AEROVOODOO

Aircraft Data Primer

Aircraft Data Primer Contents

For more information on Aircraft Data, please ask for our "White Paper on Data Collection Systems"

What is Aircraft Data?

- "Aircraft Data" in the context of this presentation is readings of key operational parameters shortly before, during, and shortly after any flight.

- Examples of these parameters include:
  - Cycles (takeoff/landing count)
  - Aircraft configuration (software and nav data revisions, options installed)
  - Location/Attitude (lat/lon coordinates, time, heading, 3-axis acceleration)
  - Air Data (air speed, outside air temperature)
  - Fuel remaining, fuel flow
  - Engine parameters (turbine or prop speed, oil temperature, throttle position)
  - Electrical system (voltage, current, other parameters if electronic CBs)
  - Discretes (doors closed, landing gear up/down, parking brake on/off)
  - Cockpit audio (including radio and intercom)
  - Errors detected by engine or avionics

Why is Aircraft Data Important?

- Analysis of aircraft data in conjunction with other data available allows:
  - Increase in operational safety:
    - Potential FOQA* program
    - Feedback enhances/improves pilot training
  - Cost savings in aircraft maintenance:
    - Faster diagnoses from a validated diagnostic fault tree
    - Longer times between maintenance supported by real field data
    - Faster access to aircraft records
  - Cost savings in aircraft warranty claims:
    - How an aircraft was operated is proven/documented by the data
  - Revenue opportunity by displaying recreated flights or other flight analysis
  - Revenue opportunity in helping fractional operators apportion flight costs
    - Also help identify if one owner operates the aircraft more harshly than others
  - Protection against unfounded liability claims
  - Data-based proof for claims of continued airworthiness
  - Accident investigations

* FOQA = Flight Operational Quality Assurance (FAA supervised safety initiative)

Who Uses Aircraft Data?
(and why do they use it?)

Purpose of Data Collection	User	Notes
Flight Operational Quality Assurance (FOQA)	Aircraft OEM and fleet operators	Includes pilot performance improvements to reduce wear of certain parts
Training adjustments	Aircraft OEM	Feedback to adjust overall pilot training or individual recurrent training
Engine trending data collection	Engine supplier	Product support agreement requirements
Customer notification of upcoming scheduled service events	Aircraft OEM	Web-based information service
"Power-by-the-Hour" type billing	Aircraft OEM	Basis for billing of defined maintenance programs ("Power by the Hour", etc.)
Fractional operator billing	Fractional operators	Basis for automated billing of fractional share owners
Fleet operator dispatch and flight planning adjustments	Fleet operators	Adjust flight plans for delays
Fleet operator fuel management	Fleet operators	Build statistics for fuel consumption on same routes
Real time critical event code (and CAS message) monitoring	Aircraft OEM	Initiate parts positioning for up-coming AOG situations
LRU fault determination	Aircraft OEM, fleet operators, engine supplier	Service centers
Maintenance efficiency enhancements	Aircraft OEM	Knowledge-based diagnostics
Event investigations/reconstructions	Aircraft OEM, FAA, NTSB	Same analysis as FOQA
Stolen aircraft location	Aircraft OEM and law enforcement	SatCom sends position information

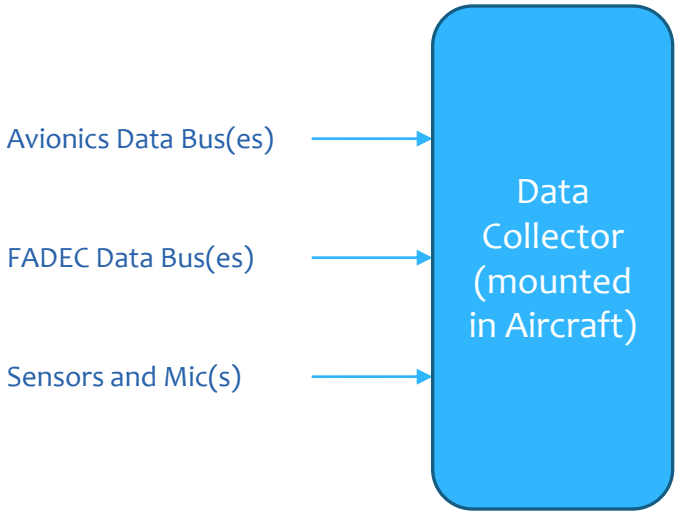
Whose Data Is It Anyway?

- This is a key issue in aircraft data management
  - Some aircraft companies claim to own all aircraft data
  - Others have not addressed the issue at all

- Best solution is to follow what auto makers do
  - Data "belongs" to the car owner; "licensed" to others
  - When the owner agrees to use OnStar (for example), he agrees to license the data to GM for them to use
    - Non-exclusive, no fee, allows GM subsidiaries to also use

How is Aircraft Data Collected?

- Aircraft-installed “box” collects and timestamps the data:
  - From avionics data buses
  - From FADECs
  - From individual sensors and microphones
- Sometimes the data collector is integrated into the aircraft avionics



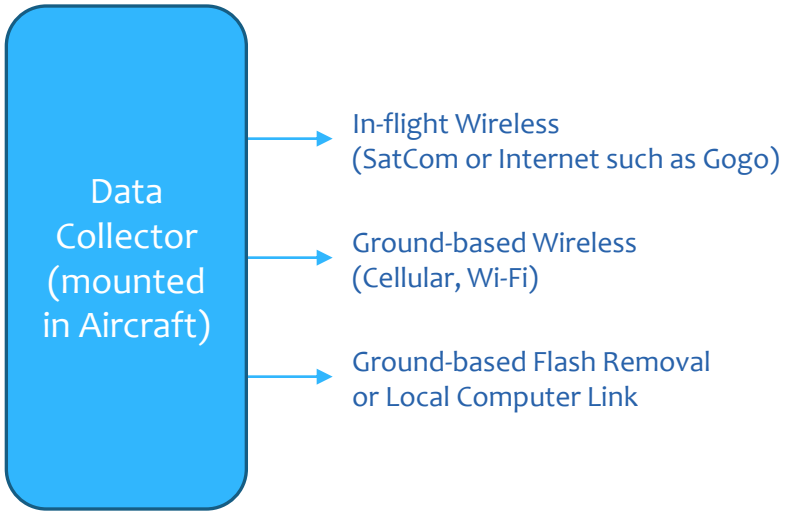
* FADEC = Full Authority Digital Engine Control (small computer that controls engine fuel in response to environmental conditions)

Data Collector Might Be an FDR

- Older Data Collectors and ones used on commercial airlines are crash-proof and adhere to FAA regulation TSO-C124b or EASA regulation ED-112
  - What data is recorded and the recorded format are fixed
  - Units that pass these regulations are called “Flight Data Recorders” (FDRs) and are very expensive
- Newer designs for General Aviation do not pretend to be FDRs and are many thousands of dollars cheaper
  - Only the data storage memory needs crash resistance
  - Crash shock generally does not make flash memory unreadable
  - However, current regulations require true FDRs (certified to TSO-124b or ED-112) on most commercial aircraft

How is Aircraft Data Retrieved?
(Getting the Data Off the Aircraft)

- In-flight Wireless (during flight)
  - SatCom (such as Iridium)
  - Using In-flight Internet (such as Gogo)
  - Only most important data is sent this way ($$$$)
- Wireless on ground
  - Cellular (best if local signal)
  - Wi-Fi (hard to manage)
- Flash Removal or Local Computer Link (hard to manage)



Retrieving Data In-flight

- SatCom (Iridium, Orbcomm, Inmarsat, Globalstar)
  - Requires special transceiver (another box)
  - Costly – Data sent should be carefully selected for value
  - World-wide coverage (except very high latitudes)

- On-board Internet (Gogo, others starting soon)
  - Inexpensive data cost if already installed for passengers
  - Link to Gogo via Wi-Fi, Bluetooth
  - Costs coming down as competition increases
  - More limited in geography than SatCom

Retrieving Data via Cellular

- Cellular bandwidth and data cost is being driven by mass market for smart phones (iPhone, Android)
- Low cost, high bandwidth solution for aircraft data retrieval
- Process can be easily automated with no manual intervention required

- Issue: Standards are changing rapidly – may obsolete radio in data collector
  - If on-board Internet is available, that might be better solution

Retrieving Data via Wi-Fi

- Three issues:
  - Coverage: Most Wi-Fi at FBOs is optimized for pilot use inside the building – seldom have coverage for aircraft
  - Access: Many public Wi-Fi access points require manual signup/sign in with varying requirements for passwords
  - Link to Internet: Some rural areas have very slow links
- Conclusion: Wi-Fi is not a good solution for data retrieval

Retrieving Data Manually

- Two methods:
  - Removal of flash memory: Requires crew access to data collector, limiting where it may be located in aircraft
  - Wired connection for USB memory stick or computer connection: Requires additional wiring, connector(s)
- Biggest issue is it cannot be automated – always requires a person to remember to retrieve the data

- Conclusion: Wireless data retrieval is a superior solution

Should Data be Encrypted?

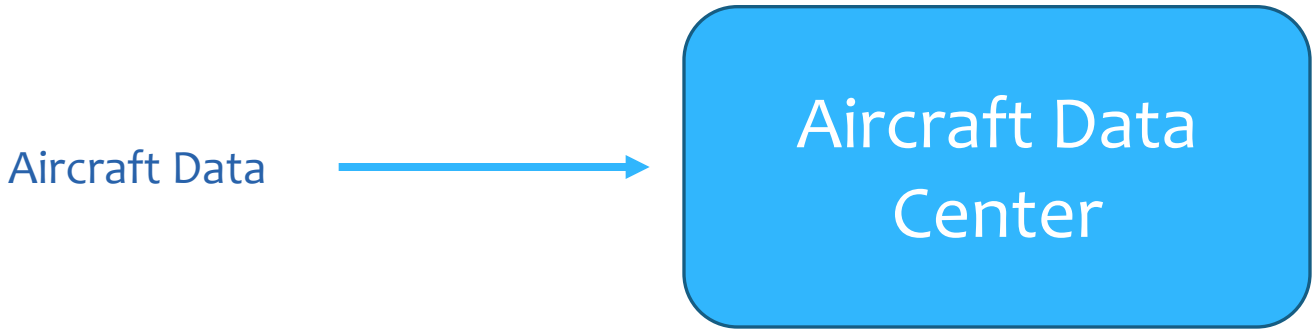
- Two places for encryption: Data transmission only or data transmission plus data stored in data collector
  - For non-military uses, neither is recommended by us
  - Benefits must be identified before requiring encryption
  - Wireless links (SatCom, Cellular) already do a form of encryption to squeeze more bits into the data link
- Implementing encryption in the aircraft increases the risk of delays due to software complexity, additional testing, and additional regulatory review.
  - Encryption of stored data may impede recovery and analysis during accident investigation

Where Does the Retrieved Data Go?

- SatCom data travels to ground station, then to a central data center (Aircraft Data Center) via Internet
- Gogo data travels to a ground station, then to the central data center via Internet
- Cellular data travels from a local cell tower to the central data center via Internet
- Wi-Fi data travels from a local access point to the central data center via Internet
- Manual data travels to a user's computer then through a data link to the data center via Internet

Where Does the Retrieved Data Go?

- Did you detect a common theme on the last slide?
- Hint: all of the retrieved data travels (eventually) by Internet and ends up at a central data center



Aircraft Data Center Design

- Aircraft data centers have a different design goal than ordinary company data centers
  - For aircraft data centers, handling the volume of data is most important. The arriving data may be thought of as transactions. Aircraft data centers are similar to credit card authorization data centers.
  - Real time is not so important to most of the aircraft data. Only the in-flight retrieved data must be processed in seconds. The rest may take many minutes.
  - Aircraft data centers may be company-owned, or leased shared capability (in the "cloud")

Comparison of Data Center Design

Company Data Center

- Architected for low latency for users
- Audits restricted to legal discovery
- Very flexible – configuration changes often to allow for company growth and changing business environment
- Location determined by business office location

Aircraft Data Center

- Architected for high volume of transactions
- Designed for frequent customer audits
- Rigid configuration management required to assure data analyses are consistent
- Location determined by communications needs

Major Aircraft Data Center Functions

- Receive, store, and analyze data for potential monetization opportunities
- Distribute select portions of data to others:
  - Engine makers, fleet operators, fractional share managers
- Host website display of customer data
  - For customers
  - For OEM engineering and service organizations
  - For third party service organizations
- Host third-party analyses programs such as FOQA
- Data backup, archive, media translation, disaster recovery

Future Trends Aircraft Data Systems

- Integration of data collection by avionic suites manufacturers will continue
- Internet access on aircraft will continue to grow
- Data transmission costs will continue to drop
- The demonstrated value of collecting aircraft data will continue to grow
- Getting all of the aircraft data off the aircraft during flight will become normal procedure (bye-bye expensive, crash-proof flight data recorders) as real-time wireless communications costs continue to drop

Turning Data into Information

- Data must be processed, compared to other data to spot trends before most benefits can be realized
  - But software on aircraft must be certified and reviewed by regulatory agencies to ensure no harm to essential avionics systems ($$$$)
  - Software in data centers do not (and should not) require such additional scrutiny
  - Software in data centers can be enhanced and improved more quickly (and less expensively) than airborne software
- Conclusion: As much as possible, number crunching belongs on the ground

Turning Information into Revenue

- Collected data turned into information becomes valuable, especially when comparisons across many aircraft are involved
- Benefits accrue to the engine maker, the airframer, and the customer
- Some of the benefits may result in lower costs rather than top line revenue
- In all cases, opportunities exist for using the information derived from the data to generate revenue or lower costs
- The only way to aggregate data across many aircraft is through the aircraft data center

Aircraft Data Issues (Recap)

- Items to consider when designing an aircraft data system
  - What data is collected?
  - Who owns the data?
  - Data processing in-flight versus on-ground
  - Encryption of data (y/n)
  - Selection of data retrieval method(s)
  - Triage of data sent via SatCom (if any)
  - Cellular Radio standards (global capability)
  - On-board Internet may be best for data retrieval
    - Future aircraft likely to be linked to Internet

AEROVOODOO

For More Information, please contact us at
www.aerovoodoo.com