Potential Uses of Virtual and Augmented Reality Devices in Commercial Training Applications

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Virtual Reality - What is it?

- Virtual reality is the term used to describe a **three-dimensional, computer generated environment** which can be explored and interacted with by a person.
Augmented Reality - What is it?

- An enhanced version of reality where physical real-world environments are augmented with computer-generated images over a user's view of the real-world, thus enhancing one’s current perception of reality

A Full Flight Simulator is an example of Augmented Reality
Augmented Reality/Mixed Reality - in a Virtual Reality World

- Live direct views of close “hands on” physical real-world components are provided by cameras installed in Virtual Reality Headset. The world beyond these components are computer-generated images – creating a “mixed reality” environment
Virtual Reality and Augmented Reality Technology

- Head mounted displays (HMD)
  - Headtracker built in or external
- Augmented reality - HMDs with cameras to provide the “real world” view
  - “Green Screen” backdrop may be required
- HMD driven by a PC/laptop
Virtual Reality
Mixed Reality
Benefits of Virtual Reality for Commercial Pilot Training

- Facilitates “Take Home Training”
  - Training costs can be reduced (facilities, lodging, travel)
  - Self paced learning (adaptive) vs traditional school house approach
    - Virtual Instructors
- Supports Cockpit procedures/ Flight Deck familiarization trainer
  - Type conversion training
- May enable additional training not considered previously
- Provide a more immersive experience on lower level training devices

Virtual Reality – May provide a more efficient training pipeline to help meet the increased demand for pilots
Take Home Training

- Use of intelligent tutoring systems
- One on one learning vs group lectures
- Reduce simulator time requirements
- Provides objective assessment of learned skills, as well as strengths and weaknesses
  - Tailor instruction based on this data
- Facilitates student driven learning
  - Practice and repeat problem areas without an instructor
Virtual Reality and Training: New Training Opportunities – Crew preflight inspection of aircraft
New applications - Virtual Reality and Crew Training

- Use of Avatars
  - Speaks and interacts with student
  - Instructor pilot role
  - Personalities – Gruff, or chatty

Boeing in conjunction with UCF continue to research
Regulatory considerations

Virtual Reality / Augmented Reality system as a Training Device

Several considerations

- Fidelity of cockpit representation
  - Instruments, displays
  - Flight controls
- Instructor console
- Audio system
- Instructors
- Observers
Regulatory considerations – Lower fidelity devices

Lower level devices MAY permit virtual cockpits

- ICAO Type: I, II and III
- FAA FTDs: Level 4, 5
- EASA: OTD, BITD, FNPT
  - Flight Deck Layout and structure
    - An enclosed, or perceived to be enclosed, spatially representative flight deck of the aeroplane or class of aeroplanes being simulated
  - Instruments and/or instrument panels
    - Electronically displayed images with physical overlay or masking and operable controls representative of those in the aeroplane are acceptable
  - Crew Training would have to be considered
  - Instructor Operator Station (IOS) required
  - In addition, two seats for observer and authority
  - Visual Systems are optional
    - Most VR systems this would come for “free”
Regulatory considerations – Mid fidelity devices

- ICAO Type IV, FAA FTD Level 6 EASA - FTDs
  - FTD must have a flight deck that is a replica of the airplane simulated
  - Must simulate all applicable airplane flight, navigation, and systems operation
  - Require flight controls: forces – stick, rudder pedals, throttles, flaps, etc
  - Screen based instruments can be supplied
  - Visual Systems optional
- Training Device Cockpit required
  - Facility required
- Augmented Reality Systems could be considered
  - Resolution of AR/HMD system and readability of instruments/displays
    - Needs improvement
  - Crew Training with AR
    - Use of virtual instructor and virtual crew
  - Cost benefits: Potentially lower cost visual system
Regulatory considerations – High Fidelity Devices

- ICAO Type V, FAA FTD Level 7
- Full Flight Simulators ICAO Type VI, VII, FAA/EASA FFS: Level C D,
  - An enclosed, full scale replica of the flight deck of the aeroplane being simulated including all: structure and panels; primary and secondary flight controls; engine and propeller controls, as applicable; equipment and systems with associated controls and observable indicators; circuit breakers; flight instruments; navigation, communications and similar use equipment; caution and warning systems and emergency equipment.
  - The tactile feel, technique, effort, travel and direction required to manipulate the preceding, as applicable, should replicate those in the aeroplane.
  - Visual System, collimated 180 x 40 FOV
  - Motion System required
- VR/AR of the future?
  - Potential to lower cost of visual system
  - Display Collimation, instantaneous field of view
Virtual and Augmented Reality Challenges

- Resolution of image
  - Current HMDs are significantly below eye-liming or “retinal” resolution
  - Effects both virtual and camera images
- Eye Strain/ fatigue
  - Vergence Accommodation
  - May limit training session time for some students
- Field of view
  - Human vision ~ 200°H x 120°V
  - Most VR/AR HMDs provide 100° x 100°
    - Reduction of horizontal peripheral vision
  - Can result in more head movement with VR/AR HMDs
  - Primarily a concern for the higher fidelity trainers
Resolution

- Closeness of the display to eye in HMDs to obtain larger field of view and small package
- Lenses used to magnify, focus and reshape the image
- Artifacts as a result of these optics and the pixel density of the screen being viewed;
  - “screen door” effect – see individual pixels
- Effects mixed reality viewing as well

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<th>Human</th>
<th>VR HMD (HTC Vive)</th>
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<tbody>
<tr>
<td>Resolution</td>
<td>30,000 x 20,000</td>
<td>2,160 x 1200</td>
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<tr>
<td>Pixels/inch</td>
<td>2190</td>
<td>456</td>
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Eye Strain

Vergence: Accommodation Conflict

- Vergence is the pointing of the eye lens to focus on an object
  - Further away: eyes pointed ~ parallel
  - Closer an object is, the eyes become more “cross eyed”
- Accommodation is the focus of the eye lens
- Human brain does a good job of moving these together to focus on an object
- HMD use lenses that have the eyes focus at a fixed distance
  - As you look at objects at different simulated distances in a VR headset your eyes could be straining since these two adjustments of your eyes are in conflict with your normal operation
Field of View

- Virtual Reality HMDs provide 360 field of regard
  - Head tracker provides adjustment of displayed image
- VR/AR HMDs provide an instantaneous field of view ~100° H x 100° V
  - Far peripheral vision in horizontal direction not present – the area from 60° to 100° for each eye
  - Peripheral vision, despite its lower resolution, can be important for providing a sense of an accurate representation of surrounding space for navigation
  - Peripheral vision used for detection of events – eyes (or head) then move to recognize the event

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Summary

- Expect an increase in the use of Virtual Reality in lower fidelity training devices
- Regulatory changes to facilitate, as well as establish minimum performance levels
- Increase in use of Artificial Intelligence for instructors, and virtual crew
- Additional training tasks that can be enabled by Virtual Reality will increase
- Full cockpit replicas with instruments and flight controls will continue to be required for mid and high fidelity trainers
  - Less of a role for Augmented/Mixed reality – until improved HMD resolution is realized
  - Completely Virtual Cockpit representation would require Regulatory relaxation of spatial and tactile requirements
  - Future Augmented/Mixed reality could be considered for these applications to provide a potentially lower cost and more immersive OTW visual experience
- The challenges of the current Virtual Reality technology will be addressed with time

Thank you