National Aeronautics and Space Administration

Armstrong Flight Research Center (AFRC)

AFRC wireless Development Plans and Needs

PWST Workshop 2019

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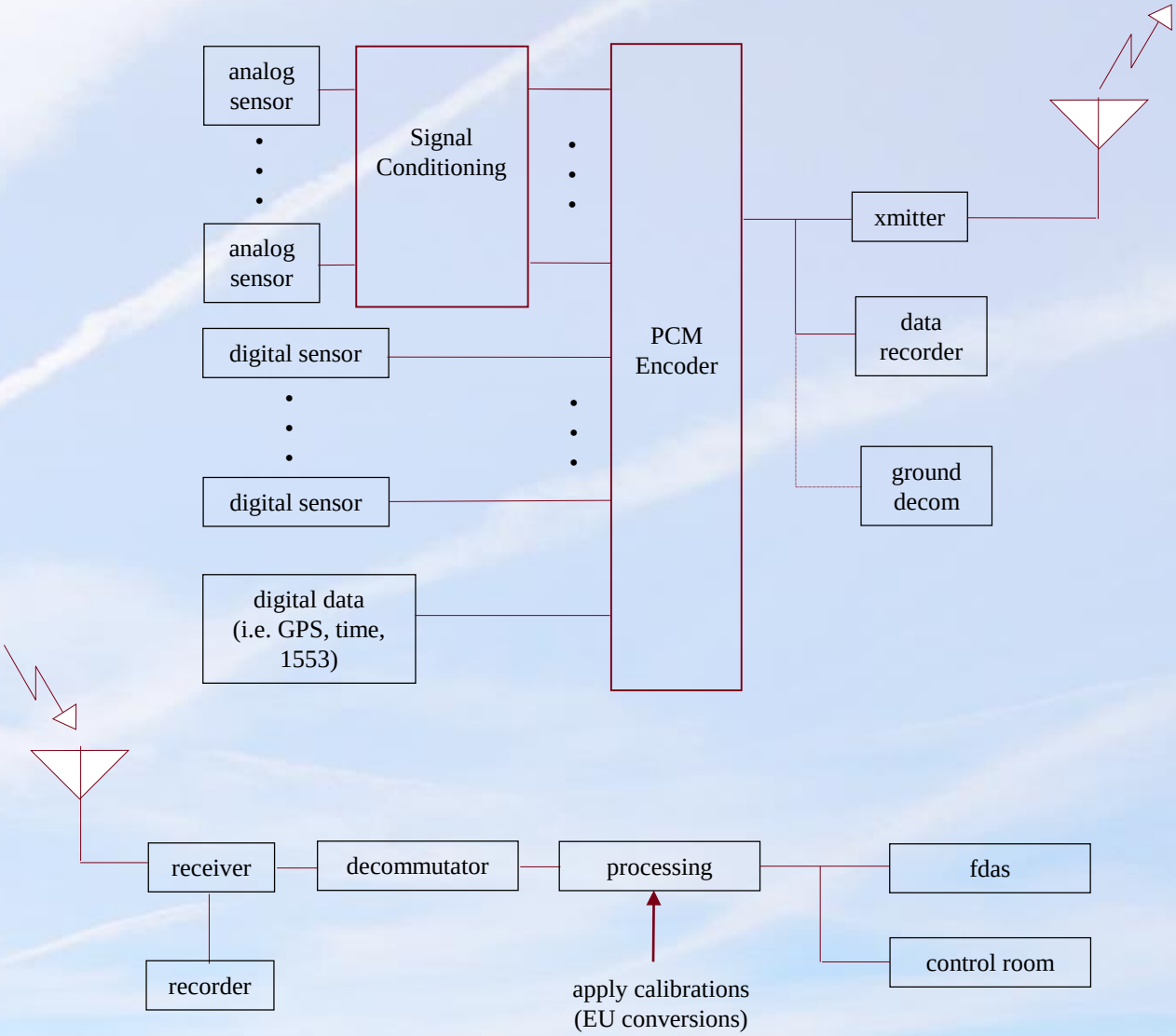
Conventional Instrumentation System



Issues with Conventional Instrumentation

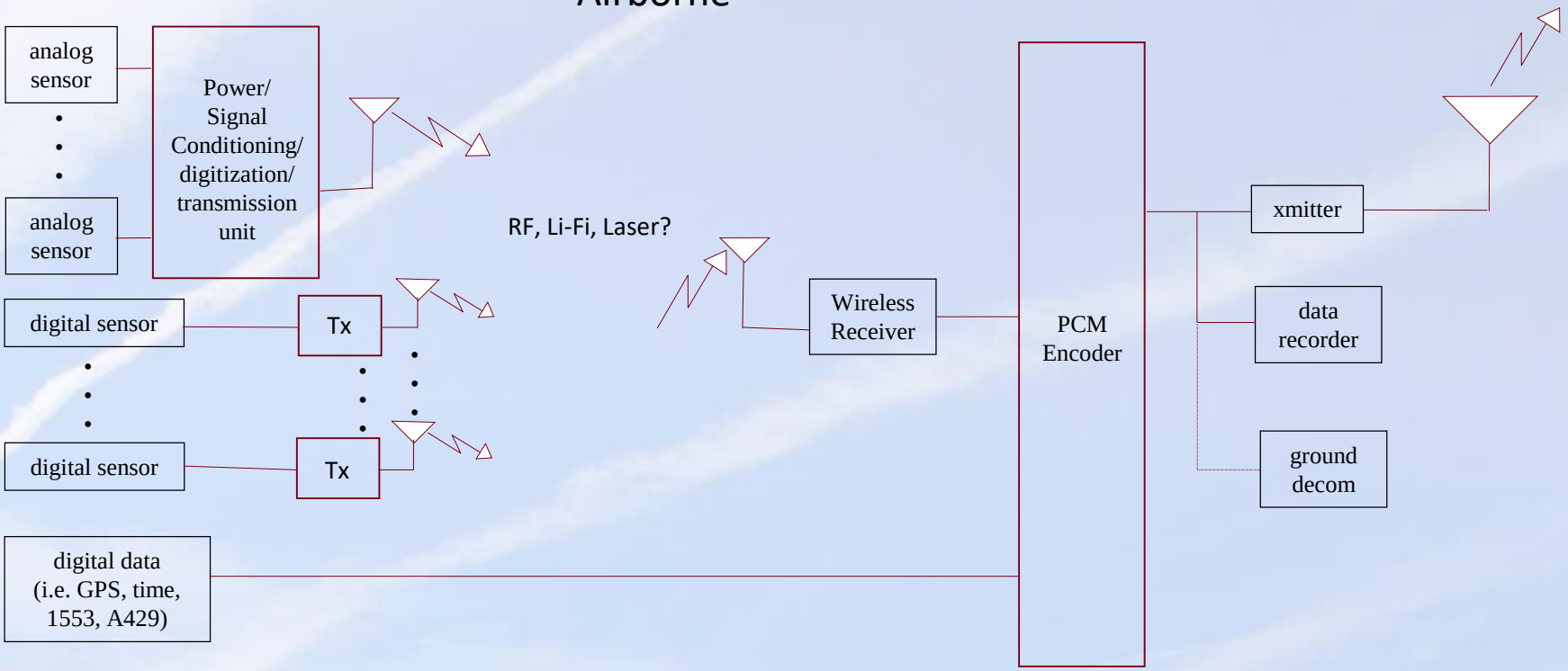
- Additional weight (wires, connectors brackets, mounting plates…)
- Must penetrate aircraft structure for wire routing
- Aircraft down time
- Extensive wiring labor
- Extensive and costly engineering
- Not convenient for quick add-ons

Wireless solutions needed to mitigate the issues.

AFRC's Required Developments for Wireless Solutions

- Develop receivers that interface to existing PCM Flight encoders.
- Develop new sensing methods to measure surfaces pressure and strain measurements.
- Develop new algorithms and software for wirelessly collecting multiple channels of high-rate, high volume data from all sensors.
- Develop smart, miniaturized, ultra-low power transceivers.
- Develop the appropriate protocol for reliable wireless operation.
- Develop a combined power source, signal conditioning, multiplexing, and digitizing module to collect multi-channels of analog signals with wireless transmitting capability.
- Develop suitable energy harvesting technologies for flight test instrumentation.
- Reuses of conventional discrete sensors whenever we can.
  - They are airworthy and reliable.
  - There was a huge investment in conventional sensors, encoder and decoder equipment.
- *All Developed solutions must pass AFRC's required airworthiness requirements*

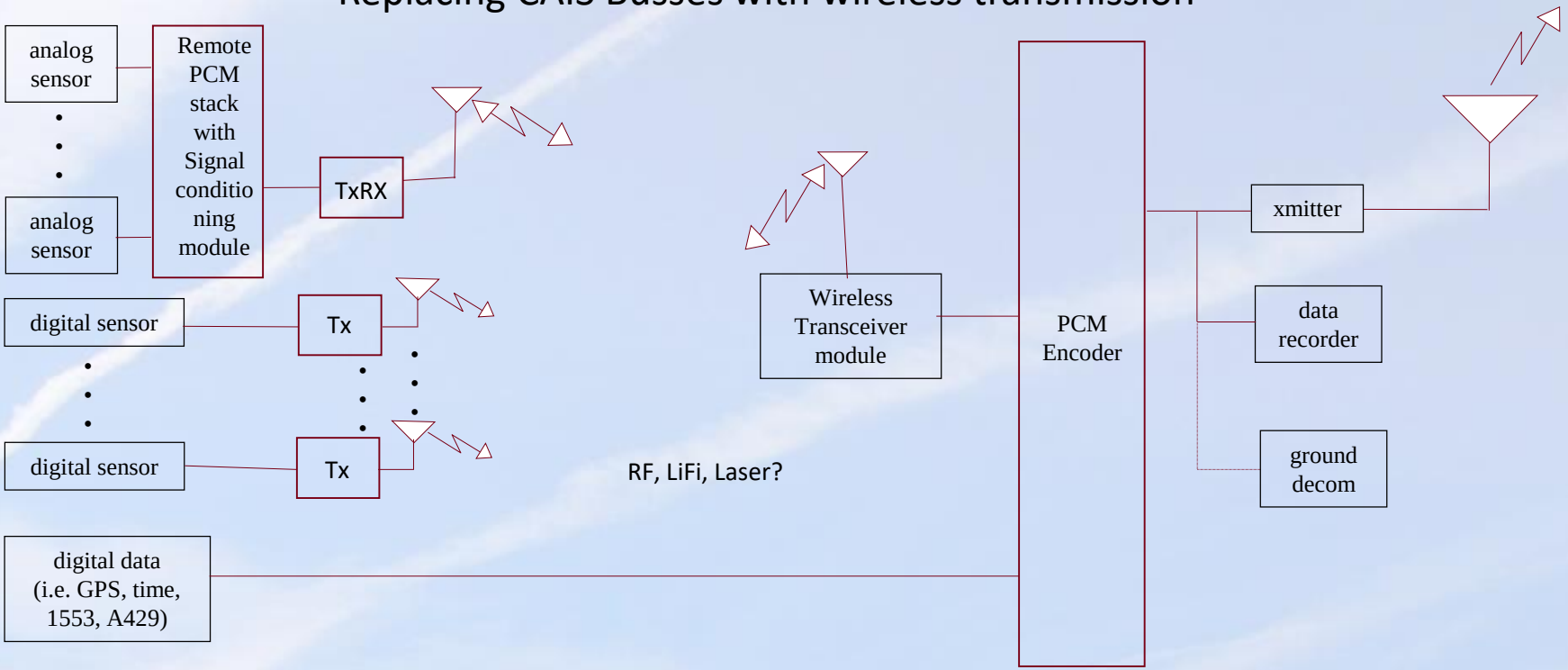
AFRC Wireless Solution -- Using conventional sensors and equipment



- RF wireless communication will be subjected to EMI/EMC, multi-paths, bandwidth and aircraft metal skin penetration issues, therefore, Li-Fi or laser technology will be investigated for this application.
- Li-Fi or laser won't be interfered by RF, it won't cause interference to other flight avionic systems. They will be interfered by cloud blocking the LOS during flight.
- The challenge is the development of the these wireless transmitting and receiving modules and get them airworthy.
- Algorithm and software for synchronization and timing for all wireless systems are to be developed

AFRC Wireless Solution -- Using conventional sensors and equipment

Replacing CAIS Busses with wireless transmission



- Replace the CAIS bus with wireless communication.
- PCM Stacks are costly, transceivers are needed for command and response operation as is in CAIS buses.
- RF wireless communication will be subjected to EMI/EMC, multi-paths, bandwidth, and aircraft metal skin penetration issues. Li-Fi or laser technology will be investigated for this application too.
- Li-Fi or laser won't be interfered by RF, it won't cause interference to other flight avionic systems. They will be interfered by cloud blocking the LOS during flight.

Overall Challenges - Slide 1 of 2

- Most conventional sensors require signal conditioning, excitation voltage, constant current or voltage source, reference junction, bridge completion and signal amplification, so, the new developed unit for wireless needs to include those requirements besides multiplexing, digitization and transmission capabilities in the unit.

- It will require multi-channel interfaces to sensors per unit. There will be limitation of the number of channels per unit based on the small sizes requirement for the unit! Multiple units or multi input modules have to be used.

- How would the wireless receiving unit synchronize multiple wireless units/channels in different frequencies? The spectrum bandwidth may not be enough for high data rate and volume!

- Handling the multi-paths, EMI and EMC issues in wireless transmission.

- How to effectively bring power to the wireless sensors without running wires? Can it be wirelessly distributed? Power over Ethernet (PoE) methodology should work but it needs to run Ethernet cables.

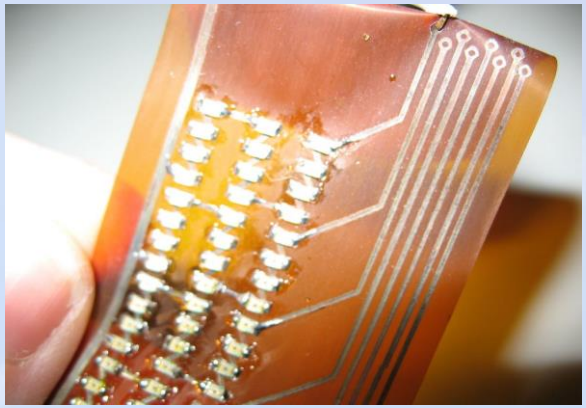
- RF wireless transmission might not penetrate aircraft metal skin or subjected to heavy attenuation. It is depending to the wave form, frequency, distance from transceivers and the power of the transceivers.

Overall Challenges - Slide 2 of 2

- The wireless interface/communication protocols for sensor-web or sensor-network still needs to be developed, and validated.
- Commercial wireless products for flight testing are limited or non-existed.
- Low profile and miniaturized smart sensors that can be applied to flight testing are not readily available in the market or just limited few.
- In general, current wireless products could not deal with high-rate, multi-channels, high volume data required for flight test.
- Existing wireless sensors or systems do not meet the airworthiness requirement for flight.
- Wireless power distribution technology (energy harvesting technology) currently cannot be applicable to flight test requirements.

Desired Wireless for A/C Wing or Large Surfaces Instrumentation

- The desire is to have conformal flexible printed sheet for pressure and strain sensor with thin semiconductor sensors and traces, that can be attached to the wing conformably.



- Interfaces to a data collection and wireless transmitting unit
- Wireless transmitting unit(s) could be RF, Li-FI, or Laser or other to meet the required data rate and data volume.
- Low power is required. Wireless power distribution is preferred if possible.
- Flat conformal antenna is preferred
- All units must be airworthy.

Wireless Sensors for Landing Gears and Engines measurements

- Discrete sensor types: Accelerometer, Position, Strain, Pressure, RPM, Temperature, Torque, Fuel flow and Level, etc.
- Sensors are new developed with built-in transmitter or transceiver and in miniaturized packages.
- Sensors are used for non-high-rate or non- high-volume data applications.
- Wireless communication protocols could be RF, Wi-Fi, Bluetooth, and others such as Li-Fi, Laser that would work well in flight test environment (EMI/EMC, multi-paths, signal penetration).
- HF RFID may work in this case if the range can be long enough.
- Low power is desired. If battery is used, wireless charging is preferred, if possible.
- Flat conformal antenna is preferred.
- *must pass AFRC's required airworthiness requirements*.

Wireless Bio-sensor Developments at NASA AFRC

- Center Innovation Fund (CIF) funded proposal on “Wireless Battery-Free Real-Time Bio-sensing” for real-time in-flight monitoring of flight crew. PI: Dr. Peake
  - Contracting with a university for sensor development.
  - The first successful biosensor built for this project is for measuring oxygen saturation from the brain.
  - The sensor is wireless and using Bluetooth 5 to send data to a tablet display in real time, or a recorder.
  - The sensor requires a battery for up to 8 hours depending on data transmission rate and mode, constantly or intermittently.
  - The sensor package can be expanded for measuring pulse rate, pulse variability and body temperature.
  - The sensor can be placed on the forehead.

Conclusion

- We need help from wireless communities to learn about what is available out there that we should investigate for usage.
- We are happy partnering with or subcontracting to wireless communities who are interested in developing wireless instrumentation for flight test.
- We highly encourage the wireless communities to submit innovative ideas on wireless instrumentation through the SBIR program, under subtopic A2.01, Flight Test and Measurement Technologies.
- We are happy to accept all recommendations/suggestions on wireless development approaches, from you!
- We are happy to hear about your advertisement on wireless products that are relevant to wireless instrumentation for flight test applications.
- AFRC has the experience and capability to support the wireless communities with sensor validation through flight tests.

Thank you!