Advanced Cockpit Concept Methodology & Design

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The Endeavor

- **Personal Background**
  - Jeremy R. Chavez
  - B.S. Mechanical Engineering from Texas Tech University
  - Certified Private Pilot (IFR training in progress)
  - Certified Remote Pilot in Command

- **Team Lead in developing a next generation fight deck for the V-280 full scale mock-up**

- **The team was given a blank canvas in which to create a vision of the "art of the possible" for the next generation tiltrotor and commercial aircraft**

- **With an open environment to explore and drive the design one question remained…**

…where do you start?

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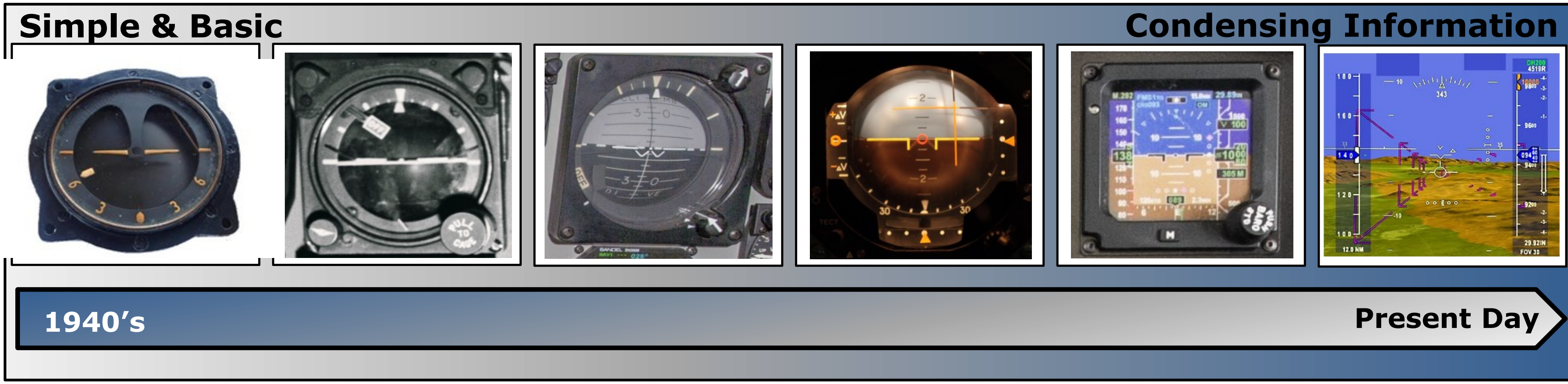
Observing the Trend – The Attitude Indicator



- **The attitude indicator is a primary flight instrument that simply informs the pilot the orientation of the aircraft relative to the earth**
  - **Over the years the attitude indicator has evolved beyond a simple aircraft orientation reference instrument to a consolidation of other critical flight information**
  - **Additional information includes heading indicators, synthetic vision flight path vectoring, etc.**

Observation: Provide precise, detailed and focused information

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Observing the Trend – Technology Interface

Manual Manipulation | **Intuitive Gestures**





1940's → **Present Day**

- **Technology interface has evolved from physical analog devices to intuitive human gestures**
  - **With the introduction of the smartphone, touch and intuitive gestures have become commonplace in our society**
  - **Voice command is becoming more prevalent, just ask Siri™ or Alexa™**

Observation: Simple & Intuitive

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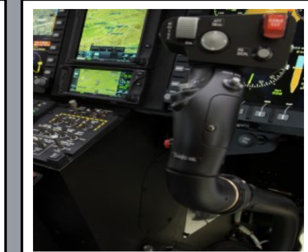
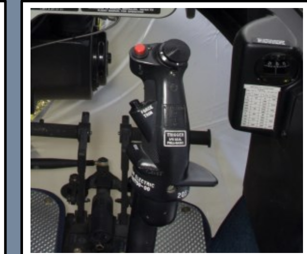
Observing the Trend – Aircraft Interface

Center Yoke **Side Stick Controls**




1940's → **Present Day**

- **Over time flight controls have remained consistent**
  - **Even with all the advancements in technology and avionics displays the physical connection between the human and the aircraft is still done with the stick and rudder**
  - **Side sticks are becoming more common as they are more ergonomic and reduce crew fatigue**

Observation: Direct physical inputs to "feel" the aircraft and provide precise touch control will likely remain even with higher levels of autonomous systems

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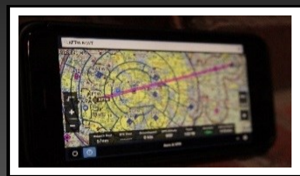
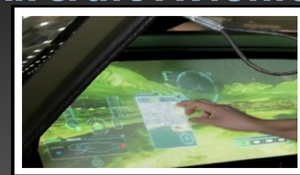
Projecting into the Future - Who are the future aviators?

Aircraft Avionics

Advanced HUD Imagery



Portable Tech w/flight instrumentation



Touch Screen Avionics Interface

Inflight Data Link (ADS-B)

Advanced Synthetic Vision & Autonomy

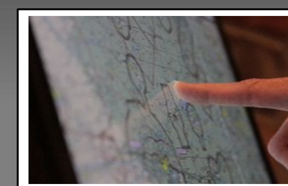
Cultural Technology

Smart Phones

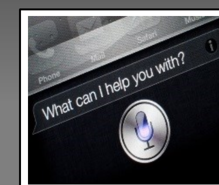
Computers / Laptops

Augmented Reality / VR

Wearable Technologyy



Computer Interface



Voice Command

Technology Consumption

Social Media

- Facebook ™
- Instagram ™
- Snapchat ™

Streaming Services

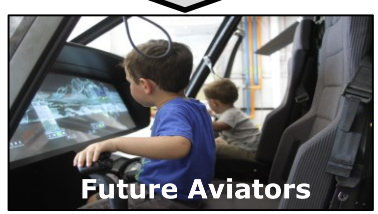
- Netflix ™
- Amazon Prime ™
- iTunes ™

User Populated Data

- Wikipedia ™
- Yelp ™
- Waze ™

Sunrise Tech (Observations)

- Autonomy / A.I.
- Intuitive & Minimalistic Design
- Voice Commands
- Hieroglyphical Communication



Future Aviators

Items Approaching Sunset (Observations)

- Mouse
- Conventional Keypad
- Traditional Telephone Communication
- Handwriting

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Embracing the Future

Bell V-280 Valor

- **Next Generation Tiltrotor**
- **Concept designed for the U.S. Army JMR/FVL effort**

Bell FCX-001

- **Advanced Commercial Helicopter Concept**
- **Represents the future path of Bell Helicopter**

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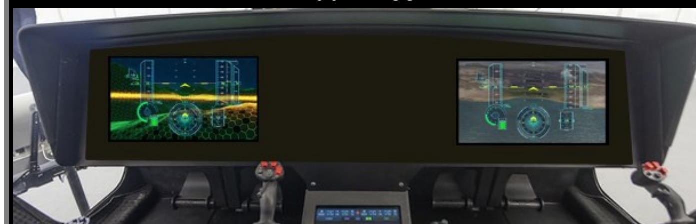
Bell V-280 Advanced Cockpit Design

- **Adaptability**
  - **Screen can adapt to fit the evolving requirements of the crew**
    - Display system can be changed from pilot in command to an interactive mission planning workspace
    - Displays can quickly recover to a known state with voice command or simple input
- **Survivable**
  - **Mosaic display stiches together the imagery from multiple screens**
    - Eliminates single point of failure
    - System logic redistributes and prioritizes information depending on inoperative tile(s)
- **Intuitive Interface**
  - **Use of touch gestures in addition to voice commands, iconology and predictive A.I.**
    - Reduce pilot strain in high workload environments
    - Reduce avionics learning curve
- **Enhanced Visual Acuity**
  - **Ultra-wide aspect ratio screen with synthetic vision or enhanced imagery serves as a large artificial horizon in DVE situations**

Dual Pilot



Dual Pilot / Different Backdrop

Mission Planner / Conventional MFD

Mission Planner /Custom Pilot

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Bell V-280 Advanced Cockpit Design

- **Enhanced Visual Acuity**

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Bell V-280 Advanced Cockpit Design

- **Enhanced Visual Acuity**

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Bell V-280 Advanced Cockpit Design

- **V-280 Screen Demonstration**

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Bell FCX-001 Cockpit Design

- **Minimalistic Design**
  - **Simplistic flight control systems**
    - Couple minimalistic flight control inputs with aircraft stability flight control laws to blend autonomy with "hand flying"
  - **Virtual flight deck**
    - Removes avionics displays with virtual displays, saving weight and cabin volume
- **Customizable**
  - **Virtual flight displays can be placed to the aviators preference and fixed in virtual space or affixed to visor movement for additional situational awareness**
- **Intuitive Interface**
  - **Use of hand gestures and voice command technology**
    - Augmented reality technology allows for the aviator to move items around a virtual work space with intuitive hand gestures
    - Voice command can be tailored to the individual normal speech patters.
- **Enhanced Situational Awareness**
  - **A.R. visor aided with aircraft flight data, GPS data and fixed spatial references allows synthetic vision to be projected through the airframe**

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Bell FCX-001 Cockpit Design

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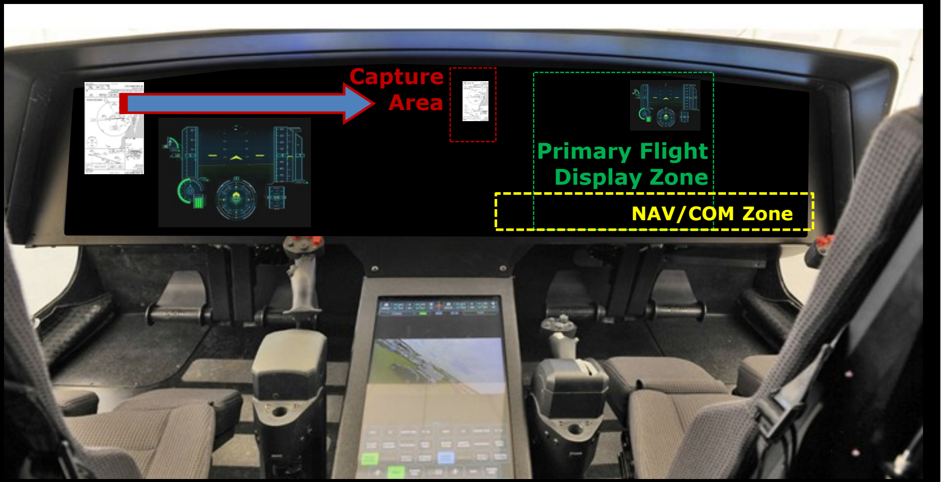
Challenges – Standardization & Certification

- **Risk / Concern**
  - **A highly adaptable screen allows the crew to repurpose screen real estate depending on evolving needs**
    - Detailed weather interrogation
    - Objective area data interpretation (UAS feeds, ground force communications, etc.)
  - **Customizable screens and the ability to turn on and off visual data presents a unique challenge**
    - Because I can move something here does that mean should I?
    - What if a contributing factor to an incident is because of data clutter?

- **Potential Risk Mitigation**
  - **Primary flight display will always be visible on both side**
  - **You can never close or turn off the primary flight display but you can minimize the display to a pre-determined "no smaller than" size**
  - **Identify the balance between free reign and home zones / keep out zones**
    - We don't want to design system flexibility into the displays only to over constrain with restrictions
  - **Sliding data across the screen places data into a capture area**



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Challenges – System Reliability

- **Risk / Concern**
  - **Level of back-ups vs. probability of failure**
    - In the event of electrical failure are stand-by instrumentation needed?
    - Are analog instruments required?

- **Potential Risk Mitigation**
  - **Triple redundant systems such as deployable HUD, Helmet Visors and deployable instrumentation (FCX-001) in addition to the primary display screen**
    - Each system intended to run off segregated systems (Electrical Bus 1, 2 or 3) to eliminate single point failure

Analog Stand by

Deployable HUD

Helmet Visor

Personal Stand by

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Challenges – L.O.S. & Data Corruption

- **Risk / Concern**
  - **LOS & data corruption**
    - With more reliance on data link and autonomy how much connectivity can we assume?
    - We need to guard against data corruption so how much encryption is required?

- **Potential Risk Mitigation**
  - **In the event of data link LOS or data corruption, the aircraft will have manual flight controls and manual flight control laws built into the system architecture**
    - In even the most technologically sophisticated aircraft, the pilot may have to resort to pilotage and dead reckoning
    - Future pilots will still need those skillsets
  - **Use multiple data links**
    - GPS / Satellite
    - ADS-B
    - Cellular Network

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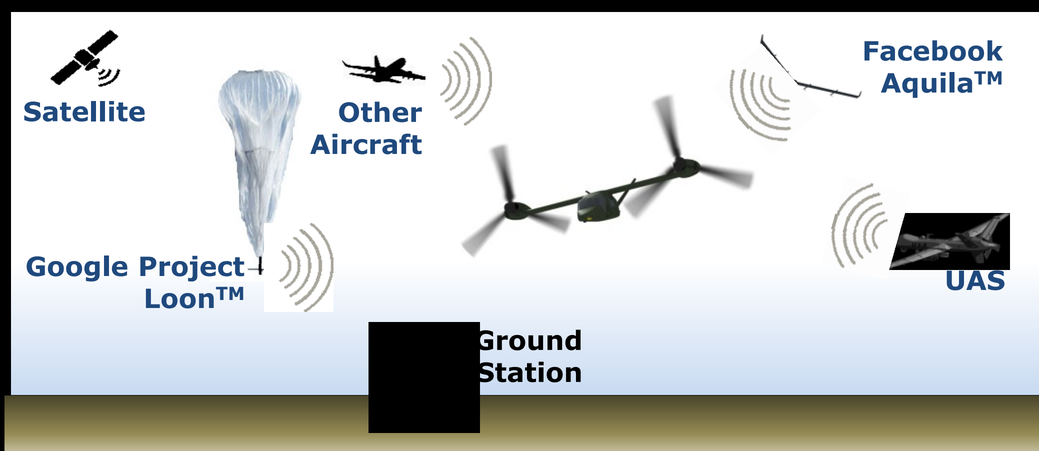
Challenges – Computational Demands

Risk / Concern

- **Future aviation and data absorption are likely to become a computational intensive environment**
  - Multiple systems competing for processing power and memory
  - Access to high speed data?
  - Latency concerns?
  - Interference?

Potential Risk Mitigation

- **Inflight data network nodes**
  - Push data when needed such as airport diagrams, approach and departure plates, etc. rather than internal storage of all the data
- **Aerial Internet Drone Network Technology**
  - Facebook Aquila™
  - Google Project Loon™
- **Standardized air-to-air data link**
  - Share info from aircraft in close proximity to one another



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Challenges – Screen Durability

- **Risk / Concern**
  - **Complete loss of critical flight data**
    - What happens if I lose the entire screen?

- **Potential Risk Mitigation**
  - **Mosaic screen construction**
    - Eliminate single points of failure
  - **Redistribution of data**
    - System logic will identify a fault in an inoperative tile(s) and will automatically reconcile and redistribute the information
    - Data will be hierarchical meaning in the event of reconciliation and redistribution, critical data (primary flight display, navigation, communication, etc.) will be given priority
  - **Reparability**
    - Tiles will be common and interchangeable

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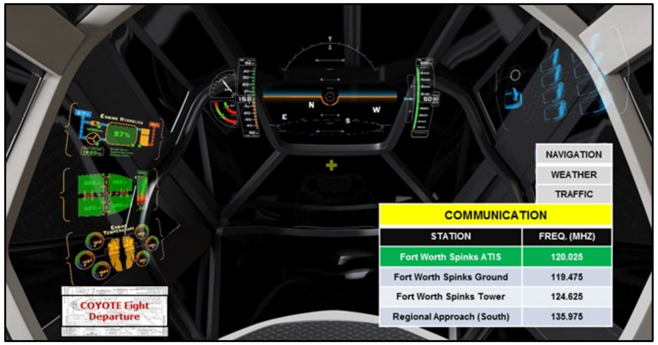
Closing Observations

- **The technology genie cannot be put back into the bottle**
  - **Cockpit design and human factors considerations must adapt to the future aviator**
- **Autonomy and A.I. will likely take over mundane tasks**
  - **Aircraft logic can help prioritize radio frequencies, adjust barometric settings, monitor traffic, provide departure / approach procedures, etc.**
- **Bandwidth, global access to high speed data and data encryption will likely become a critical feature to future flight.**
  - **Reliance on up-to-date data for safe flight (navigation, autonomy, aircraft performance) can create an Achilles heal that needs to be protected.**
- **Future aviator tasks will focus on cognitive thinking such as adaptive mission planning and critical decision making based on evolving or incomplete data**
  - **Technology can be a wonderful servant and horrible master**
  - **The human will always be in the loop to use intuition and good sense**
  - **End game scenarios**



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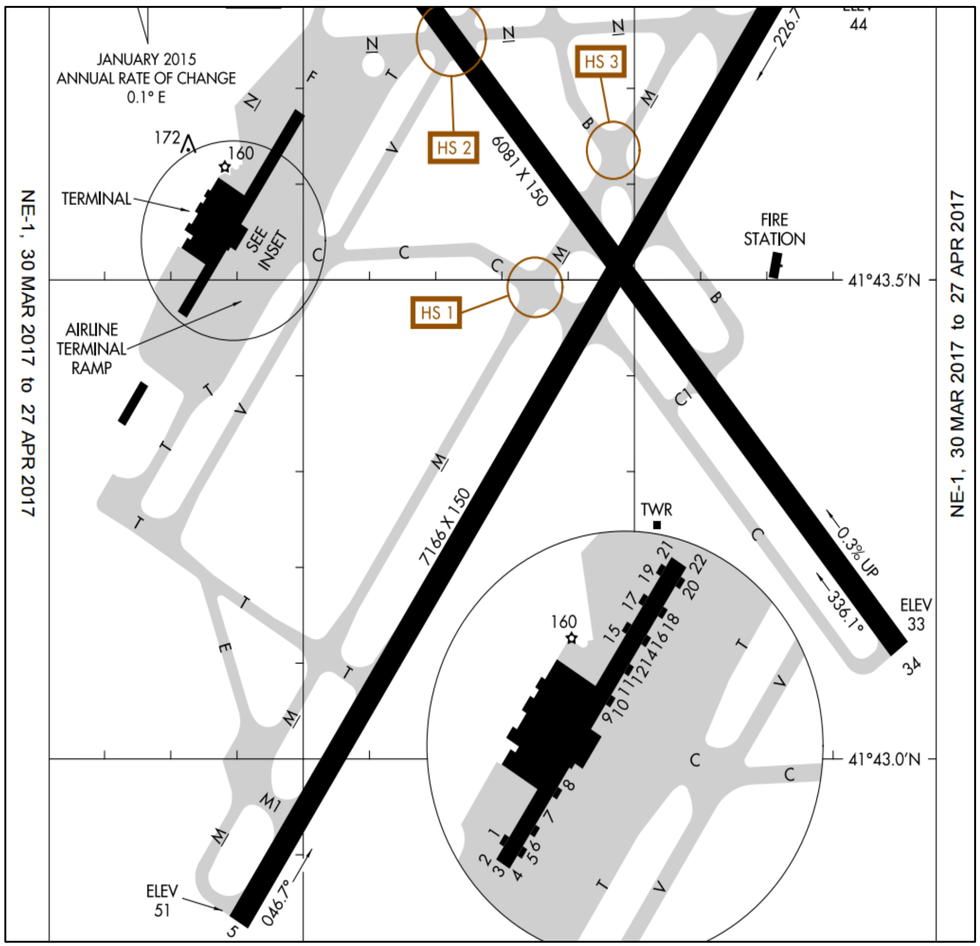
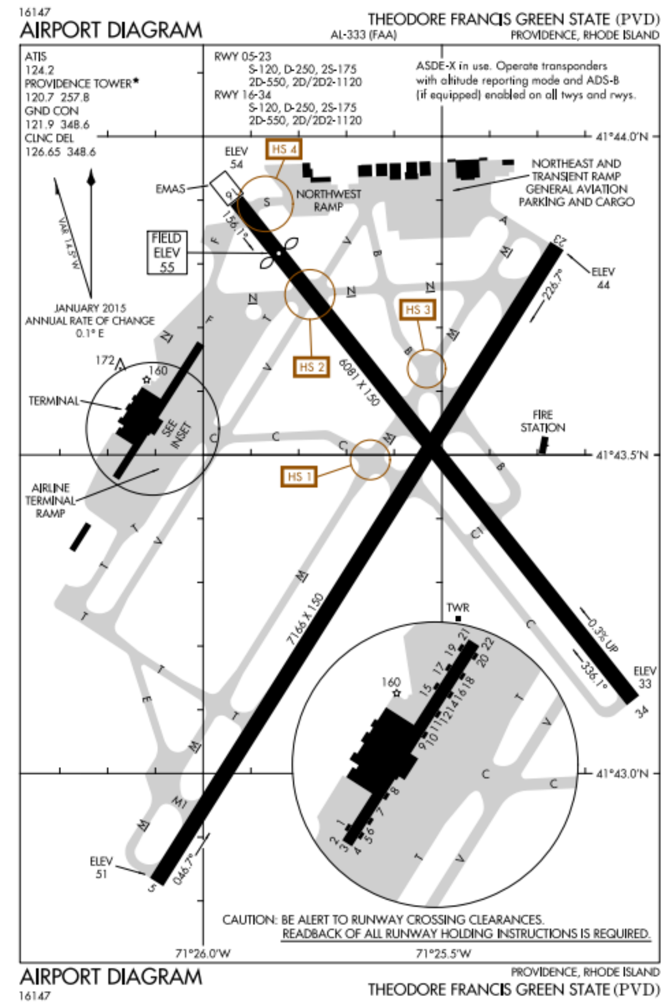
Closing Observations

- **United 1448 lost in the fog**





Questions?