XR in Aviation Training: Insight from Academia, Industry, and Non-Profit Institutions

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The Future of XR in Training: A Conversation

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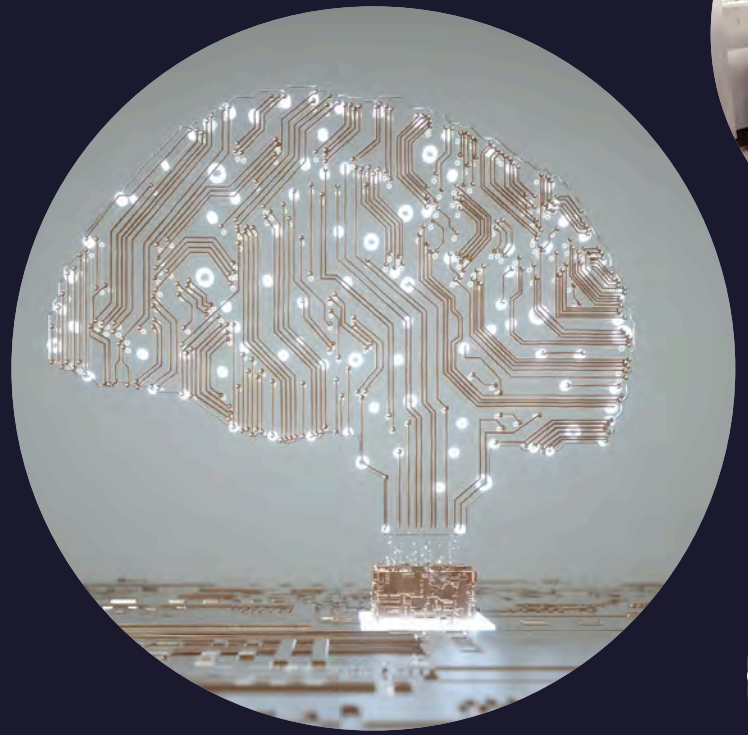
XR Research Goal

- A focus on characterizing the VE and all it entails as a multidisciplinary system for consistent performance evaluation

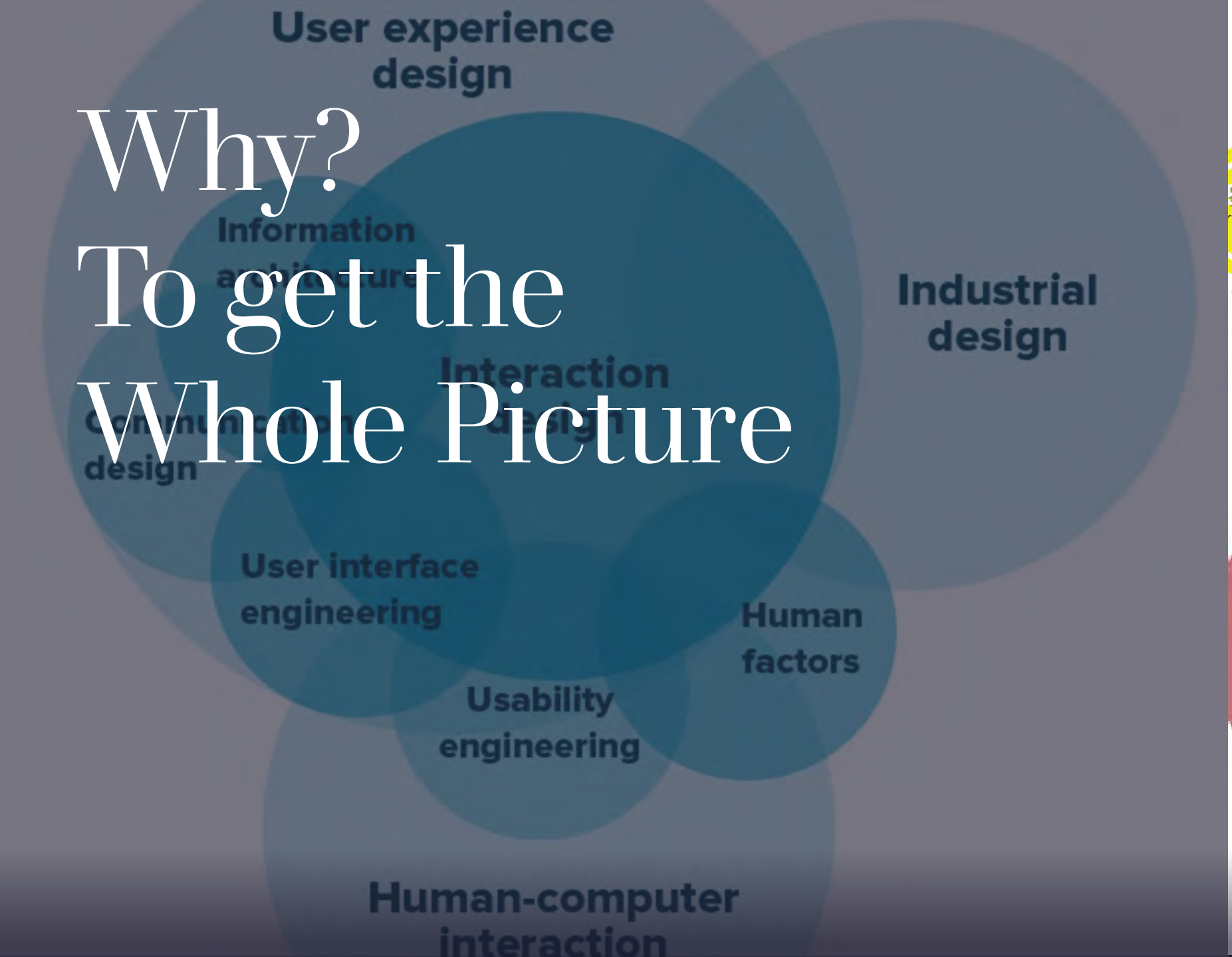
- *Disclaimer: This is what BK and I say- the lab does not have a formal mission statement etc. at this time.*

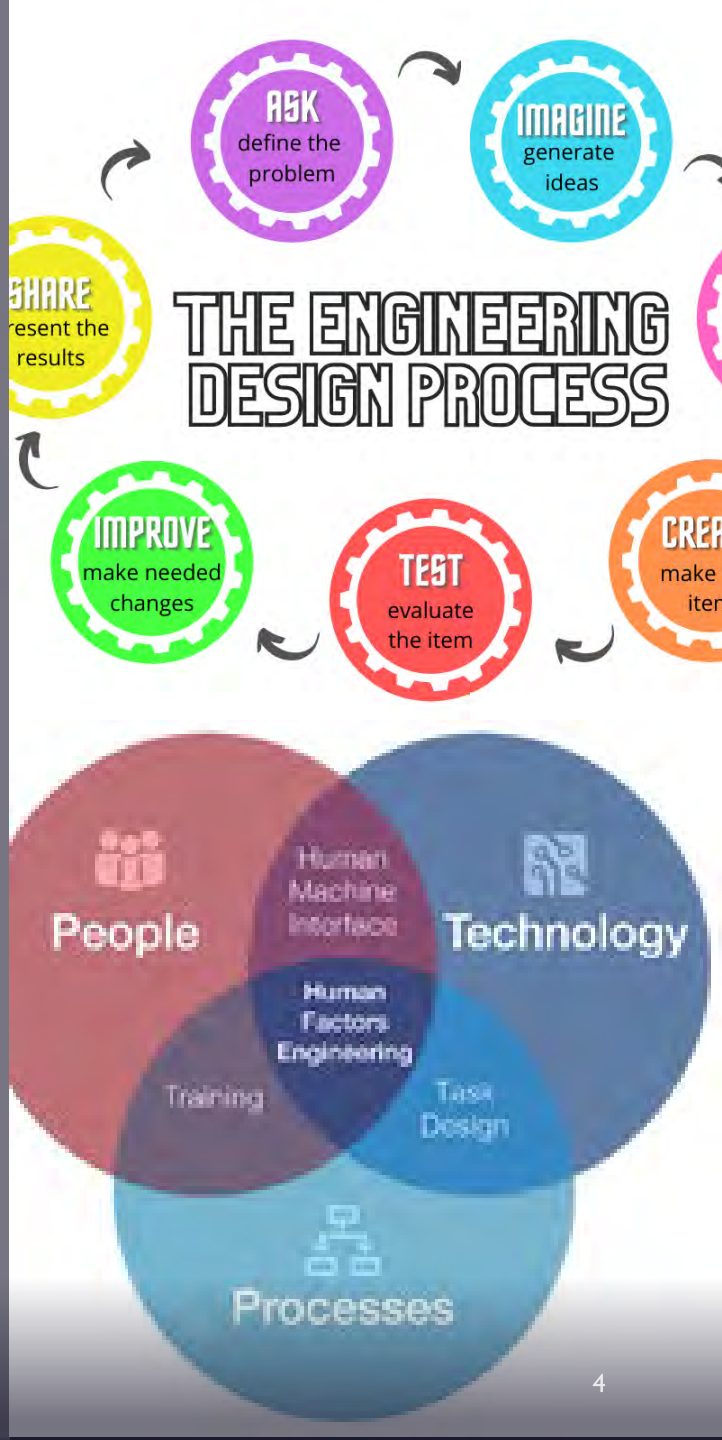


How?

- Efficiency
- Usability, UXD, UCD
- Systems engineering
- Optimization
- Physiology
- Learning/Teaching Theories

Why?
To get the Whole Picture





Features and Attributes to Consider

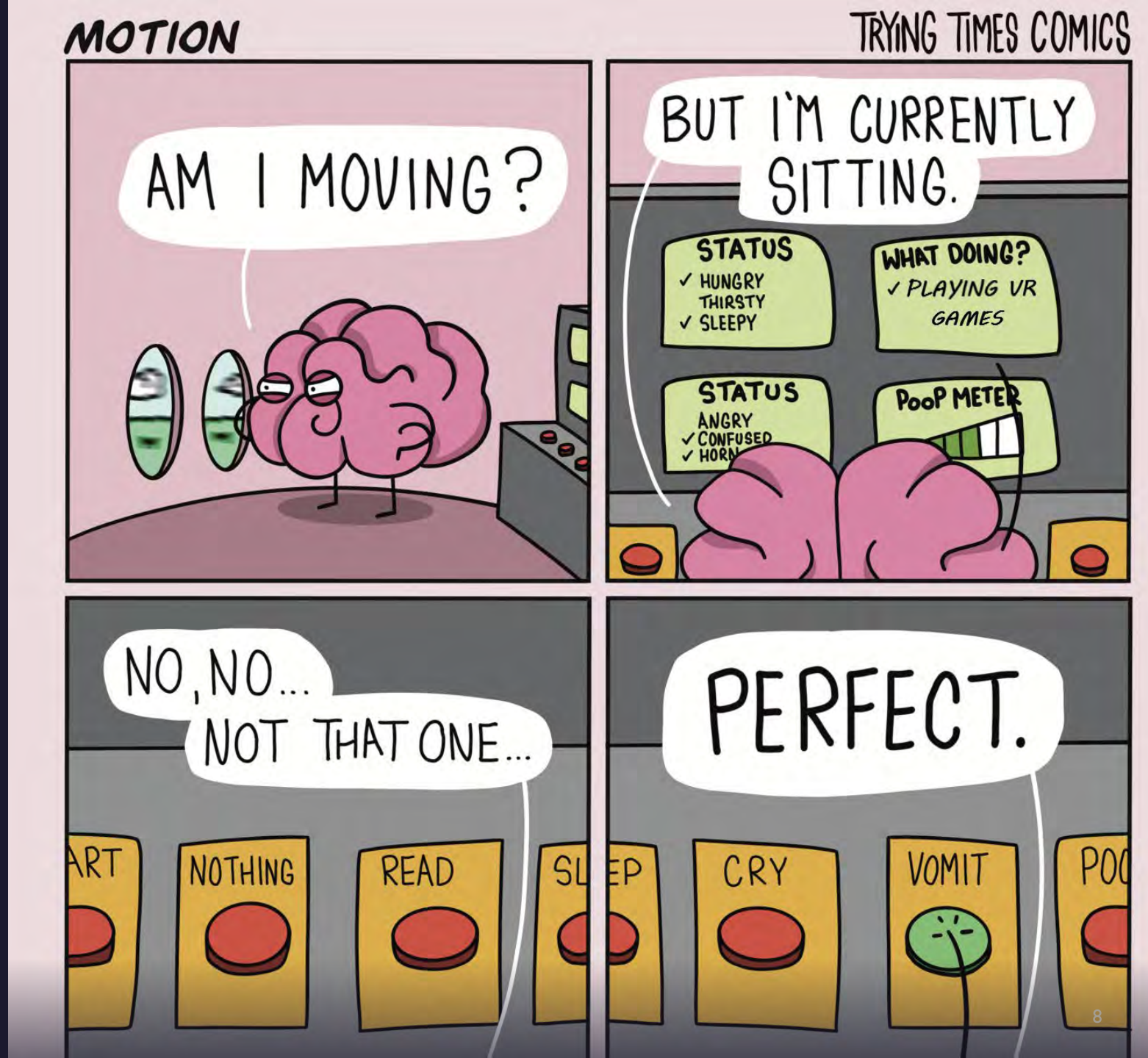
- Characteristics of the virtual learning environment
- Type of learning
- Technical specifications of the HMD
- Physiological considerations
- Theories or principles related to learning and education
- Human factors and user experience design

Fall 2022 – Spring 2023: CFI Case Studies

Spring 2023: Student Pilot Familiarization

Cyber Sickness

- Causes
- Mitigation
- Design
- Physiology



Future research

- Replication
- More research on tech specs and relationships
- Quantify affordances using the confirmed methodology
- Iterate with other HMDs
- Transfer of training experiments

THE FUTURE OF XR IN TRAINING

James Birdsong, PhD
Kurt Reesman, PhD
Auburn University

Challenge:

Interactive procedure trainers are constrained by location; students have limited access.

Question:

Can we learn basic flight deck crew procedures in XR, and transfer this skill to the FSTD to more effectively and efficiently use valuable FSTD time to focus on crew-based SBT?

Sign into session.

Select crew position.

Select area of focus.

Begin learning.

An observer's view.

WHERE DOES XR FIT?

WHERE DOES XR FIT?

VR is not one size fits all.
Tethered/untethered.
Tech specs - FOV, refresh rates, etc.
$ - $$$

WHERE TO START?

Studies

- Pilot Training Next (PTN); Army Training Next (ATN); Naval Aviation Training Next (Project Avenger)
- Cross, J. I., Boag-Hodgson, C., Ryley, T., Mavin, T., & Potter, L. E. (2022). Using Extended Reality in Flight Simulators: A Literature Review. IEEE Transactions on Visualization and Computer Graphics, 1–1. https://doi.org/10.1109/TVCG.2022.3173921

Academia – XR Consortium

- POC – Dr. Stephanie Fussell, Kent State University

Industry

- VRpilot: https://vrpilot.aero
- Visionary Training Resources (VTR): https://www.vtrvr.com

QUESTIONS?

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EMBRY-RIDDLE
Aeronautical University

Current Virtual Reality Training at Embry-Riddle's Daytona Beach Campus

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Overview

- PILOT Program
  - TCS – VR Flight Simulation
  - CAART – VR Procedural Trainer
- VRAIT – Virtual Reality Aviation Illusion Trainer

PILOT: New Private Pilot Training Program

- Purpose: To increase the capacity, efficiency, and effectiveness of private pilot training through the utilization of VR software and flight simulation applications.

- Expected Results:
  1. Increase in student preparation for private pilot training
  2. A reduction in student training time
     - flight hours and calendar days
  3. A reduction in student training cost

PILOT – Stage 1

- Duration – 4 weeks
- Scheduling – Weekdays (M-F) with course makeup during weekends
- 5 activities in 4 labs per day (4.2 hours of training)
- Homework: Pre-Activity Computer Exercises (PACE)

ORAL

Flight Sim

VR Flight Sim

VR Procedure/ATC Trainer

VRAIT

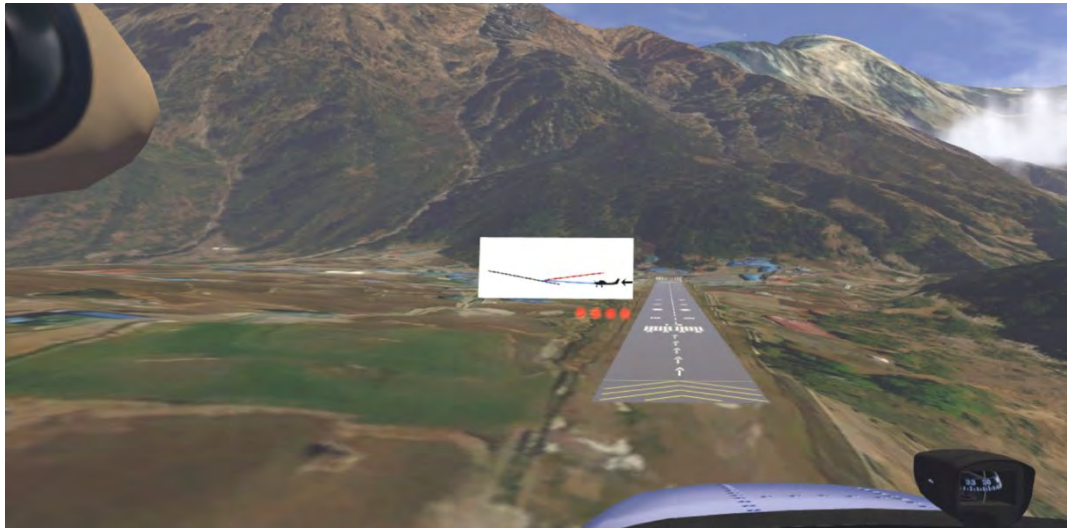
- Virtual Reality Spatial Disorientation Trainer
  - Development began in 2020
- Goal: Use virtual reality and a motion platform to provide training by giving conflicting inputs to visual and vestibular senses
- Created 12 scenarios to demonstrate common aviation illusions
- Challenge was how to develop this training?

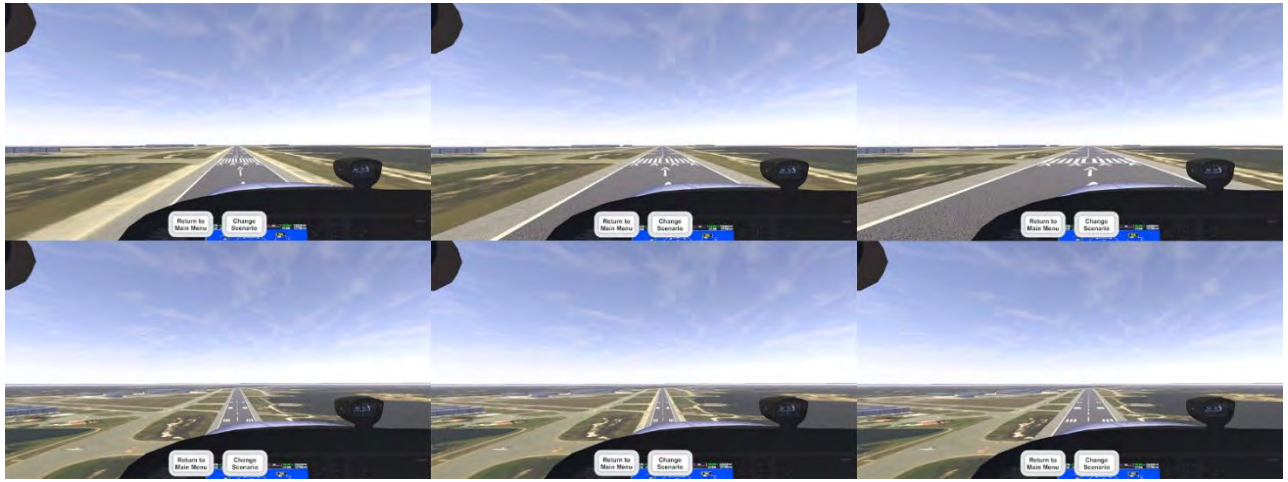
Phase 1 VR Equipment

- Utilizes a Commercial-off-the-shelf (COTS) VR headset and computer
  - VR computer with a high-end graphics card
  - Valve Index VR headset and hand controls
- Only for visual illusions

Examples of Visual Illusions

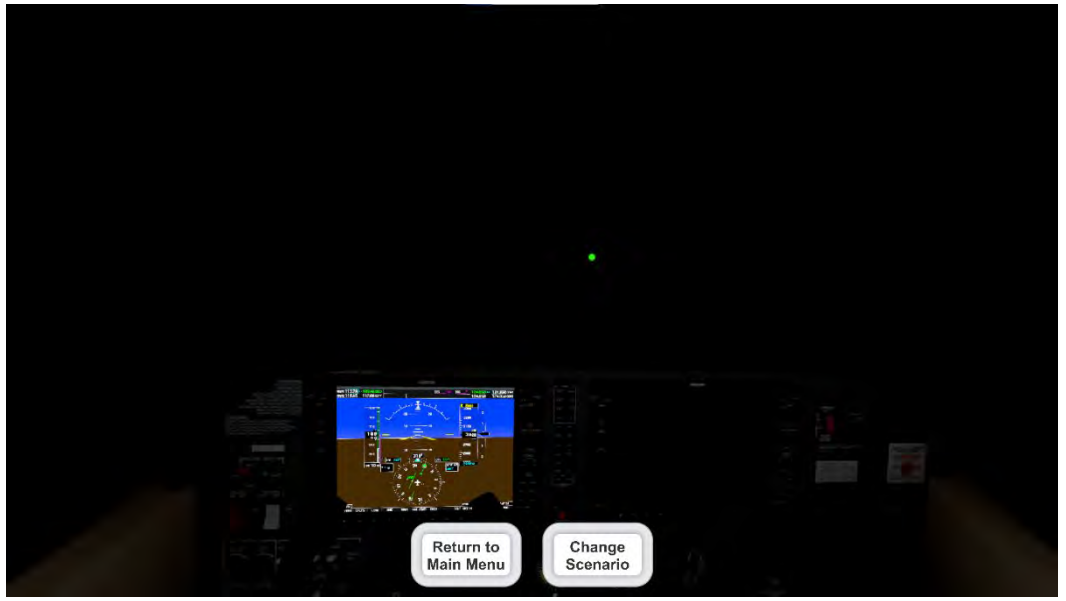
- Runway Width
- Runway Slope
- Black Hole





Examples of Visual Illusions

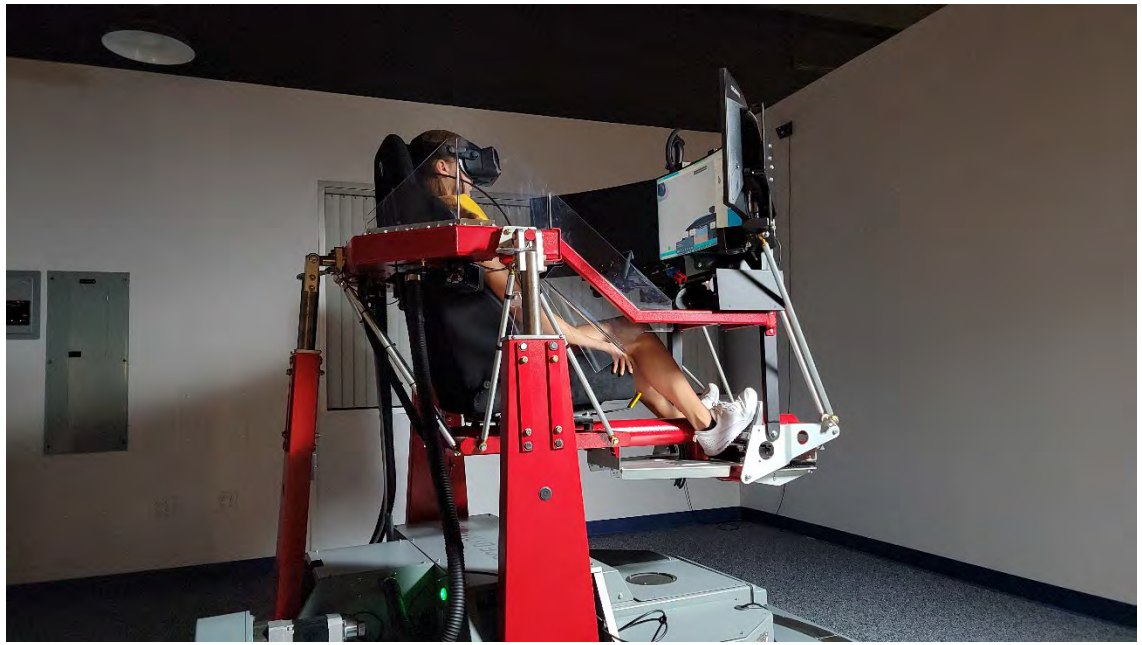
- False Horizon Day (FHD)
- False Horizon Night (FHN)
- Autokinesis



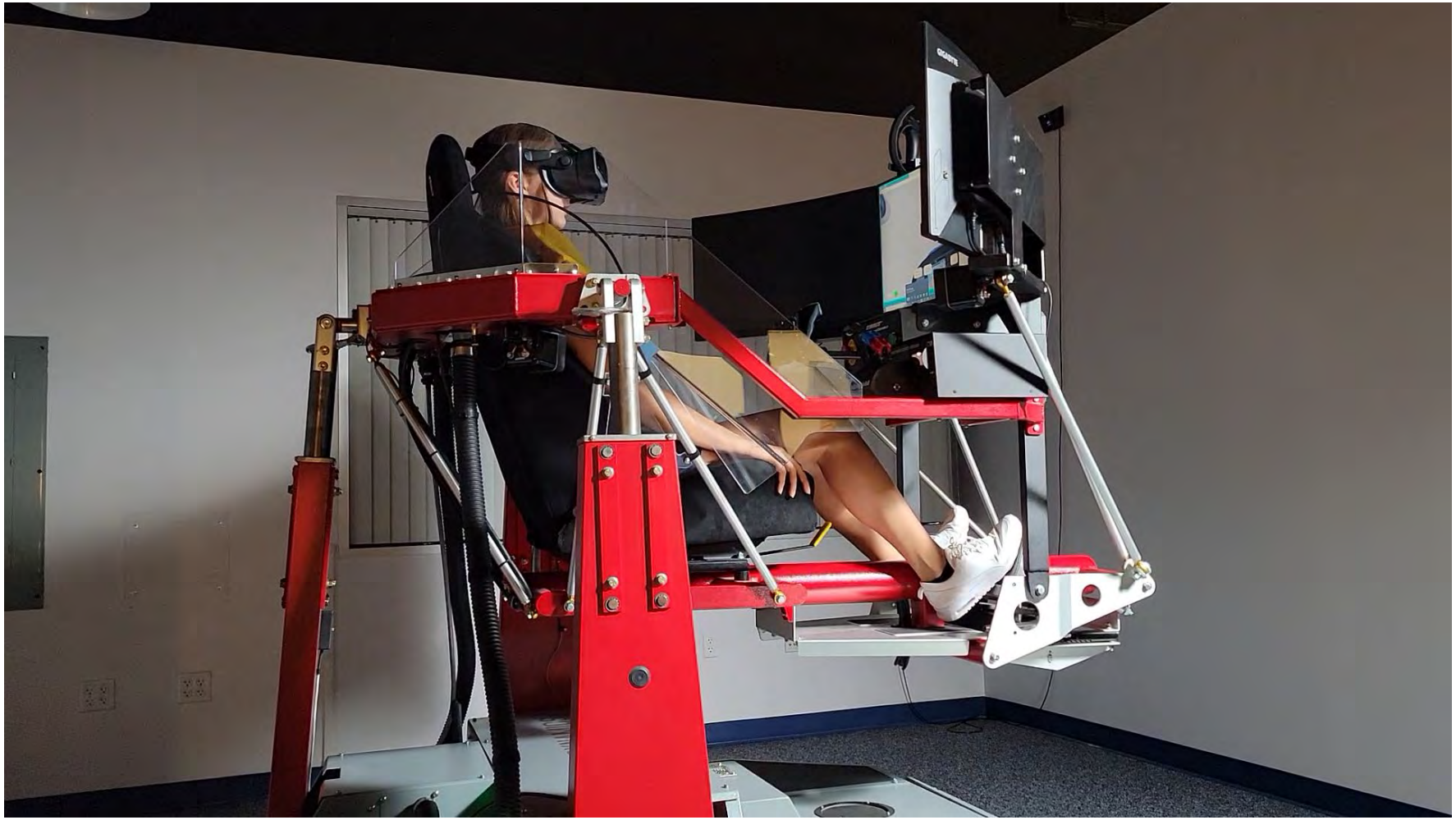
Phase 2 VR Equipment

- Steam Valve Index VR Headset

- Force Dynamics 401CR motion platform
  - Full 360° rotation unlimited
    - Roughly 3 seconds per rotation
  - Pitch 30°
  - Bank 30°
  - Vertical Motion - 7 inches



Phase 2 VR Equipment



All Illusions

VRAIT Sequence and Timing		
	Illusion	Time (minutes)
1	Runway Width	5
2	Coriolis	4
3	Sloped Runway	5
4	Leans	6
5	Black Hole	4
6	Graveyard Spiral	5
	INTERMISSION	
7	False Horizons Day	6
8	Nystagmus	4
9	False Horizons Night	5
10	Oculogyral	4
11	Autokinesis	4
12	Somatogravic	4
	TOTAL VRAIT VR	**60**

Data Collection & Measures

- Participant knowledge pre- & post-training
  - Defining, recognizing, and how to prevent/mitigate the effects of the illusion
  - 2 Parallel versions of the test

VRAIT Pre-Training Knowledge Test

Runway Width

1. A wide runway width compared to a normal runway width will give the pilot the illusion of being:
   a. Higher than actual altitude
   b. Lower than actual altitude
   c. No illusion will be felt

2. Runway width illusions are least prevalent:
   a. At 300 feet on final approach
   b. Just before touchdown
   c. During the flare

Data Collection & Measures

- Self-efficacy questionnaire pre- & post-training
  - Rating confidence on ability to define, recognize, and apply proper corrective actions in flight
  - Participants self-report the self-efficacy level before and after training

Runway Width

1. I can define the illusion.
2. I can recognize the illusion in flight.
3. I describe how to prevent/mitigate the effects of the illusion.
4. I can perform the proper corrective actions when I experience this illusion in flight.

Data Collection & Measures

- Simulator Sickness Questionnaire (SSQ) post training

- igroup Presence Questionnaire (IPQ)
  - 14 question survey
  - measures the sense of presence in the virtual environment

- System Usability Scale (SUS)

- Training Satisfaction survey
  - Enjoyment
  - Technological Satisfaction
  - Validated at ERAU (Pending publication)

Future Research Plans

- IRB Approval Pending
- Run approximately 100 participants
- Verify ability to cause intended illusions
- Rollout to larger student base
- Exploring the possibility to test Visual Illusions at other institutions

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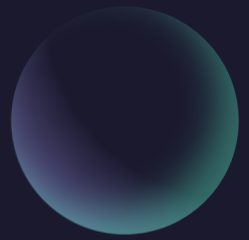
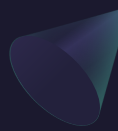
Best Practices





Have You Accounted For...

- Type of learning will influence the choice of a VR HMD
- Realism and immersion may be less critical for learning procedural tasks
- Actions, knowledge, and skills should be able to translate from VE to real world
- It is evident that the design of the HMD, from an ergonomic standpoint, contributes to the overall experience, usability, and perceived workload
- The impact of immersion and presence on learning, skill acquisition, and mastery needs more investigation
- The relationship of discomfort, simulator sickness symptoms, duration, and task type needs to be studied

Oculus Quest 2

PROS

- Lowest price, weight of 503g
- Wireless use
- Heavily marketed and produced
- Respectable resolution and pixel density

CONS

- Fewer fit customization abilities
- Three preset lens distance positions
- Lowest FOV
- Fit can be very uncomfortable based on user physiology, HMD design, etc.

HTC Vive Pro

PROS

- Heavily produced and marketed
- High resolution, pixel display, refresh rate, FOV
- IPD can be adjusted
- Low ratings of sim sickness symptoms

CONS

- Heaviest HDM, 850g
- Controller design
- Fit can be very uncomfortable based on user physiology, HMD design, etc.

Valve Index

PROS

- Highest FOV
- High ratings and open-ended responses related to presence, immersion, and realism
- Generally comfortable to wear based on user physiology, HMD design, etc.
- User-friendly controller design

CONS

- Lowest pixel density and resolution

Varjo Aero

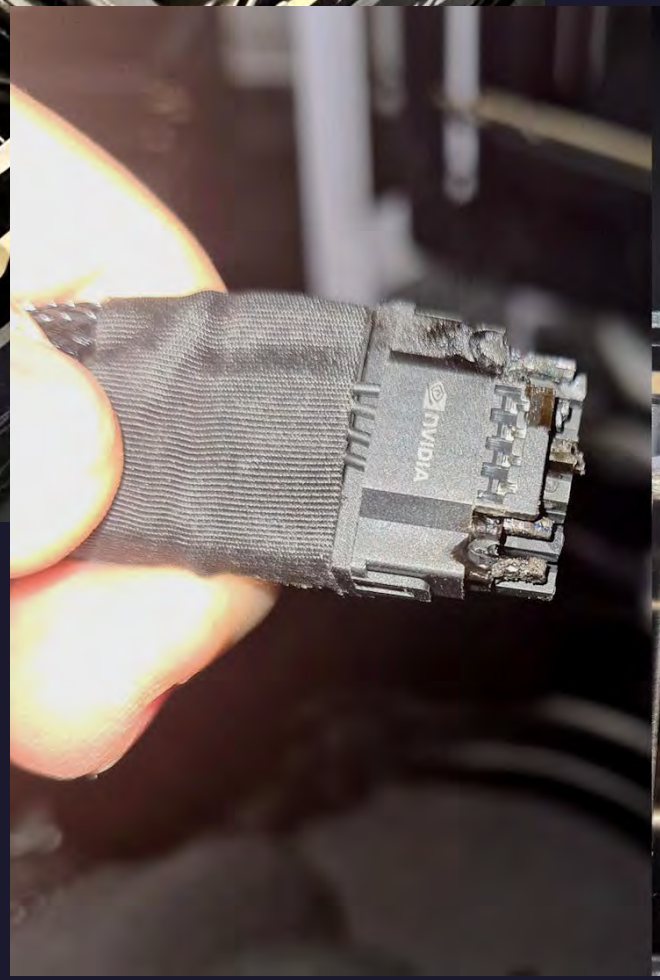
PROS

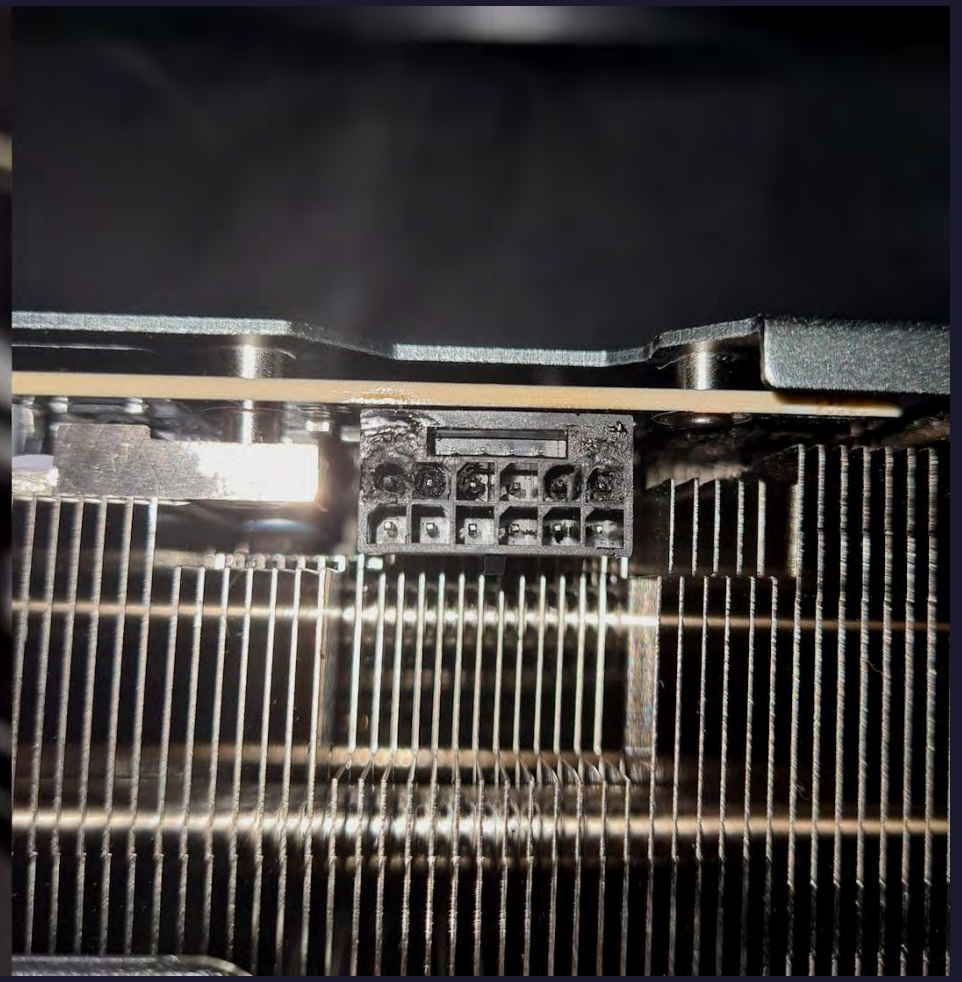
- Professional grade for industry and advanced users
- Highest resolution and density
- High FOV
- Three points of fit, active face cooling, IPD calibration
- High ergo score

CONS

- Most expensive
- Mixed feedback in general

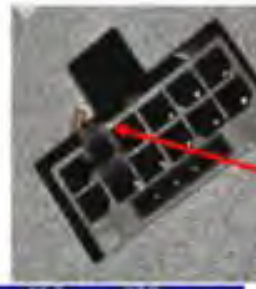
Understanding VR Hardware Demands


NVIDIA

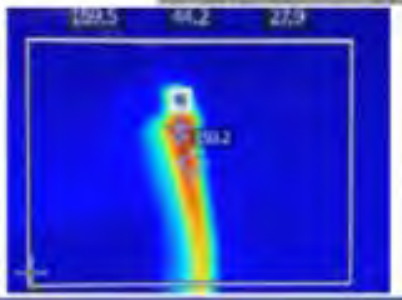


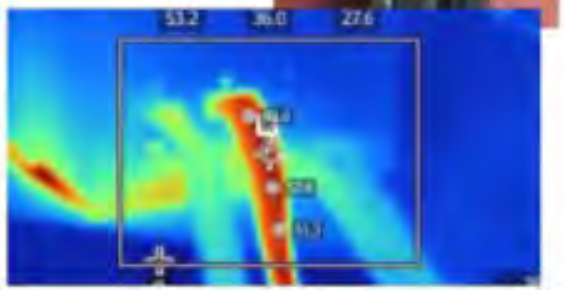
Observations

- Images below show overheating of the power connector at mating point. Multiple suppliers and designs have failed
- Cables with low cycles and without bend condition have not failed
- Failures observed on both rows of pins depending on load direction
- Hot spots observed @~2.5hrs, melting 10-30hrs
- Note - Also observed after high mating cycles ~40, straight plug w/o side load



Pin 11





Pin 6

Pin 2

Pin 1

Pin 2