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Naturalistic Flying Study as a Method of Collecting Pilot Communication Behavior Data

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Why Investigate Human Factors?

- Communication: exchanging information among actors
- Human factors directly cause or contribute to many aviation accidents.
- Should investigate human behaviors to design cognitive communication systems.

Aircraft Pilot Behavior Studies…

- **Datalink Communication (DataComm) will be the mandatory communication method in NextGen; pilots' behavioral tendencies may change**
- **Field Study**
  - High cost, insurance for participants
- **Human-In-The-Loop (HITL) Simulation Tests**
  - Can collect specific behavior or performance data
  - Implementing many independent variables will be very hard
  - Hawthorne effect
  - Hard to create operational tension
- **Mathematical Models**
  - Include possible situational variables
  - Cannot show actual unpredictable human responses
- **The Naturalistic Study Method**
  - Monitoring human behaviors within an unobstructed environment for a prolonged duration
  - Has been used to resolve the practicality problems.

Aircraft Pilots' Cognitive Properties for the Future Air Transport Cognitive Communication Systems

- Perception, reasoning, memory, adaptation, etc.
- How do pilots communicate with ATCs and other air traffics?
- NextGen requires higher technical demand: aircraft pilots will be in more vigilant environment.
- Cognitive communication systems using computerized automated functions need to be developed.
- For the high-level conceptual design, monitoring the properties during a full course of flight mission will be required.
- The constitution of naturalistic setting for the transportation research became more applicable with the advancement of technologies.

Naturalistic Driving Study (NDS)

- **A successful naturalistic study project for the transportation field**
- **100-Car Naturalistic Driving Study Project (finished in 2005)**
  - 241 drivers, 100 cars for 12-13 months in Northern VA
  - 5 channel-video sensor kit installed around the driver's seat
  - Vehicle kinematics recorded in conjunction with the driver's data
  - Driving behavior (e.g., eye direction, severe drowsiness, impairment, and judgment error) in crash, near-crash, or other incident situations were monitored and recorded.
  - 6.4 terabytes of collected video files, electronic driver and vehicle performance data
- **The second Strategic Highway Research Program (finished in 2014)**
  - 2,800 drivers, 450 vehicles in six different states for 1 to 2 years
  - More advanced data acquisition devices
  - 4 petabytes data adding inattention and cellphone use, and driver interaction with roadway features in conjunction with roadway data
- **Data is open to researchers for their own analysis projects**

Naturalistic Flying Study (NFS)

- **NFS needs to be initiated implementing all situational variables during flight operations based on the NDS references.**
- **A large database of pilot behavior information during full flight operations**
- **Should be open to aviation researchers for human factors and safety studies; highlighting the future cognitive communication environment in the aviation/aerospace fields.**
- **Answer to questions related to the pilot behavior in the cockpit.**
  - How do pilots interact with DataComm systems especially in the highly-congested terminal airspace?
  - What is the common error during DataComm procedures?
  - What is the communication error associate with other situational variables?; certain location / operational stage / weather condition

Pilot Error Pattern

- **Most aviation accidents were due to the human error committed by pilots**
- **NFS needs to be investigated wrt pilot error pattern.**
- **Cockpit task management error is an important causal factor for safety-critical incidents.**
- **Pilot Errors in GA (Ison, 2005):**
  1. weather
  2. controlled flight into terrain
  3. **poor communication**
  4. low-level maneuvering
  5. inadequate preflight inspections
  6. inadequate preflight planning
  7. failure to use a checklist
  8. failure to perform the “I’m safe” checklist
  9. running out of fuel
  10. **mismanagement of technology**

D. Ison, “Top 10 Pilot Errors,” Plane & Pilot Magazine, 01-Aug-2005. [Online]. Available: http://www.planeandpilotmag.com/article/top-10-pilot-errors/#.WQcZEoWcFUI .

Videotaping Pilots' Environments

- **The pilot errors could be better investigated using videotaped pilot behavior data.**
- **Videotaped CRM scenarios have been utilized to train pilots' interpersonal skills and investigate personality traits for enhanced pilot performance.**
- **NTSB recommended installation of video recorders.**
  - To overcome the weakness of existing voice-only flight recorder
  - The cockpit video recorders would work for transparent flight data retrieval associated with the use of recent glass cockpit and controller-pilot data link communication (CPDLC) systems during accident investigations.
- **However, pilot communities have not agreed with the installation of in-cockpit video recording system**
  - Misinterpretation and adverse effect of illustrating their task situations.
- **ICAO has not accepted it as the standard equipment list in future commercial aircraft cockpits.**
- **This problems shall be resolved.**

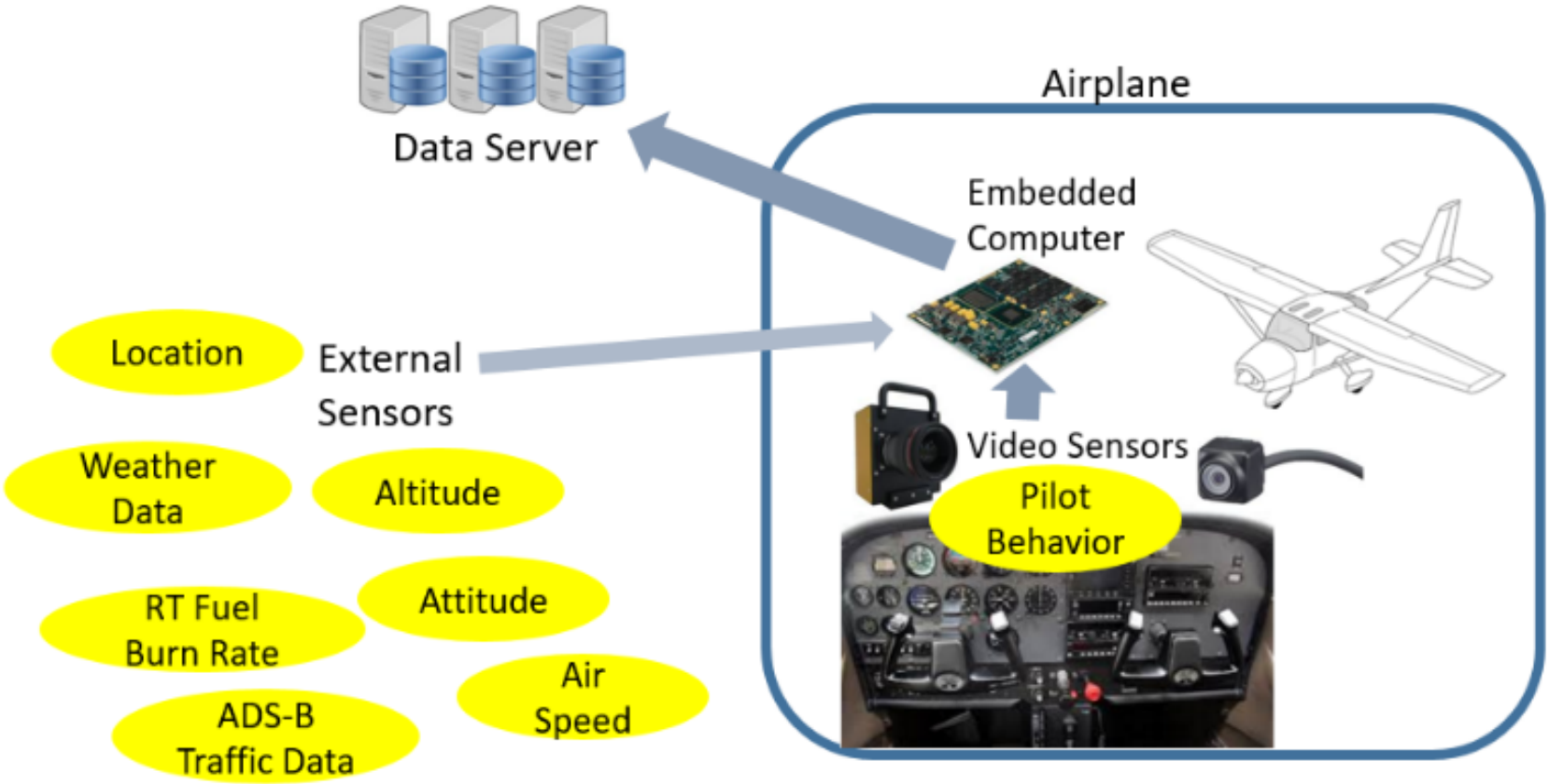
Comparison of NFS and NDS

Criteria	NFS	NDS
Number of People to Monitor	One or Two	Mostly One
Essential External Variables to Connect	3D Flight Data, Weather Data, Air Traffic Data, Other Data Connected to the Central Information Center	2D Kinematic Driving Data, Traffic Signals
Number of People Who May Operate the Same Vehicle	Mostly Multiple	Mostly One
Vehicle Classification	Single-Engine vs. Multi-Engine Light vs. Heavy	Sedan, SUV, Truck, Bus
Performance Factors to Monitor	Aviation, Navigation, Communication	Driving Along the Lane, Complying with Traffic Signals, Navigation

Preliminary NFS

- The preliminary phase is to assess the experimental attributes and validate the practicality of study condition before entering a large data collection project.
- Installs multi-channel video sensor systems in the cockpit to monitor pilots' interaction with cockpit systems.
- Collection flight operational data (altitude, attitude, airspeed, current location, weather, and real-time fuel-burn rate data, etc.) and synchronization with the pilot behavior data for the in-depth analysis.
- No reservation of extra ports to connect each sensor component to additional instrument displays: using off-the-shelf micro electro-mechanical systems (MEMS) that produce these sensor signals for additional displays such as iPad within the cockpit.
- The collected data saved in the embedded computer disks need to be transferred to the data server periodically for the comprehensive management.

Illustration of NFS



The Recommended Guidelines for NFS

- **The data to collect should include all formal/informal data that are directly/indirectly related to the pilot operations for the future use of big data analytics.**
  - Integrating the NFS data to all kinds of aeronautical, weather, and airport data will create additional insights to improve the research on pilots' communication behavior.
- **Since the DataComm procedure is not mandatory yet, a pseudo naturalistic study (providing pilots with a specific task as a training during the NFS data collection) could provide insights on how pilots interact with DataComm.**
- **The high level of security should be maintained in the data management system because the aviation is subject to the national protection in most countries.**

The Collected NFS Data for Cognitive Communication System Design

- **The aviation research communities may use the collected NFS data for cognitive communication system design.**
- **Examples of expected NFS data for the communication system design**
  - Pilots' properties associated with cockpit task management: cockpit task prioritization and handling multiple concurrent tasks.
  - Pilots' tendencies while encountering off-nominal events and resolving their problems for communicating with ATC
  - Pilots' tendencies on how to comply the officially defined DataComm procedure
  - Situations that pilots commit errors in contacting or replying to an ATC or an air traffic

Potential Problems

- Connecting the NFS database with other heterogeneous dataset including SWIM database, ASRS database, and the data from sensor for monitoring engine health requires a high level of technology and cost.
- The consideration of in-cockpit videotaping system installation in all classes of aircraft still needs negotiation with pilot communities.
- Evaluating pilots' objective cognitive performances in certain criteria such as situation awareness may not always be available using NFS data.

Conclusions

- NFS is a promising method for aircraft pilot behavior research to enhance the quality of the cognitive communication system design.
- Based on the reference of NDS accomplishments, the NFS needs to tailor the experimental attributes to be established as the cognitive communication evaluation method in the aviation/aerospace fields.
- The NFS should also consider a big data acquisition/analytics system, customized naturalistic testing conditions, and a high level of security standard.

THANK YOU