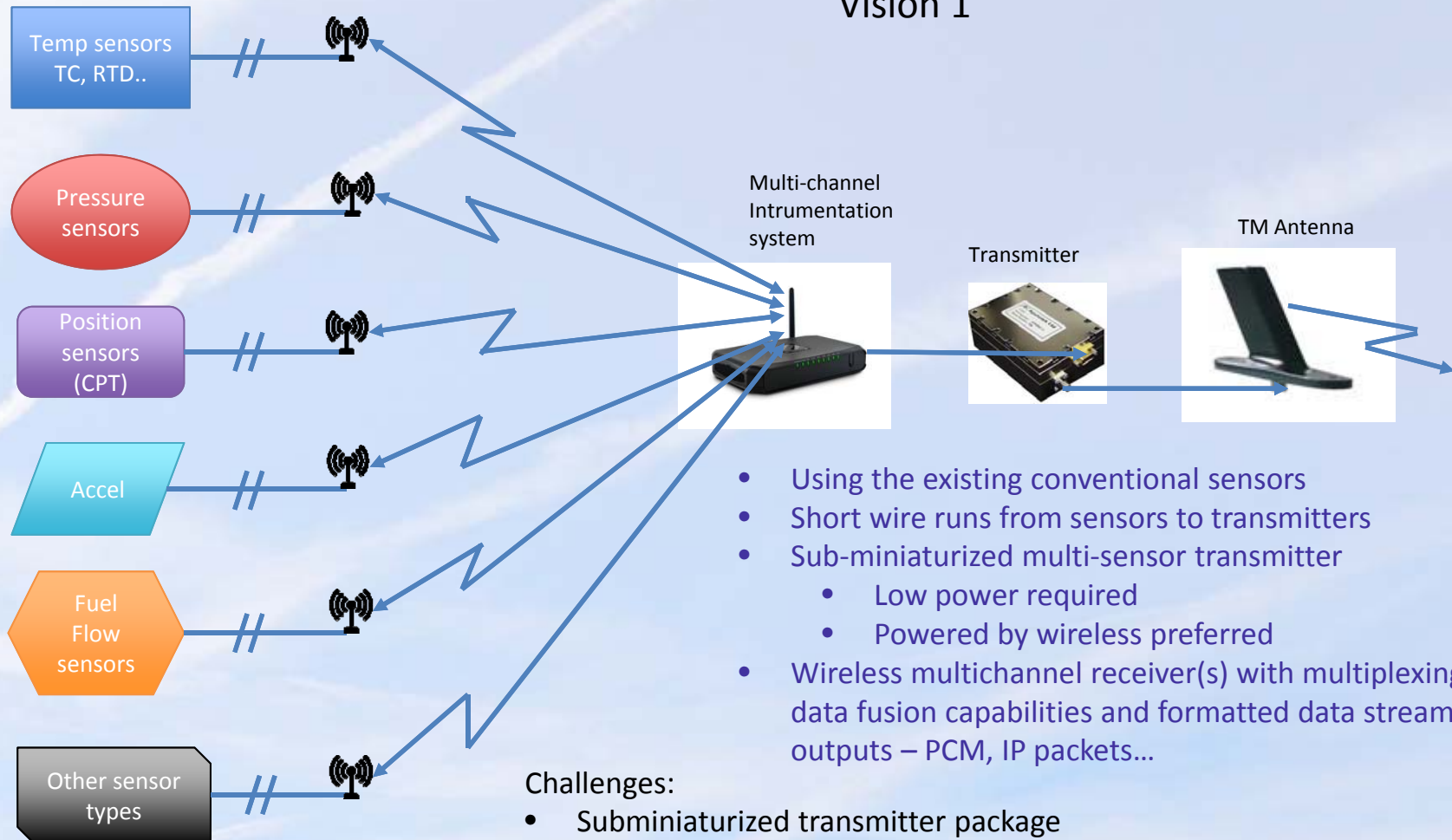
- AFRC has a broad flight test capability that is suitable for flight testing of any wireless sensor suite. We can help you to further your wireless sensor technology through flight test.
- AFRC is developing systems to flight test your wireless technology at minimum cost and time.
- AFRC is looking for innovative ideas for wireless instrumentation system used in flight test applications, and is interested in partnership or collaboration opportunities with the Wireless Community.



# Backup Slides

# AFRC Vision of Active Wireless Systems for Flight Test

## Vision 1



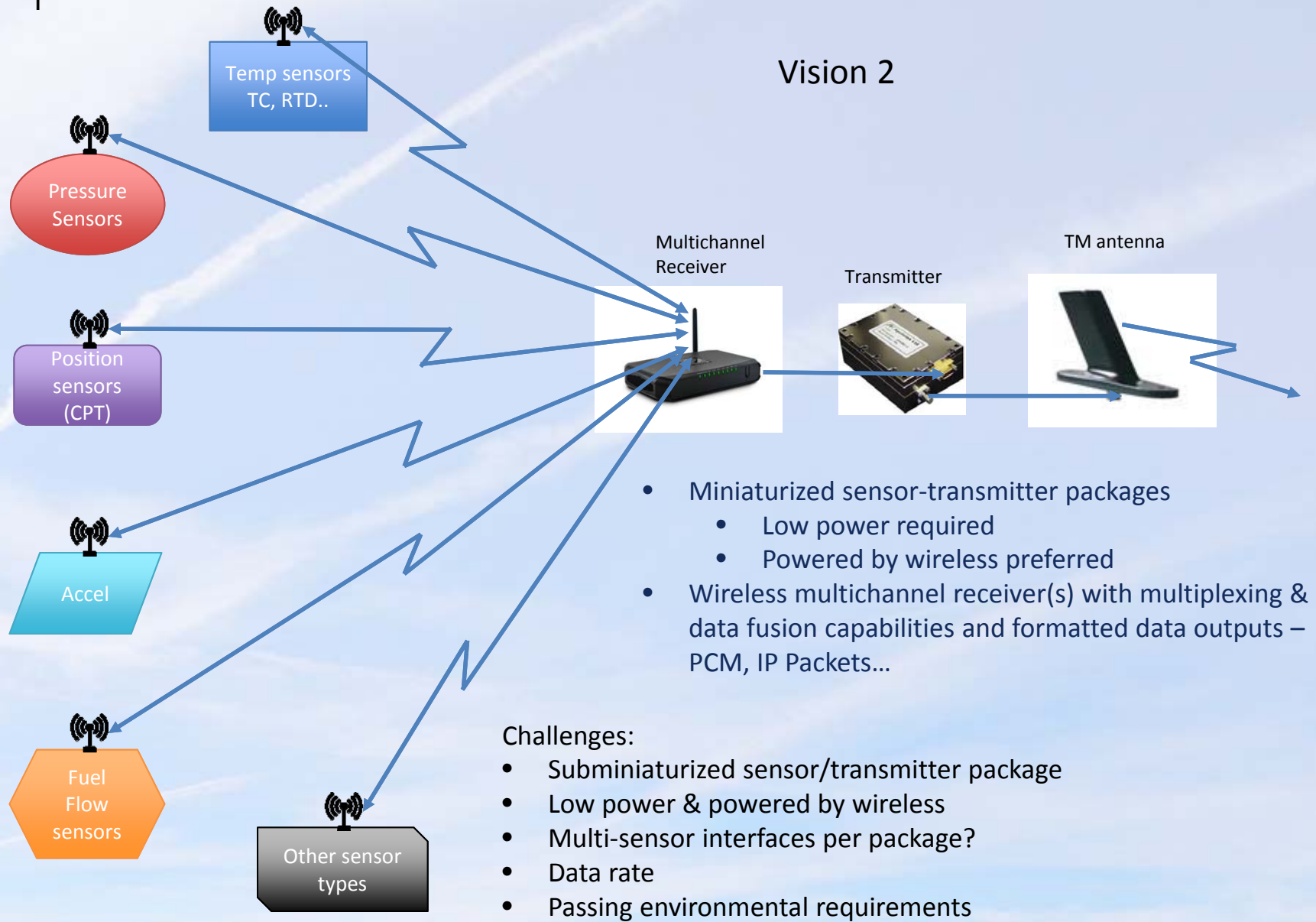
- Using the existing conventional sensors
- Short wire runs from sensors to transmitters
- Sub-miniaturized multi-sensor transmitter
  - Low power required
  - Powered by wireless preferred
- Wireless multichannel receiver(s) with multiplexing & data fusion capabilities and formatted data stream outputs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

### Challenges:

- Subminiaturized transmitter package
- Low power & powered by wireless
- 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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# Passive Wireless Sensors for Flight Test

