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 flight 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?
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**
- 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
• 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 Technology
- Computer Interface
- Voice Command

**Social Media**
- Facebook™
- Instagram™
- Snapchat™

**Technology Consumption**
- 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**
- Netflix™
- Amazon Prime™
- iTunes™

**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
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 stitches 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
Bell V-280 Advanced Cockpit Design

- Enhanced Visual Acuity
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Bell V-280 Advanced Cockpit Design

• Enhanced Visual Acuity
Bell V-280 Advanced Cockpit Design

• V-280 Screen Demonstration
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 patterns.

• 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
### 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
**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
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
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
### Challenges – Screen Durability

<table>
<thead>
<tr>
<th><strong>Risk / Concern</strong></th>
<th><strong>Potential Risk Mitigation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete loss of critical flight data</td>
<td></td>
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<tr>
<td>• What happens if I lose the entire screen?</td>
<td>Mosaic screen construction</td>
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<tr>
<td></td>
<td>• Eliminate single points of failure</td>
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<tr>
<td></td>
<td>Redistribution of data</td>
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<tr>
<td></td>
<td>• System logic will identify a fault in an inoperative tile(s) and will automatically reconcile and redistribute the information</td>
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<tr>
<td></td>
<td>• Data will be hierarchical meaning in the event of reconciliation and redistribution, critical data (primary flight display, navigation, communication, etc.) will be given priority</td>
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<tr>
<td></td>
<td>Reparability</td>
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<tr>
<td></td>
<td>• Tiles will be common and interchangeable</td>
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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
Closing Observations

• United 1448 lost in the fog