QUANTUM IMPROVEMENTS CONSULTING

Mixed Reality Aircrew Training Simulator Evaluation

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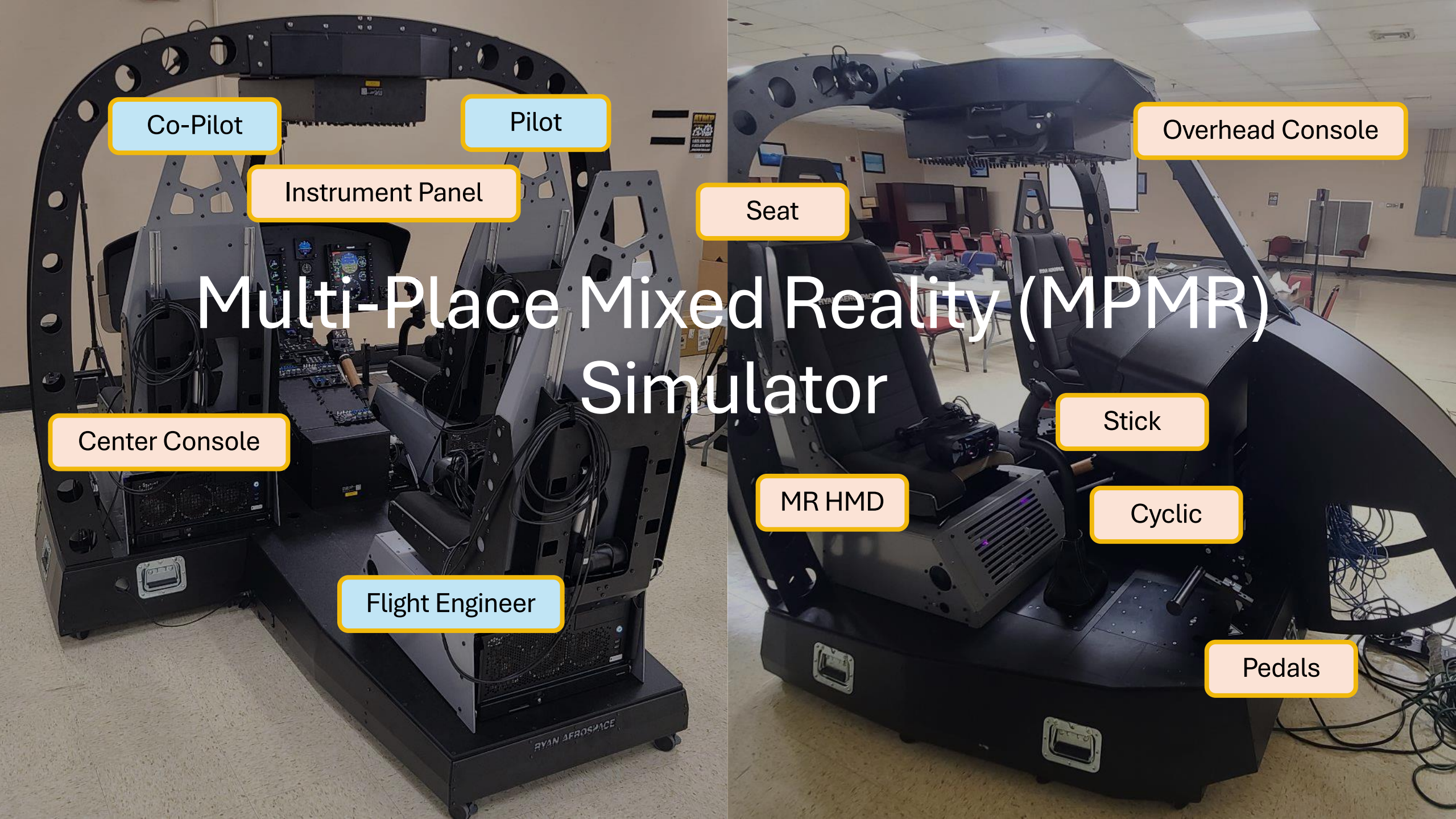
Acknowledgments

The presenters acknowledge Vertex Solutions as the prime contractor and system developer. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of U.S. Air Force (USAF), the U.S. Government, or Vertex Solutions, LLC.

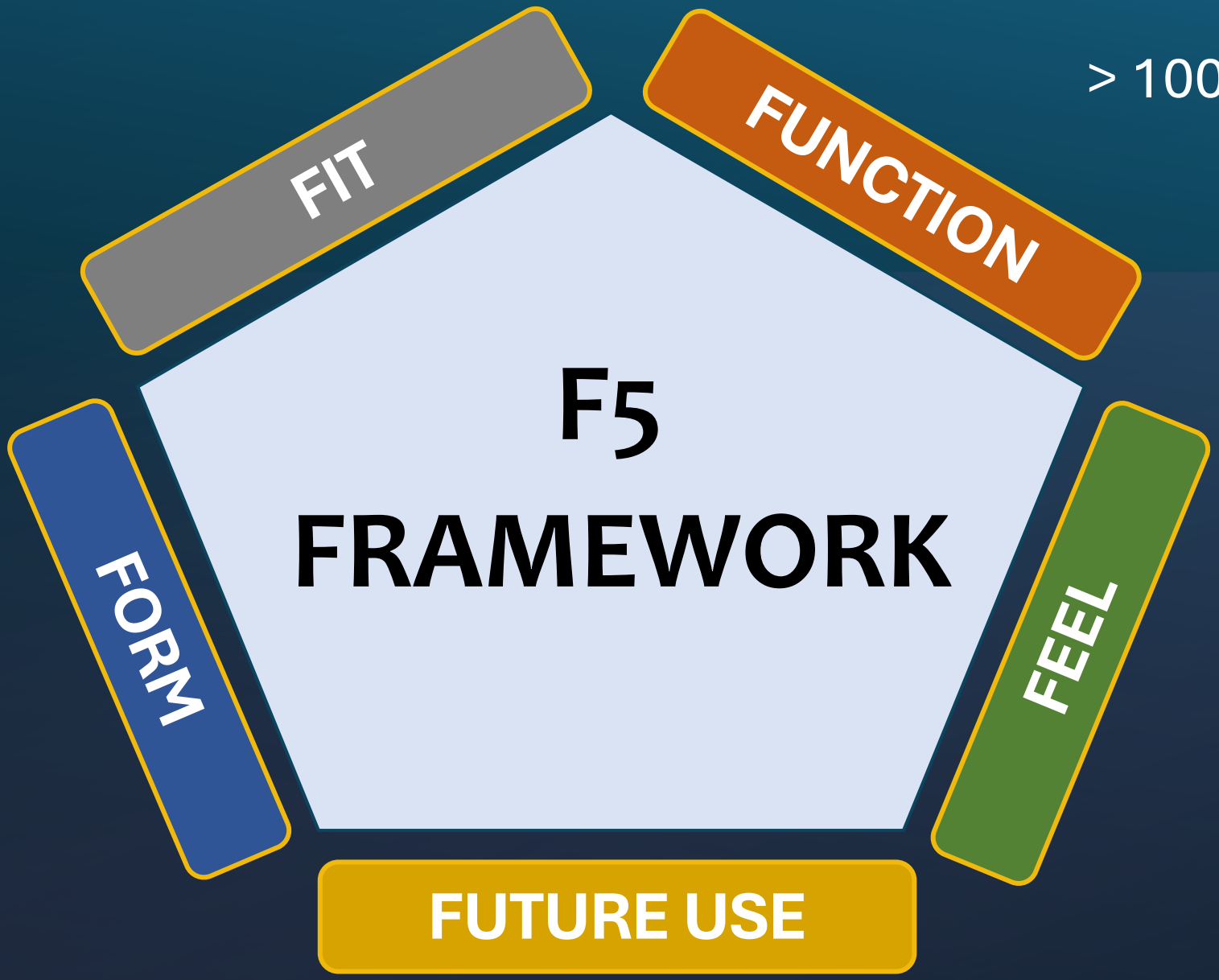
Retrofitted

Increase Qualified Training Throughput

- USAF goal - 90 helicopter pilots annually
- Helicopter-only training pipeline
- Increase sim training
- Reduce the types of simulators



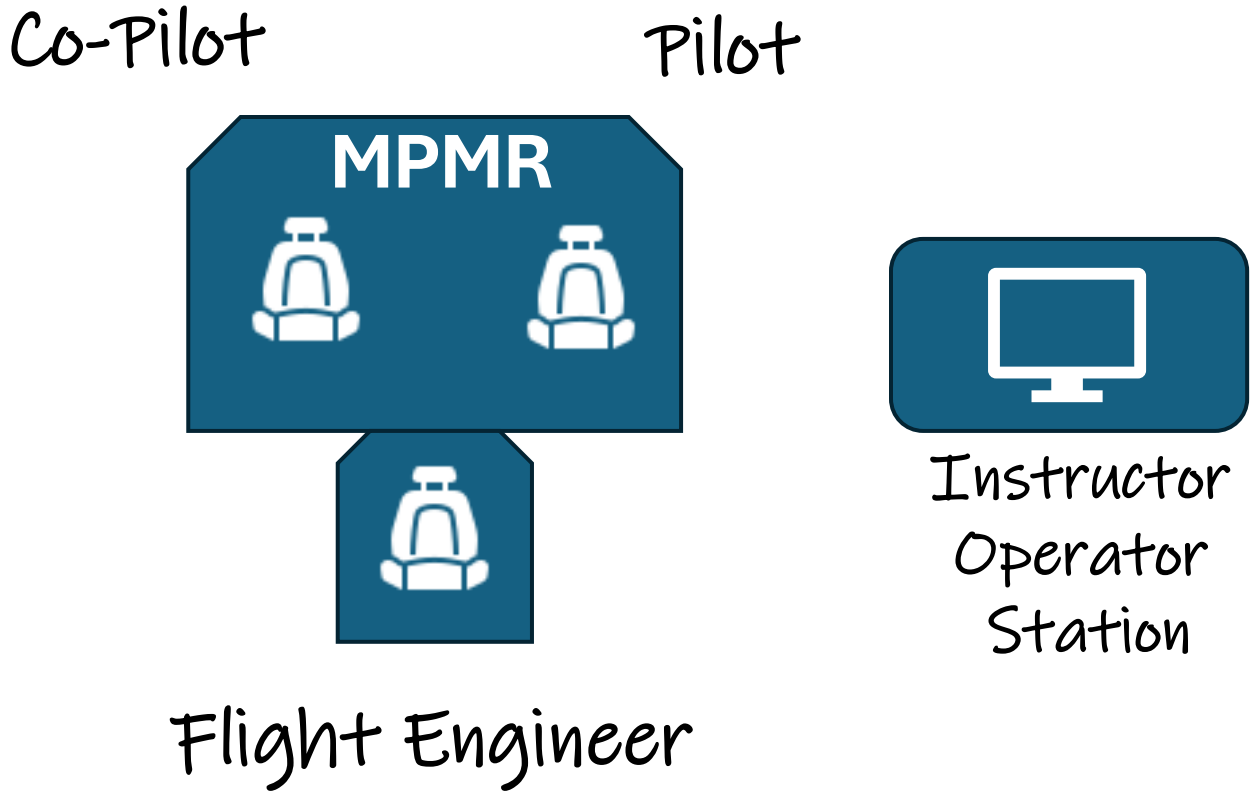
Multi-Place Mixed Reality (MPMR) Simulator



> 100 critical aspects evaluated

Abich & Sikorski, 2022. https://doi.org/10.2514/6.2022-4142

Methodology



Flight Crew Measures

- Demographics
- Technology Self-Efficacy
- Simulator Sickness
- Helicopter Simulator Experience

Instructor Measures

- Demographics
- Technology Acceptance
- Instructor Experience

Training Tasks

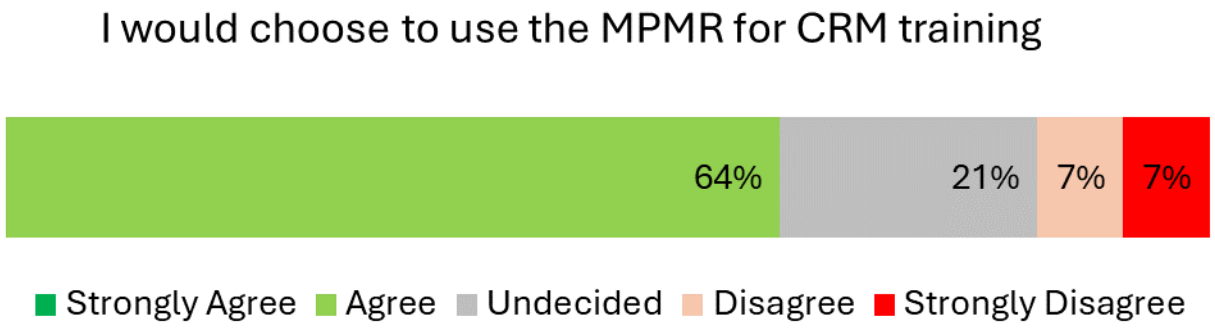
- Aircraft operations
- Instrument procedures
- Navigation air failures
- Emergency procedure conditions

Air Crew Training Participants

	Instructors	**Instructors in Training**	**Students**
Sample Size	N = 16	N = 2	N = 2
Flight Hours	~ 2400 hours	~1600 hours	~145 hours
XR Training Experience	~ 8 times	~5 times	~15 times

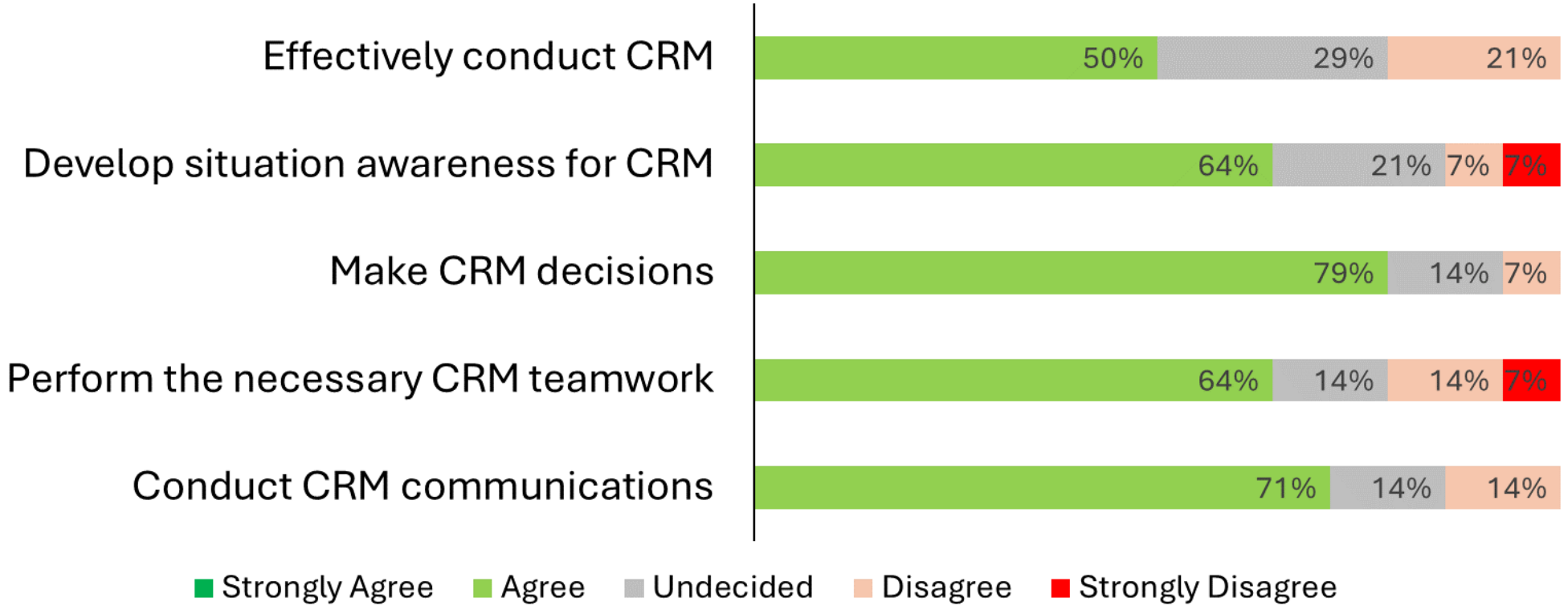
Crew Resource Management - Training

- Communication Skills
- Situation Awareness
- Decision-Making
- Checklist and Procedures
- Emergency Procedures
- Teamwork & Conflict Resolution
- Stress Management
- Resource Management

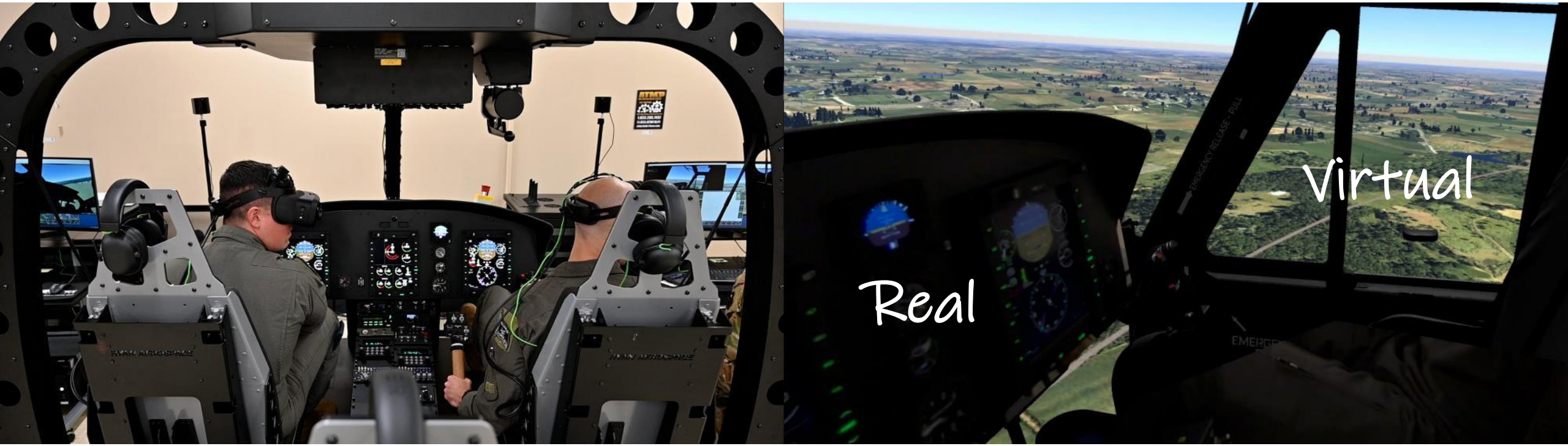


Crew Resource Management - Training

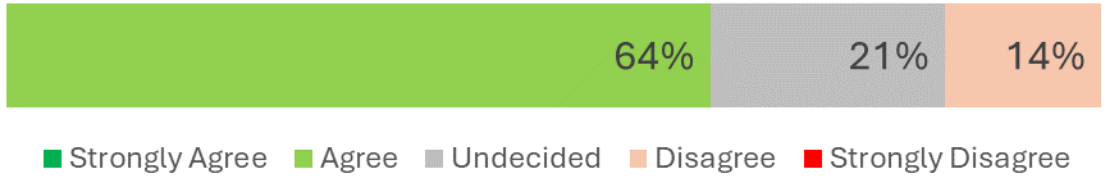
I was able to…



Mixed Environment Integration



I would choose to use this **MR HMD** for rotary aircraft training



Mixed Environment Integration

Feedback

- Difficult to see across full instrument panel
- Angle of view altered digital overlays
- Challenge transitioning from near to far focus

Recommendations

- Turn off foveated rendering
- Expand personal masking window
- Improve rendering to quickly read instruments and consoles

Physical Controls and Interaction View

Feedback

- Mismatch between pilot input to aircraft response
- Physical component locations

Recommendations

- Adjust physical location of all controls relative to each other
- Ensure menu navigation and icons match real aircraft
- Calibration of pilot input to aircraft response

Flight Engineer

Pro

- Creates more opportunities for flight engineers CRM training

Con

- Highest sim sickness ratings

Recommendation

- Evaluate impact of location and role in sim

- Ensure MR masking allows full view of pilots

Perceived Effectiveness

Aircraft Operations

1. Before Starting Engine Checklist - 80%
2. Starting Engine Checklist – 70%
3. Hover/Taxi Checklist – 91%
4. Before Takeoff Checklist – 80%
5. Landing Checklist – 100%
6. Engine Shutdown Checklist – 57%

Instrument Procedures

1. Instrument Cockpit Check – 51%
2. Instrument Takeoff – 71%
3. Instrument Enroute Procedures – 100%
4. Precision Approach Procedures – 77%
5. Non-precision Approach Procedures – 60%
6. Missed Approach – 75%

~70 – 100 % Agreement

Emergency Procedures

1. Engine Malfunction – Partial autorotation – 42%
2. Hung Start – 100%
3. Droop Compensator Failure – 50%
4. Engine Failure – 33%
5. Engine Overspeed – Nf Governor Malfunction – 80%
6. Engine Overspeed – Fuel Control Malfunction – 66%
7. Engine Underspeed – 100%
8. Engine Oil Pressure Low – 100%
9. Engine Fuel Pump Malfunction – 100%
10. Fuel Boost Pump Failure – 100%
11. Transmission Oil – Low Pressure - 100%
12. Rotor Brake Warning Light – 100%
13. Hydraulic Power Failure – 17%
14. Partial Power Loss – 50%
15. Loss of Tail Rotor Effectiveness - 66%
16. Fixed Pitch Failures – Hovering - 33%
17. Inlet Guide Vane Actuator Failure – 60%

Implement user-centered design

Usability/User Experience evaluations are necessary

XR can facilitate full crew training

Avoid “The aircraft doesn’t fly like this” statements

Stay Connected

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