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User-Centered Design of a Flight Medic Augmented Reality Heads-Up Display (AR-HUD) for U.S. Army Aviation

by Derek Millard, Bradley Davis, Jesus Anaya, and Gina Hartnett

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DEVCOM Analysis Center

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The focus of the study was to evaluate a prototype flight medic augmented reality heads-up display (AR-HUD) to determine how to visualize relevant information with priority by using a user-centered design process. Six subject matter experts participated in this study that used a virtual reality simulation programmed in Unreal Engine 5. Future Army technology will allow the designed flight medic HUD to be integrated with an aircraft cabin to align with Army 2040 technology goals.					
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1. INTRODUCTION

Access to relevant medical and flight information is essential for flight medics to help preserve life during medical evacuation (MEDEVAC) missions. Currently, flight medics do not use a heads-up display (HUD) and have limited information about the patients and flight route details.

A flight medic augmented reality heads-up display (AR-HUD) was designed to increase situation awareness and decision quality, providing Army flight medics with a convenient and concise method of viewing relevant information.

The prototype flight medic AR-HUD is an iteration of previous user-centered design sessions that focused more heavily on the pilot's perspective in a MEDEVAC mission, using a novel type of display element called a Dynamic InfoGraphic (DIG) (Hartnett, 2021). An AR-HUD design, tailored to the flight medic's role, that provides relevant data selected and displayed by an intelligent agent, or IA (Norouzi et al., 2019), integrated with the Internet of Battlefield Things, or IoBT (Papakostas et al., 2021), showed value during interviews with flight medics and MEDEVAC pilots during the previous user-centered design sessions. The flight medic AR-HUD intends to increase flight medics' ability to process and react to information needed for emergency medical treatment during air transport. This study used a user-centered design process to gain insight and improve initial design concepts drafted from various sources including medical applications, flight information, and subject matter expert interviews by demonstrating these concepts to medical experts and representative users for input and feedback.

The focus of the study was to evaluate the prototype flight medic AR-HUD to determine the relevant information and how it is best displayed. Future flight medic technology will allow the designed flight medic AR-HUD to be integrated with an aircraft cabin to align with Army 2040 technology goals.

This effort was an outcome of the Department of Defense Historically Black Colleges and Universities/Minority Institutions Summer Research Program and their mentors at the U.S. Army Combat Capabilities Development Command (DEVCOM) Analysis Center (DAC). Together, the team researched relevant sources, conceived, prototyped, and programmed the flight medic AR-HUD and scripted a simulation of a relevant use case. Additionally, they conducted a user jury at DAC's Immersive Systems Integration Center located at the University of Alabama in Huntsville during Summer 2023.

This project supports the Army's Holistic Situational Awareness and Decision-Making Program by evaluating concepts and capabilities to design the Army of 2040.

2. METHODOLOGY

2.1 Participants

Researchers leveraged existing contacts in the Army aviation and medical communities to recruit six participants. Three participants were active-duty U.S. Army (MOS 61N, 68Z, 68W), one was a retired U.S. Navy Nurse, and two were civilian medical subject matter experts.

Demographic data was collected with a short questionnaire (Appendix A, Figure A-1). Three participants were male and three were female (ages 27–56, M = 42.8). All participants had medical experience either military or commercial/academic.

This project was reviewed by the Army Research Laboratory Human Research Protections Program (determination number ARL 22-106).

2.2 Flight Medic AR-HUD Design

The flight medic AR-HUD (Figure 1) includes six main display elements including, 9-line MEDEVAC DIG, casualty overview DIG, patient digital clipboard DIG, medical treatment facility (MTF) DIG, patient mortality risk indicator (PMRI), and the common operating picture (COP).



Figure 1. Flight medic AR-HUD

The simulated flight environment included a UH-60 helicopter model meant to represent an idealized future transport/MEDEVAC aircraft (the V-280 Valor was selected for this role in the Future Long Range Assault Aircraft or FLRAA program) equipped with an IA and integrated with the IoBT. The flight medic was equipped with a HUD that uses display elements both spatially located in the cabin environment, world-fixed or world-locked (Feiner et al., 1993) and elements located in the user's vision that remain fixed in view even when they move their head (head-locked) (Peereboom et al., 2023).

The IA receives information from sensors, databases, users, and battlefield devices, processes it, and selectively displays which information should be viewed at a given moment. The IA coordinates decision making with the user by providing suggestions or reasoning (eXplainable AI or XAI), as well as providing forecasting of near-term events through trend analysis. These elements are described further in the DIG Levels of Situation Awareness (DIG-LoSA) developed by Hartnett (2021) to serve as a guide for future DIG development and for developers of IA systems.

The simulated scenario was developed in Unreal Engine 5 with the various display elements Unreal Engine's user interface tools (<https://www.unrealengine.com/en-US/unreal-engine-5>). Icons were created by editing free images gathered from the internet (<https://thenounproject.com/>) on the free and open-source image editing software GIMP (<https://www.gimp.org>). Free 3D models were obtained through Unreal Engine's store and websites like CGTrader, (<https://www.cgtrader.com/>). These models were either edited in Unreal Engine or in the free and open-source software Blender (blender.org).

The simulation was displayed using an HTC Vive Pro 2 (<https://www.vive.com/us/product/vive-pro2/overview/>) with hand controllers that could be used to simulate medical tasks. Since the display elements needed to be legible inside the virtual reality (VR) headset, head-locked elements were centrally located above and below the center of the screen and physically placed far enough away so that both eyes could be used to view the display with the highest resolution. This is not the ideal design because it may potentially obscure the view of the surroundings when elements are added to the display, but it worked well enough to evaluate the overall concept of the design. Moving display elements farther to the corners of the user's vision while maintaining visibility is optimal. The head-locked elements were designed to be visible on top of anything else in the world, including other AR elements. World-locked elements were large enough to be legible when viewed directly from a realistic distance. The specific settings in Unreal Engine used to get the display elements to remain unpixellated and legible with a steady frame rate were not trivial but can be accomplished using Unreal's VR rendering

The information from the 9-Line MEDEVAC requests were displayed with the 9-Line MEDEVAC dynamic infographic (Figure 3). The list that follows describes the nine lines in Figure 2 to the infographic data in Figure 3.



Figure 3. The 9-Line MEDEVAC dynamic infographic

Line 1, “Location of Pickup Site” is in the top left of the infographic labeled “LOC” and gives the location of the pickup site in the Military Grid Reference System (MGRS) format with fabricated data.

Line 2, “Call Sign and Frequency” is in the top right of the infographic labeled “Freq” and “CS” and provides the source of the 9-Line MEDEVAC request. In this scenario, the request originated from the troops at the pickup site with the callsign C4 and can be reached on the radio frequency: 121.500 mhz.

Line 3, “Number of Patients by Precedence” is in the lower center of the infographic labeled by 1U (urgent), 1P (priority), and 1R (routine) and is also represented in the colored circles on the left and right. Some special categories are used like Urgent Surgical that are not depicted in either Figure 2 or Figure 3.

Line 4, “Special Equipment Required” is in the bottom right corner of each of the two white outlined boxes showing an icon for a ventilator (left box) and text for no equipment (right box). Other icons that were not used here include a hook (hoist) and sheers (extraction equipment).

Line 5, “Number of Patients and Type” is in the top right corner of the white outlined boxes, and details how many patients are ambulatory or requires a litter and combines this with their precedence information indicated by the color of the background circle taking on the color of the highest precedent patient in the list.

Line 6, “Security at Pickup Site” is in the center of the DIG and is depicted by the traffic lights which color codes the security level of the pick-up site with green (no enemies),

yellow (possible enemies, proceed with caution), orange (enemies present, proceed with caution), or red (enemies present, wait for escort).

Line 7, "Method of Marking Pickup Site" is in the center of the DIG and pictured by the green tiles. Other icons not used here of fire (pyrotechnics) and smoke could optionally be shown in their respective colors.

Line 8, "Patient Nationality and Status" is in the bottom left of the white outlined boxes within the DIG and provides the nationality and status of the patients in shorthand text with US nationality assumed unless specified as "non".

Line 9, "NBC Contamination (Wartime)" is in the center of the DIG and indicates the Nuclear, Biological, or Chemical (NBC) contamination status at the pickup site. This is reserved for wartime operations and may be used to describe the terrain during peacetime efforts. In Figure 3, "No NBC" is the text that gives indication of the contamination at the pickup site; shorthand text is used for the nuclear (NUC), biological (BIO), or chemical (CHEM) contamination type with a red background if any is present.

2.2.2 Casualty Overview Dynamic Infographic

The Casualty Overview Dynamic Infographic, shown in Figure 4, is displayed using the M.I.S.T format. "M" stands for method of injury, "I" represents the injury, "S" stands for symptoms, and "T" stands for treatment. In this infographic, the patient's age, precedence, gender, and name are depicted for flight medics to view and prepare for the mission. This infographic was inspired by the DD Form 1380 Tactical Combat Casualty Care Card (TCCC Card), which is filled out by ground medics and transferred to flight medics during pickup (Figure 5).

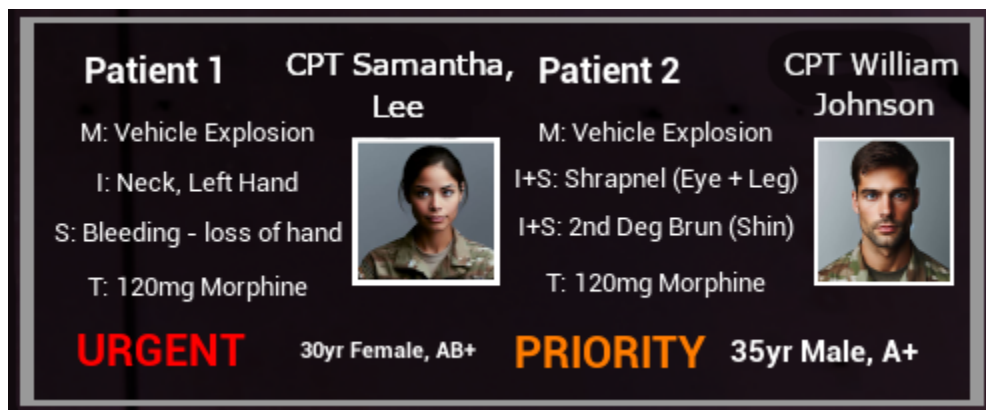


Figure 4. Casualty overview dynamic infographic

TACTICAL COMBAT CASUALTY CARE (TCCC) CARD

BATTLE ROSTER #: _____

EVAC: Urgent Priority Routine

NAME (Last, First): _____ LAST 4: _____

GENDER: M F DATE (DD-MMM-YY): _____ TIME: _____

SERVICE: _____ UNIT: _____ ALLERGIES: _____

Mechanism of Injury: (X all that apply)

Artillery Blunt Burn Fall Grenade GSW IED
 Landmine MVC RPG Other: _____

Injury: (Mark injuries with an X)

TQ: R Arm

TYPE: _____

TIME: _____

TQ: L Arm

TYPE: _____

TIME: _____

TQ: R Leg

TYPE: _____

TIME: _____

TQ: L Leg

TYPE: _____

TIME: _____

Signs & Symptoms: (Fill in the blank)

Time				
Pulse (Rate & Location)				
Blood Pressure	/	/	/	/
Respiratory Rate				
Pulse Ox % O2 Sat				
AVPU				
Pain Scale (0-10)				

DD Form 1380, JUN 2014 TCCC CARD

BATTLE ROSTER #: _____

EVAC: Urgent Priority Routine

Treatments: (X all that apply, and fill in the blank) Type

C: TQ- Extremity Junctional Truncal _____

Dressing- Hemostatic Pressure Other _____

A: Intact NPA CRIC ET-Tube SGA _____

B: O2 Needle-D Chest-Tube Chest-Seal _____

C:

	Name	Volume	Route	Time
Fluid				
Blood Product				

MEDS:

	Name	Dose	Route	Time
Analgesic (e.g., Ketamine, Fentanyl, Morphine)				
Antibiotic (e.g., Moxifloxacin, Ertapenem)				
Other (e.g., TXA)				

OTHER: Combat-Pill-Pack Eye-Shield (R L) Splint
 Hypothermia-Prevention Type: _____

NOTES:

FIRST RESPONDER
NAME (Last, First): _____ LAST 4: _____

DD Form 1380, JUN 2014 (Back) TCCC CARD

Figure 5. Tactical combat casualty care card

2.2.3 Patient Mortality Risk Indicator

The PMRI in Figure 6, displays a sorted list of the patients by highest mortality risk in the center with the higher risk patients listed above the lower risk patients.

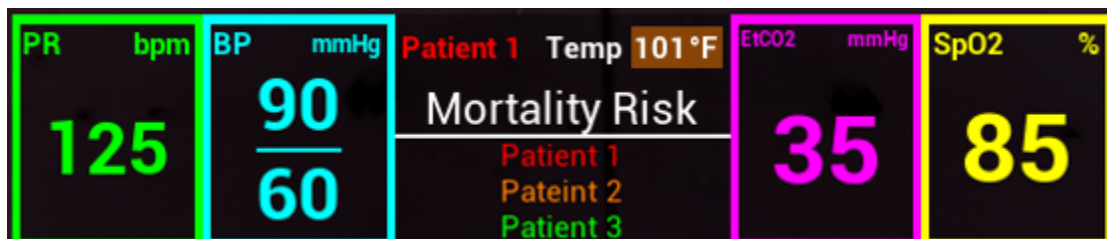


Figure 6. Patient mortality risk indicator

The vitals and temperature of the patient with the most critical needs are displayed in a display scheme that mimics the format of a Propaq vital signs monitor, a device that is familiar to medics (Figure 7). The vitals include heart rate, blood pressure, end-tidal carbon dioxide and blood oxygen level. The ranking of the patients uses an algorithm to rank the order of the patients' mortality. The PMRI was developed in a user-centered

design process by students at Texas A&M University for their senior capstone project that partnered with DAC.

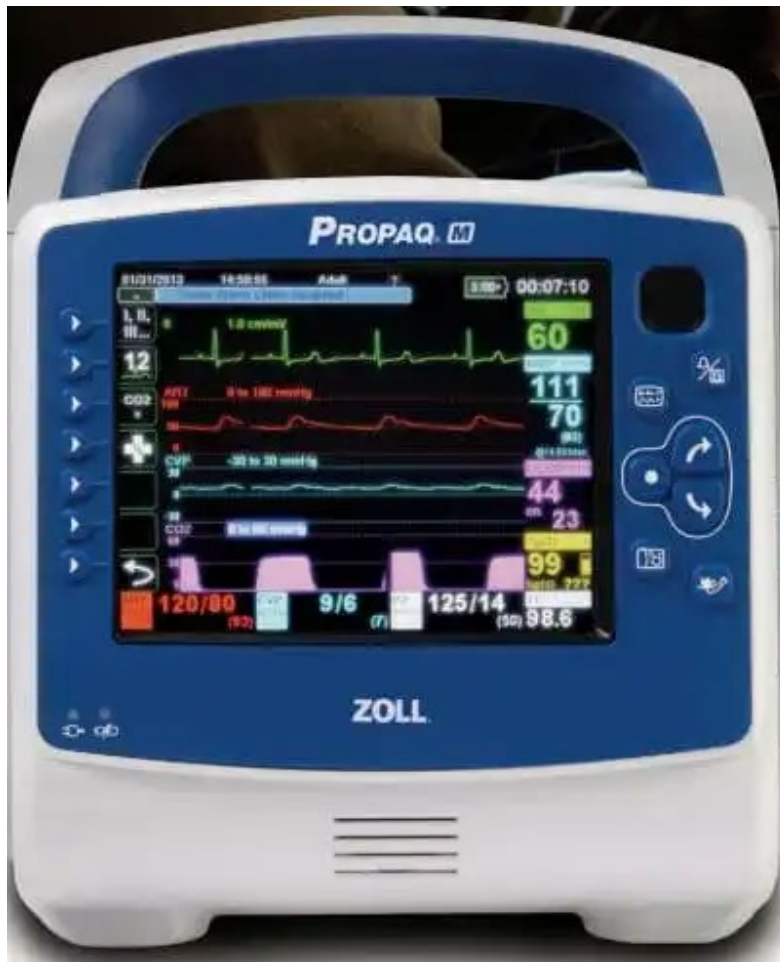


Figure 7. Propaq M portable vital signs monitor

2.2.4 Medical Treatment Facility Dynamic Infographic

The MTF dynamic infographic shown in Figure 8, provides active data for field hospitals, or MTFs, that the IA is recommending. The IA selects or recommends the optimal MTF based on factors such as the patients' logged injuries, its analysis of active data tracked in the system from sensors and communication with the flight medic, and key battlefield information incorporated from the flight plan and IoBT. The IA also provides explanations as to why it recommends a certain facility, with the top factor displayed on the DIG. The IA design is imagined to be capable of answering queries for more reasoning, much in the manner that Chat-GPT type programs can provide conversational explanations for Internet searches like Bing Chat and Google Bard. The scenario had the agent show its top two options, with all available data, and provides

reasoning for why it picked one over the other for the flight medic to verify (Appendix B, Figure B-1). The MTF DIG details include, among other things, beds available, patients occupying the facility, blood types available, and medical procedure capabilities.

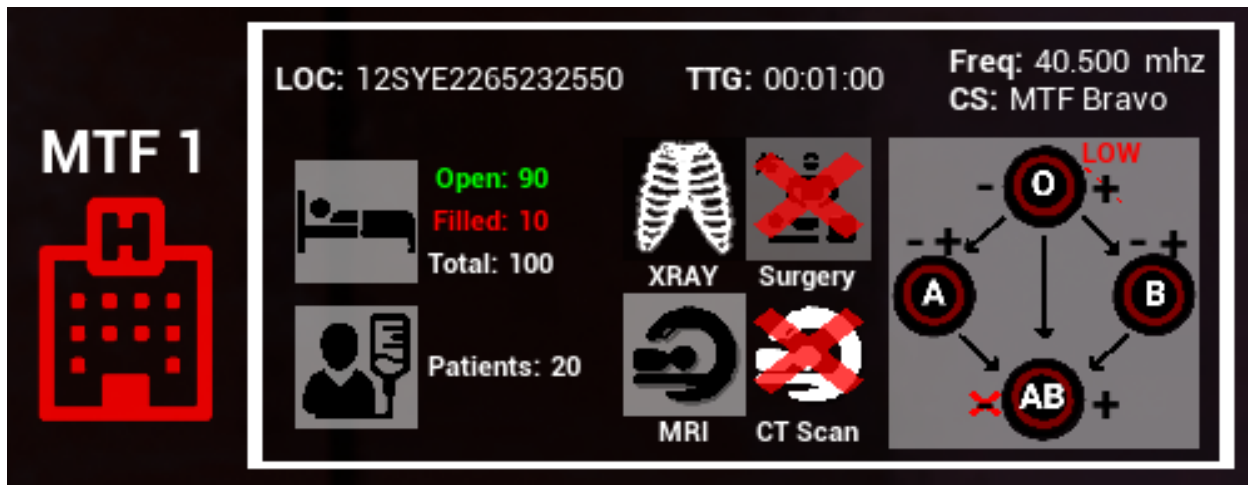


Figure 8. Medical treatment facility dynamic infographic

2.2.5 Patient Digital Clipboard Dynamic Infographic

Each patient has a digital clipboard attached to the foot of their gurney bed (world-fixed) that shows the patient's status and demographics, a body chart indicating their injuries, and three selectable tabs that list IA-recommended equipment, active vitals, and drugs taken and/or needed (Figure 9). In the equipment tab, each piece of equipment has a color-coded dot that matches to an injury from the body chart (seen on the body chart, middle left of Figure 9). The vitals tab displays real-time vitals and if a vital is out of a healthy range, then it highlights orange (for vitals trending toward problematic) or red (currently dangerous) to indicate the severity of the vital (Appendix B, Figures B-2). The drug tab keeps a record of all medications administered to the patient and may recommend drugs based on the IA's analysis.

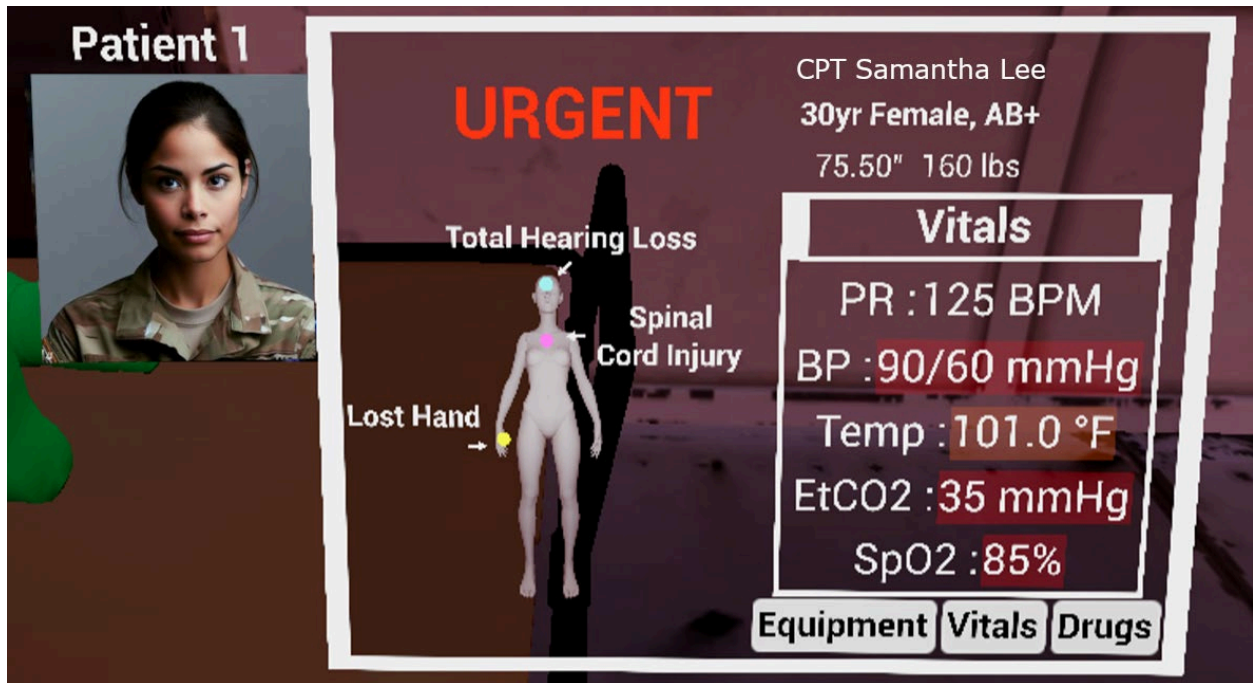


Figure 9. Patient digital clipboard dynamic infographic

2.2.6 Common Operating Picture

The COP, as shown in Figure 10, encompasses display elements available to all crew members for coordination and task sharing. For non-rated crew members, a prototype COP was spatially located in the front of the cabin between and behind the pilots' seats. On this display element, the aircraft's flight path is visible on a moving map that matches the pilot's along with flight information such as the air speed, heading, and altitude (shown on the left). When relevant, video feeds and other data sources may be displayed here such as the unmanned aerial system's (UAS's) live video feed of the pickup site (Figure 10, right).



Figure 10. Common operating picture

On the moving map and projected out to the real world, crewmembers had a view of an icon and beacon indicator of the pickup location showing the distance and time to the location. Specialized icons for each landing zone were developed in the previous user-centered design sessions and used in this scenario. In addition, the IA's recommended flight path is displayed using magenta chevrons that are augmented to the ground level out the window, and these are visible on the moving map and UAS feed (Figure 10).

2.3 Questionnaires

A usability questionnaire and a design preference questionnaire were administered to assess the usability of the AR-HUD and its various display elements, as well as the importance of each.

2.3.1 Usability

A usability questionnaire was created based on the Usability Metric for User Experience-Lite or UMUX-Lite (Lewis et al., 2013) and the System Usability Scale or SUS (Brooke, 1996). Additionally, custom items were created to address the usability of the major display elements of the flight medic AR-HUD. The usability questionnaire consisted of 12 items, rated on a 7-point Likert scale where 1 = Strongly Disagree and 7 = Strongly Agree (Appendix A, Figure A-2). Items 1 and 2 make up the UMUX-Lite questionnaire (Lewis et al., 2015). This score can be converted into a SUS score through Eq. 1:

$$SUS\ Score = 0.65 * ((Item\ 1 + Item\ 2 - 2) * \frac{100}{12}) + 22.9 \quad (1)$$

2.3.2 Design Preference

A design preference questionnaire was constructed to allow the participants to rate the importance of each display element of the flight medic AR-HUD. Participants rated the importance of each element on a 7-point Likert-type scale, where 1 = Very Unimportant and 7 = Very Important (Appendix A, Figures A-3 and A-4).

2.4 Study Procedures

The roughly 30-min-long user-centered design sessions were conducted in person at DAC's Immersive Systems Integration Center, located at the University of Alabama in Huntsville campus. Upon arrival, each participant was given an overview presentation describing the purpose of the study and the flight medic AR-HUD design, including the details of each display element and their functionality/behavior. After the overview, participants received a demonstration of the simulation. Next, the participant donned the VR headset and were given a hand controller to interact with display elements and task simulations.

The scenario consisted of a route with two stops, one at the pickup site and the final stop at the MTF. The simulation begins with the participant starting with a view of the helicopter cabin with empty litters, no DIGs, and a view of the COP located toward the front of the cabin. Once the participants adjusted to their new environment, the 9-Line MEDEVAC, and the casualty overview, DIGs were introduced while enroute to the pickup site. While en route the participants could see the beacon marking the location growing larger as they approached the pickup site.

On arrival, participants saw the cabin doors open and the helicopter's altitude descend until it landed. Once the green patients were inside the cabin, the 9-line MEDEVAC and casualty overview DIGs were replaced by the mortality risk indicator and the MTF DIGs. At the foot of the bed, the patient digital clipboard was visible for the participants' view since the patients were inside the cabin. Participants were shown how to interact with the digital clipboards by going through the vitals, equipment, and drugs tabs. The participants were then presented two MTF options and were shown the IA's recommendation and reasoning for validation. In this case, the IA chose MTF 2 because of its surgical capabilities. Once the participant verified the MTF recommendation, the MTF DIGs disappeared and the MTF beacon was shown. While enroute to the MTF, the participants simulated patient treatment and were advised by the IA through the mortality risk indicator. In this case, patient 1 was ranked highest, so participants were supposed to treat them first. During treatment with patient 1, the mortality risk indicator would change to show a new ranking with patient 2 as a higher priority and participants

were advised to stop treatment to focus on treating patient 2. The simulation concluded with participants arriving at the MTF 2.

While participating in the simulation, participants gave verbal comments on the flight medic AR-HUD that were summarized by the researchers. After the simulation, the demographics, usability, and design preference questionnaires were administered. Lastly a short, structured interview was conducted wherein the researchers asked the participant what information they would add, remove, or change, as well as any other feedback they had about the scenario or flight medic AR-HUD design.

3. RESULTS AND DISCUSSION

Descriptive statistics were computed for the questionnaire data collected and participant comments were aggregated. Higher values on the means shown in the figures indicate higher (better) ratings for usability and importance.

3.1 Usability

Figure 11 illustrates the mean usability ratings by questionnaire item. The overall mean usability rating was computed by averaging the 12 items. Items 3 and 4 are graphed as their reverse score since they are negative statements; a higher score here shows disagreement with that statement. The mean usability rating was 5.6 (standard deviation [SD] = 1.7). Participants indicated a neutral feeling toward the AR-HUD being too cluttered (item 3), which had the lowest mean value, with two of the six participants leaving a negative score.

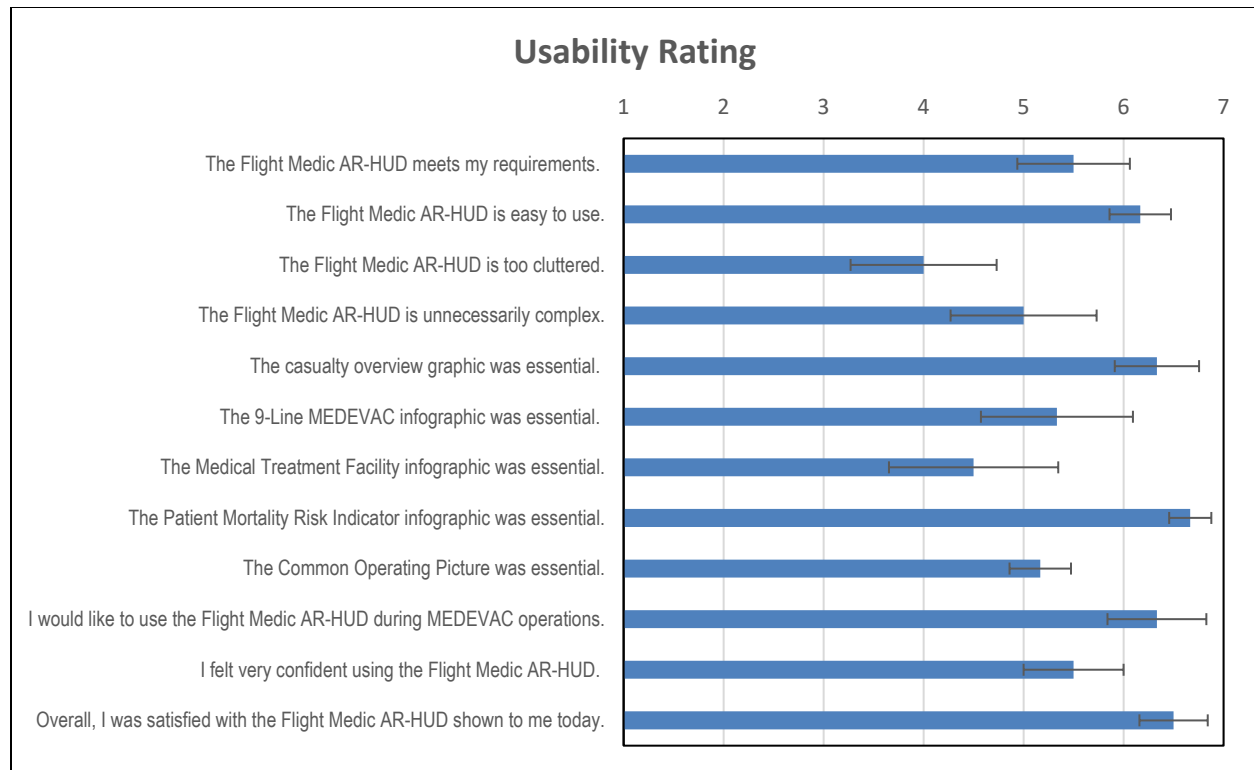


Figure 11. Mean usability ratings (error bars represent the standard error of the mean)

Out of the display elements, the MTF infographic was rated as the least essential, but still had a positive mean rating. The PMRI received the highest mean essential score and all participants indicated that they were satisfied with the AR-HUD shown. Equation 1 produced a SUS mean score of 75.25 for the flight medic AR-HUD.

3.2 Design Preference

Mean importance ratings (Figure 12) for the six display elements of the flight medic AR-HUD were compared. Ratings for the casualty overview (M = 6.9, SD = 0.3), PMRI (M = 6.9, SD = 0.3), and patient digital clipboard (M = 6.6, SD = 0.6), were highest. The COP was the lowest rated display element for importance (M = 4.9, SD = 0.8).

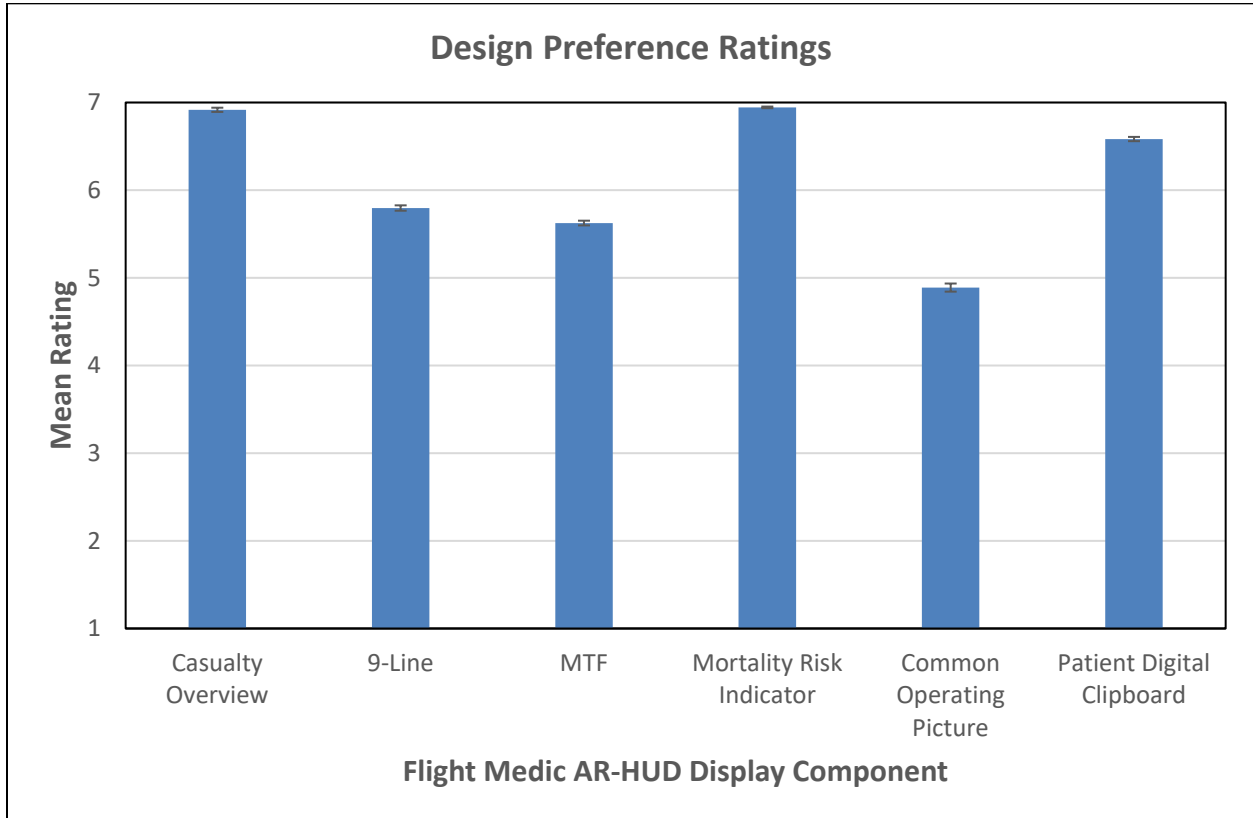


Figure 12. Design Preference Mean Responses (error bars represent the standard error of the mean)

These results suggest that the information most important to flight medics is concerning the immediate patient situation, versus overarching mission and flight information. The design should take this into consideration by making the most important information the most salient and including a selective declutter feature for less important information.

3.3 Interview Comments

At the conclusion of the session, participants were interviewed to determine what information they would add, remove, or change, as well as any other feedback they had about the scenario or flight medic AR-HUD design. The comments that could result in a potential design change are listed.

Add: What additional information would you need to improve situation awareness?

- The COP should have ambient temperature air quality index
- Add inventory of equipment available
- Run sheet of vitals, historical timeline of patient
- Baro Altitude (mean sea level)
- Roll-up of equipment needed before mission
- Show vitals on HUD for who they are caring for
- Flash mortality risk indicator when something changes
- Expand MTF info to include detailed surgical capabilities
- Adding an explanation for mortality risk change
- Need to know estimated blood loss (EBL)
- A cumulative usage for a clinical picture of all transfusions (packed red blood cells, whole blood, plasma expanders, saline/lactated ringers)
- Wants a log of actions performed
- Better alert for patient critical status
- Add trend data for patient vitals

Remove: Would you remove any information?

- For the COP turn on as needed or when essential (on/off switch)
- Location, 9-line, and frequency not needed
- UAS video feed not important
- Remove “bleed out” information
- COP usually not needed
- Declutter flight information
- 9-line location/callsign not needed
- MTF info is not relevant to medic

Change: Would you change the placement of any of the information?

- Patient DIG and mortality risk overlap
- Move mortality risk when it overlaps patient information
- Do not put any information in the center of screen
- Patient clipboard needs to be moved to the head of the patient
- Move demographics to picture area (logical grouping of information)
- Move blood loss information to vitals tab
- Move clipboard to patient head or chest
- Patient info is ok at the foot of bed
- Move 9-line to the corner
- Keep information on the periphery (central vision open)

-
-
- Keep the clipboard at the foot of the bed
 - Keep the clipboard where it is at
 - Clipboard could be useful at the foot and head of bed
 - Contrast between text and background
 - Waypoint icons are too big
 - Text clarity needs to be improved
 - Customizable/tailorable display
 - Text too small (causality overview)
 - Waypoint beacon too big
 - Keep patient clipboard and mortality risk visually separated
 - Add alert for changes mortality risk (PMRI)
 - Causality overview needs bigger text
 - Low contrast on text needs opaque background

Other: Do you have any further suggestions?

- Patient info blurry (casualty overview)—Text is slightly small
- White text against white background hard to read; need more contrast
- How do you accommodate people with less than perfect vision?
- Add direct line of communication (voice and data) between flight medic and ground medic
- Consider how to enter data during flight
- Consider audio cues integration (include ability to mute/silence)
- Amount of blood loss as a number
- How will it be maintained? Will there be training for it?
- The MTF info needs to be relevant to the mission and changing
- Look up ATP 4-02.4
- In future scenarios include more patients and interactions
- Take it to a unit to get more feedback
- Use form DD-1380 (TCCC Card) to enter patient care
- Tailoring of further suggestions
- Make scenario more stressful, add realism, add noises
- Integrate audio alert
- Flash bottom of clipboard as alerts
- Make MTF frequency and call sign more prominent

These suggestions should be integrated into the next phase of the user-centered design process and re-evaluated.

4. CONCLUSION

A flight medic AR-HUD was designed to increase situation awareness and decision quality, providing Army flight medics with a convenient and concise method of viewing relevant information. This supports the Army's Holistic Situational Awareness and Decision-Making Program by evaluating concepts and capabilities to design the Army of 2040. Another iteration of this user-centered design process is recommended to address the participants' usability concerns with an eventual objective assessment of the design versus a baseline to quantify the added value of the AR-HUD for flight medics.

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Appendix A – Questionnaires

This appendix appears in its original form, without editorial change.

A.1 Demographic Questionnaire

Flight Medic AR-HUD – Demographic Questionnaire

Participant ID: _____ Date: __/__/____

Please provide the following demographic information:

Age: _____

Gender: _____

MOS: _____

Rank: _____

Time in Service: _____

Total U.S. Army Flight Hours (approximately): _____

Overview: The purpose of the Flight Medic Augmented Reality HUD is to aid in flight medic’s awareness of flight and patient information while en route. The feedback will be summarized and reported back for potential improvements to the concept. We appreciate your open and honest feedback.

Figure A-1. Demographic questionnaire

A.2 Usability Questionnaire

Flight Medic AR-HUD – Usability Questionnaire

Participant ID: _____ Date: ___/___/___

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Agree	Strongly Agree
1. The Flight Medic AR-HUD meets my requirements.	1	2	3	4	5	6	7
2. The Flight Medic AR-HUD is easy to use.	1	2	3	4	5	6	7
3. The Flight Medic AR-HUD is too cluttered.	1	2	3	4	5	6	7
4. The Flight Medic AR-HUD is unnecessarily complex.	1	2	3	4	5	6	7
5. The casualty overview graphic was essential.	1	2	3	4	5	6	7
6. The 9-Line MEDEVAC infographic was essential.	1	2	3	4	5	6	7
7. The Medical Treatment Facility infographic was essential.	1	2	3	4	5	6	7
8. The Patient Mortality Risk Indicator infographic was essential.	1	2	3	4	5	6	7
9. The Common Operating Picture was essential.	1	2	3	4	5	6	7
10. I would like to use the Flight Medic AR-HUD during MEDEVAC operations.	1	2	3	4	5	6	7
11. I felt very confident using the Flight Medic AR-HUD.	1	2	3	4	5	6	7
12. Overall, I was satisfied with the Flight Medic AR-HUD shown to me today.	1	2	3	4	5	6	7

Figure A-2. Usability questionnaire

A.3 Design Preference Questionnaire

Flight Medic AR-HUD – Design Preference Questionnaire

Participant ID: _____ Date: ___/___/___

Below is a list of features that are part of the Flight Medic AR-HUD.

How important is each feature to you?

	Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important
Casualty Overview Dynamic Infographic							
1. MIST Information	1	2	3	4	5	6	7
2. Patient Information	1	2	3	4	5	6	7
9-Line MEDEVAC Dynamic Infographic							
3. Location of the pick-up site.	1	2	3	4	5	6	7
4. Radio frequency, call sign, and suffix.	1	2	3	4	5	6	7
5. Number of patients by precedence	1	2	3	4	5	6	7
6. Special equipment required	1	2	3	4	5	6	7
7. Number of patients	1	2	3	4	5	6	7
8. Security at pick-up site	1	2	3	4	5	6	7
9. Method of marking pick-up site	1	2	3	4	5	6	7
10. Patient nationality and status	1	2	3	4	5	6	7
11. NBC Contamination	1	2	3	4	5	6	7
Medical Treatment Facility Dynamic Infographic							
12. MTF Location	1	2	3	4	5	6	7
13. Time To Go (TTG)	1	2	3	4	5	6	7
14. Distance to MTF	1	2	3	4	5	6	7
15. Frequency and Call Sign	1	2	3	4	5	6	7
16. MTF Bed Information	1	2	3	4	5	6	7
17. MTF Equipment Availability	1	2	3	4	5	6	7
18. MTF Blood Availability	1	2	3	4	5	6	7
19. MTF Reasoning	1	2	3	4	5	6	7

Figure A-3. Design preference questionnaire (page 1)

Flight Medic AR-HUD – Design Preference Questionnaire

Participant ID: _____

Date: ___/___/___

	Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important
Patient Mortality Risk Indicator							
20. Heart Rate (PR)	1	2	3	4	5	6	7
21. Blood Pressure (BP)	1	2	3	4	5	6	7
22. End-Tidal Carbon Dioxide (EtCO2)	1	2	3	4	5	6	7
23. Blood Oxygen Level (SpO2)	1	2	3	4	5	6	7
24. Body Temperature	1	2	3	4	5	6	7
25. Mortality Risk	1	2	3	4	5	6	7
Common Operating Picture							
26. Aircraft Flight Information	1	2	3	4	5	6	7
27. UAS Video Feed	1	2	3	4	5	6	7
28. Augmented Reality Waypoint	1	2	3	4	5	6	7
Patient Dynamic Infographic (Digital Clipboard)							
29. Patient Injury Diagram	1	2	3	4	5	6	7
30. Patient Vitals	1	2	3	4	5	6	7
31. Patient Demographics	1	2	3	4	5	6	7
32. Patient Overall Status	1	2	3	4	5	6	7

Figure A-4. Design preference questionnaire (page 2)

Appendix B – Additional Images

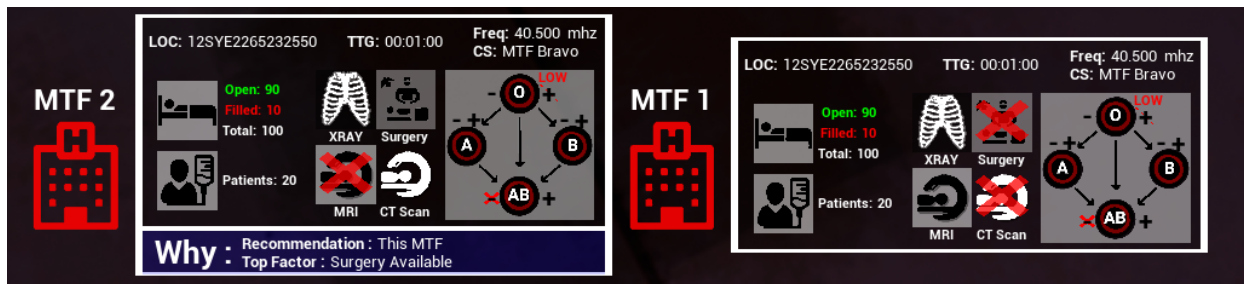


Figure B-1. Medical treatment facility (MTF) 1 and 2 presented during simulation

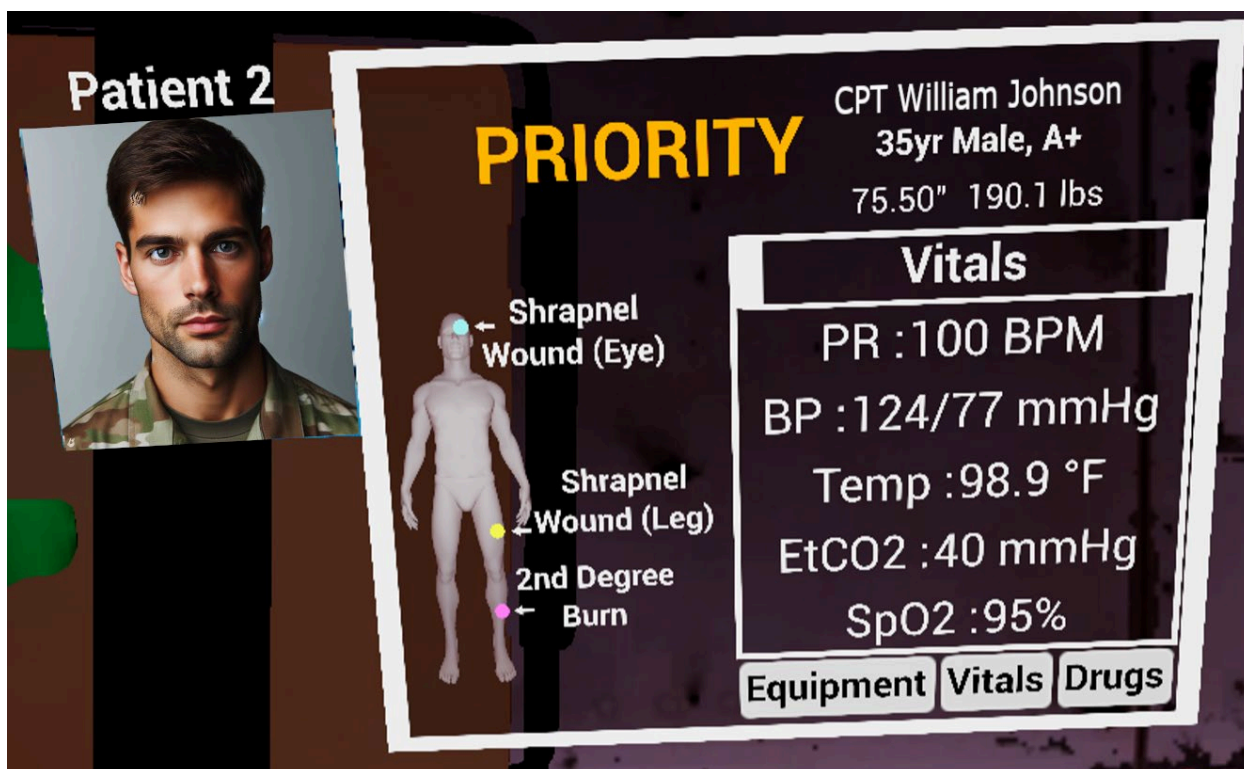


Figure B-2. Patient digital clipboard with vitals tab open

LIST OF ACRONYMS

AR	augmented reality
AR-HUD	augmented reality heads-up display
BIO	biological
CHEM	chemical
COP	common operating picture
DAC	DEVCOM Analysis Center
DEVCOM	U.S. Army Combat Capabilities Development Command
DIG	dynamic infographic
DIG-LoSA	DIG Levels of Situation Awareness
FLRAA	Future Long Range Assault Aircraft
HUD	heads-up display
IA	intelligent agent
IoBT	Internet of Battlefield Things
JVMF	Joint Variable Messaging Format
MEDEVAC	medical evacuation
MGRS	Military Grid Reference System
MTF	medical treatment facility
NBC	Nuclear, Biological, or Chemical
NUC	nuclear
PMRI	patient mortality risk indicator
SD	standard deviation
SUS	System Usability Scale
TCCC Card	Tactical Combat Casualty Care Card
UAS	unmanned aerial system
UMUX-Lite	Usability Metric for User Experience-Lite
VR	virtual reality

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