U.S. Army Research, Development and Engineering Command

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A Method To Assess The Human Factors Characteristics of Army Aviation Helicopter Crewstations

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Objective

An overview of the assessment methodology used to ensure that Army Aviation crewstations are designed to help pilots effectively perform their flight and mission tasks.

- Crewstation design should augment the cognitive and physical abilities of aircrews.
  - Minimize pilot workload
  - Enhance situational awareness
  - Enable crew coordination
  - Contribute to successful mission performance

- The methodology to assess crewstation design includes:
  - Human-figure modeling
  - Simulation
  - Operational testing

Aircraft

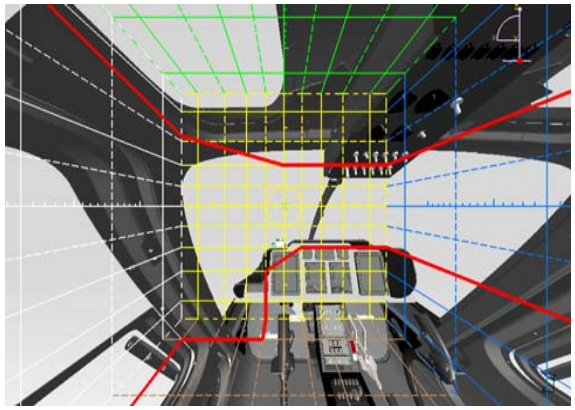
This methodology has been used to develop all modernized Army Aviation including:

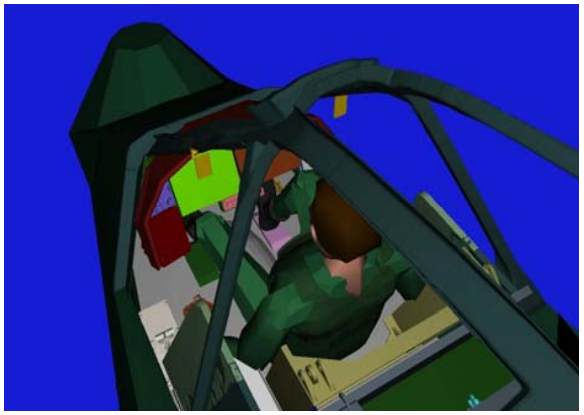
AH-64D Apache Longbow	OH-58F Kiowa
UH-60M Blackhawk	CH-47F Chinook
UH-72A Lakota	

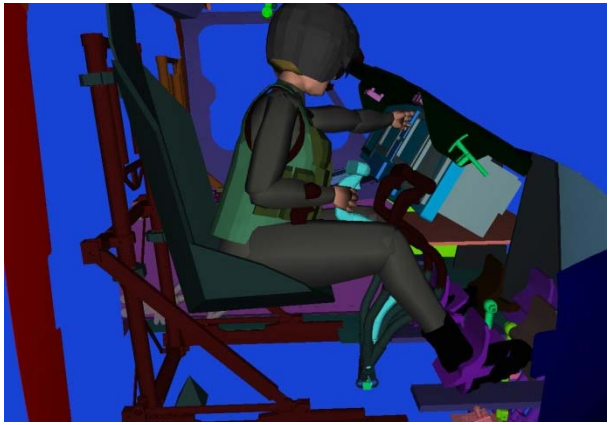
Modeling

Human-figure modeling for crewstations evaluates:

- Anthropometric requirements
- Visual access
- Physical reach
- Flight control envelope
- Pilot/equipment space restrictions



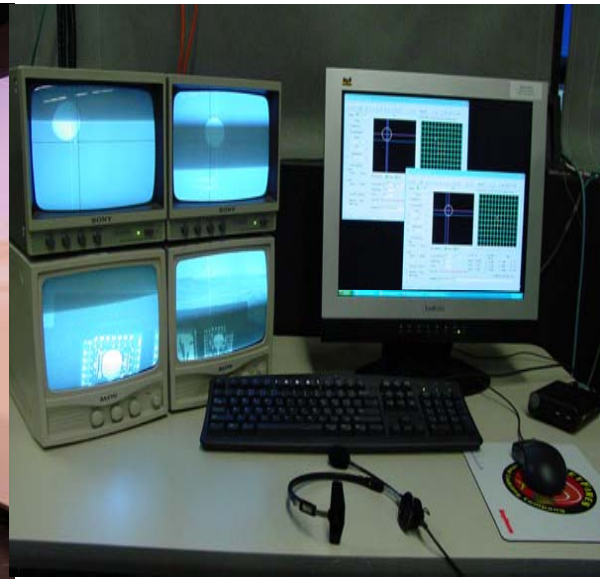




Simulation

- ARL HRED has partnered with AMRDEC and Program Managers to assess and develop crewstations via simulation.
  - Near production representative simulators
  - Aircrews

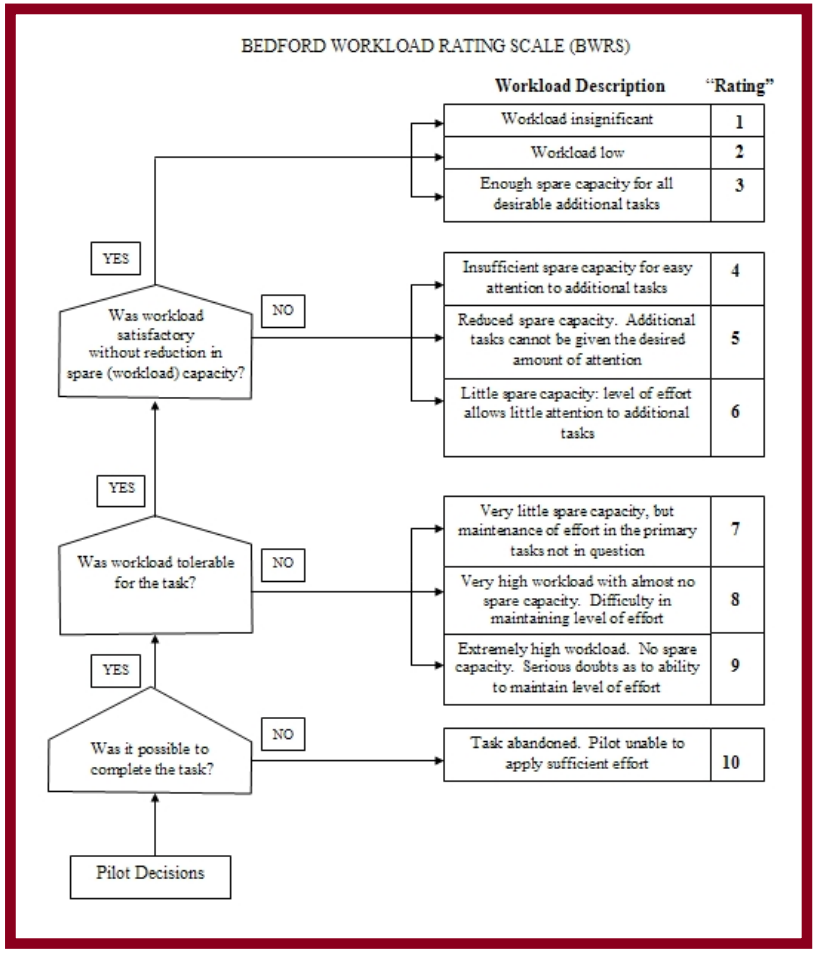
- The simulators are used to assess pilot performance during operationally realistic missions.
  - Pilot workload
  - Situation awareness
  - Crewstation interface
  - Crew coordination
  - Head and eye tracker
  - Simulator Sickness



Testing

- ARL HRED partners with ATEC to help conduct operational testing.

- Methods of data collection include:
  - Bedford Workload Rating Scale (BWRS)
  - Situation Awareness Rating Technique (SART)
  - Pilot-Crewstation Interface (PCI)
  - Crew coordination
  - Independent Evaluation Committee
  - Audio/Video collection/Pilot interviews



Simulation &Testing

Aircraft	Simulation/Test
OH-58F	Human Factors Engineering (HFE) #1, 2, 3 Design Assessment
AH-64D	Unmanned Aircraft System (UAS) Teaming Limited User Test (LUT) Force Development Test and Evaluation (FDT&E) Initial Operational Test and Evaluation (IOT&E)
ARH-70	Common Aviation Architecture System (CAAS) Assessment Limited User Test (LUT)
CH-47F	Common Aviation Architecture System (CAAS) Assessment Initial Operational Test and Evaluation (IOT&E)
RAH-66	Force Development Test and Experimentation (FDT&E)

Aircraft	Simulation/Test
UH-60M	Early User Demonstration (EUD) Limited User Test (LUT) Limited Early User Evaluation (LEUE) Initial Operational Test and Evaluation (IOT&E)
C-27J	Initial Operational Test and Evaluation (IOT&E)

Simulator Sickness Questionnaire

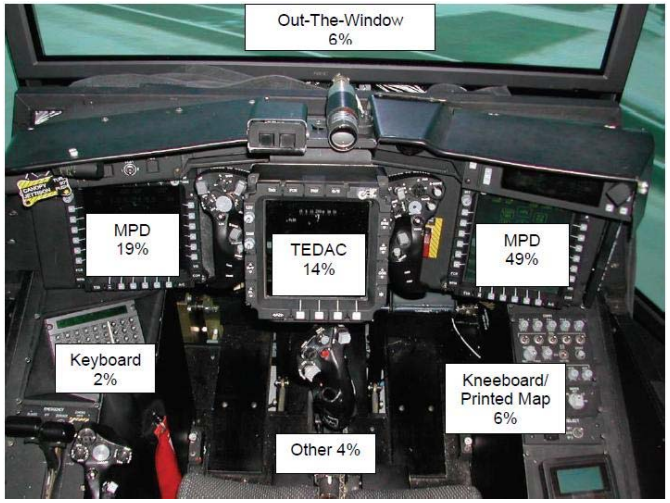
SSQ Total Score	Categorization
0	No symptoms
< 5	Negligible symptoms
5–10	Minimal symptoms
10–15	Significant symptoms
15–20	Symptoms are a concern
> 20	A problem simulator

Simulator	Nausea Subscale	Oculomotor Subscale	Disorientation Subscale	Total Severity Score (Mean)
ARH-70 (BHIVE)	18.02	21.48	9.28	20.15
OH-58F (BHIVE)	8.86	21.32	18.91	19.23
CH-47F (CHEAC)	12.52	18.48	10.15	16.75
RAH-66 (EDS)	11.84	14.98	4.54	13.25
RAH-66 (CPC)	6.73	15.40	4.32	11.40
UH-60M – LEUE (BHIVE)	6.36	11.81	3.09	9.15
AH-64D – Integrated (UAS) (RACRS)	9.01	7.58	4.64	8.51
UH-60M – EUD (BHIVE)	13.88	6.89	0	8.5
UH-60M – LUT (SIL)	6.36	8.64	2.71	7.49
AH-64D – Non-Integrated (UAS) (RACRS)	3.18	5.05	4.64	4.98

*See acronym list.

Eye Tracker

Simulator (Cargo/Lift)	Seat	Outside Cockpit	Inside Cockpit
UH-60M – LEUE (BHEAC)	Co-Pilot	26%	74%
	Pilot	61%	39%
UH-60M – LUT (SIL)	Co-Pilot	28%	72%
	Pilot	86%	14%
UH-60M – EUD (BHEAC)	Co-Pilot	---	---
	Pilot	72%	28%



Eye Tracker

Simulator (Attack/Recon)	Seat	Outside Cockpit	Inside Cockpit
AH-64D – Integrated UAS (RACRS)	Co-Pilot	6%	94%
	Pilot	75%	25%
AH-64D – Non-Integrated UAS (RACRS)	Co-Pilot	3%	97%
	Pilot	75%	25%
AH-64D – non-UAS (RACRS)	Co-Pilot	3%	97%
	Pilot	75%	25%
ARH-70 (BHIVE)	Co-Pilot	7%	93%
	Pilot	61%	39%
OH-58F (BHIVE)	Co-Pilot	7%	93%
	Pilot	63%	37%

Workload

Examples of Bedford Workload Ratings - Overall Workload Averages		
System/Test	**Co-Pilot**	**Pilot**
AH-64D – Integrated (UAS)	2.60	2.90
AH-64D – Non-Integrated (UAS)	3.30	2.60
RAH-66 – FDTE 1	3.08	2.90
ARH – CAAS	3.71	3.94
UH-60M – LEUE	3.33	2.98
UH-60M – LUT	2.80	2.58
CH-47F – CAAS	2.66	2.70
OH-58F – HFE #2	3.17	3.00

Capabilities Development Document (CDD):
Objective: 5 Threshold: 6 (Requirement)

Situation Awareness

Examples of Situation Awareness Rating Technique - Overall Averages		
System/Test	**Co-Pilot**	**Pilot**
AH-64D – Integrated (UAS)	18.40	23.20
AH-64D – Non-Integrated (UAS)	19.00	21.30
RAH-66 – FDTE	21.86	22.40
ARH-70 – CAAS	17.67	17.22
UH-60M – LEUE	26.42	25.25
UH-60M – LUT	28.28	28.22
CH-47F – CAAS	23.83	20.13

Summary

- 300+ crewstation issues identified and resolved (i.e. improved display of operational limits, optimized crewstation switch locations and functions)
- Methodology is very productive in rolling results and recommendations back into system design
- Iterative crewstation assessments used to drive continuous incremental improvements
- Able to identify changes that work (i.e. better pilot performance) in near real-time
- Identify areas that still need more work (i.e. causing high workload, low situation awareness, etc.)
- Issues identified for one system often apply to new systems—helps with early identification of issues for new systems
- Results feed the MANPRINT Assessment for each system

ARL HRED will continue to use and improve the crewstation assessment methodology to meet the demands of the next generation aircraft for the Army.

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Simulator Acronyms

- BHEAC – Blackhawk Engineering and Analysis Cockpit
- BHIVE – Battlefield Highly Immersive Virtual Environment
- CHEAC – Cargo Helicopter Engineering and Analysis Cockpit
- CPC – Comanche Portable Cockpit
- EDS – Engineering Development Simulator
- RACRS – Risk and Cost Reduction System
- SIL – System Integration Laboratory