INTERFACE DESIGN AND ASSESSMENT OF SITUATIONAL AWARENESS AND WORKLOAD FOR AN ADAPTABLE MULTIMODAL CREW ASSISTANCE SYSTEM BASED ON NATO GENERIC VEHICLE ARCHITECTURE

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Manas Pradhan
Daniel Ota
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OVERVIEW

- Introduction: Motivation and Background
- System Objectives
- System Design Concepts
- Test-Bed Set-Up
- User Evaluation: Methods and Results
- Conclusion and Future Work

Motivation: Integration of Sensors

- Military situations evolving.
- Incorporating latest sensor technologies to improve military vehicles.
- Support for crew members for tactical and operational efficiency.
- Address human factors realm along with technology components.

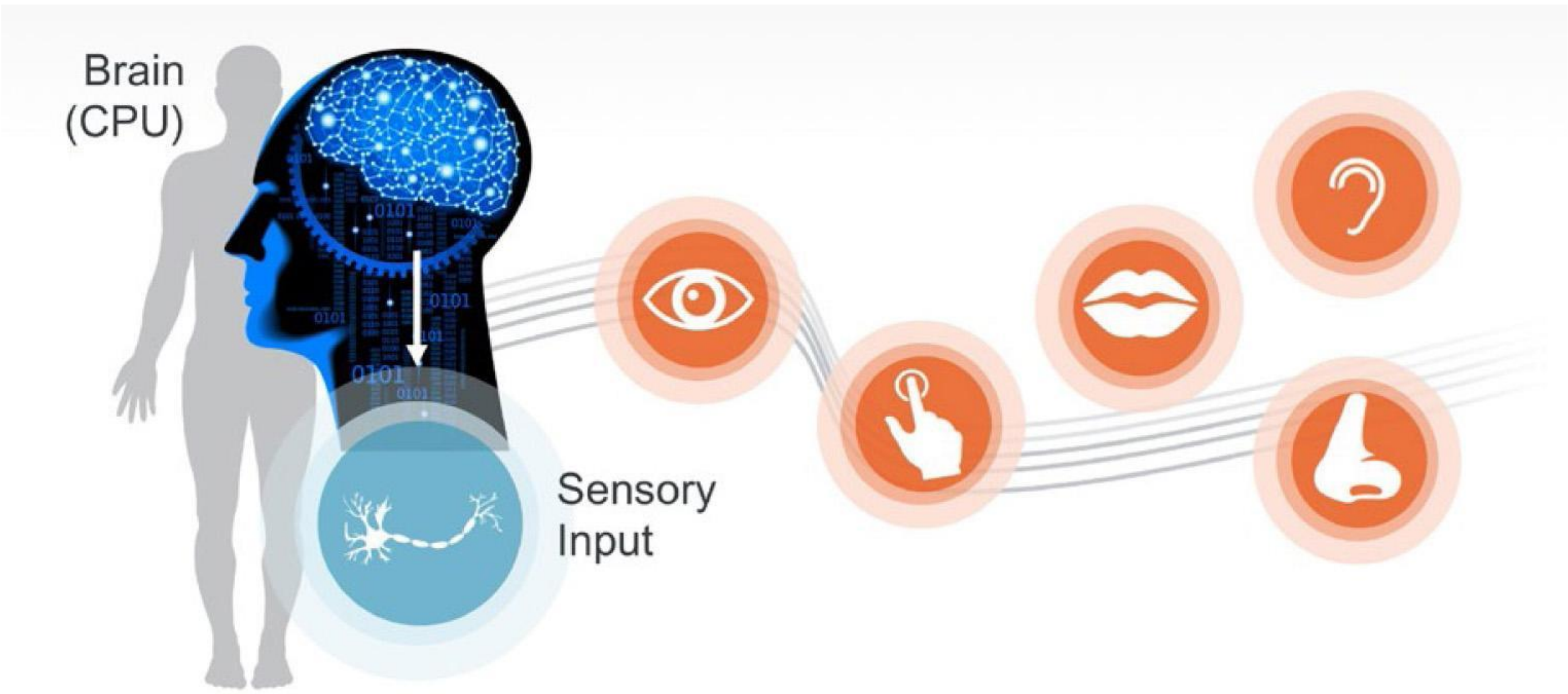
Motivation: Assisting Humans

- Presentation of data to support users' cognition and affordances.
- Allow for faster, more accurate decision making.
- Assist/take over human actions.
- Provide acceptable/usable levels of automation.

Concepts Involved

- Human Sensory System
- Utilizing Sensor Data
- Problem of Automation
- Situational Awareness
- Workload
- Feedback Mechanisms
- Change Blindness

Human Sensory System



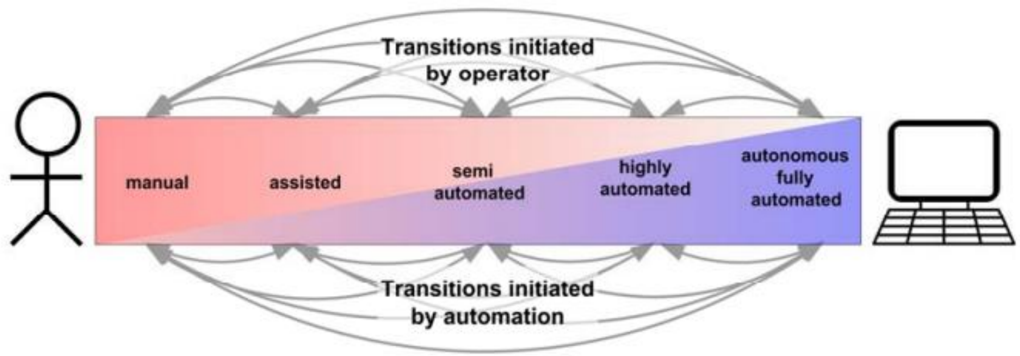
Source: http://www.mouser.com/images/microsites/sensor-fusion-iot-fig01.jpg

Utilizing Sensor Data

- Automation requires active sensor data usage.
- Sensor fusion techniques aid to achieve mission objectives.
- Data presentation to suit user‘s natural cognitive behaviour.
- Analogous to Human Perception Mechanism.

Problem of Automation

- Deciding amount of automation critical to prevent “Ironies of Automation”. (Lisanne Bainbridge,1983)
- Allow balanced levels of automation.
- Different capabilities of users in cognitive sphere.
- Skill vs Knowledge vs Rule based approaches. (Jens Rasmussen,1983)
- Adaptable Systems.



Levels of assistance and automation

Source: Flemisch, Frank, et al. "Cooperative Control and Active Interfaces for Vehicle Assistance and Automation." (2008).

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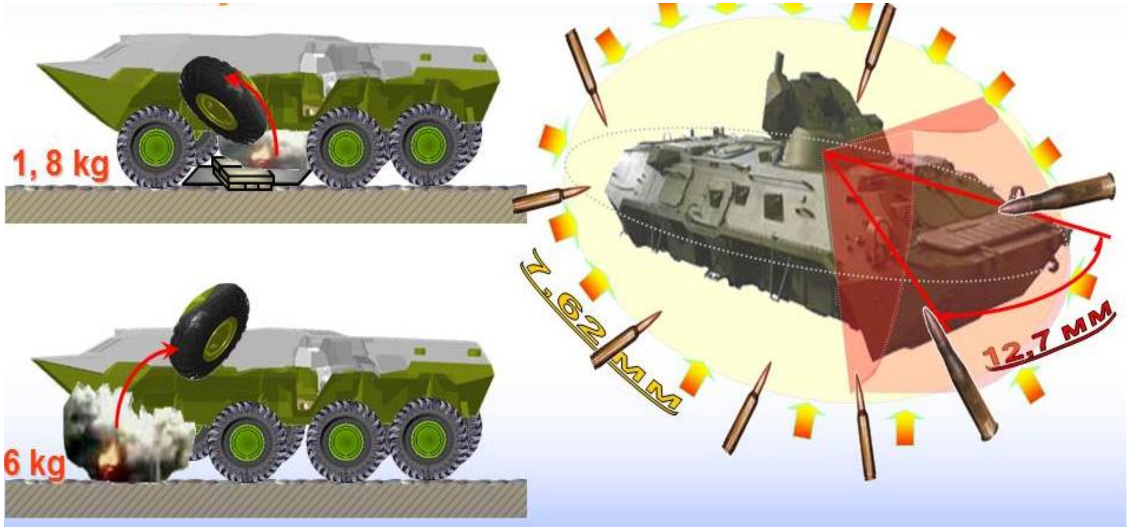
Situational Awareness

“Situational Awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.” (Mika R. Endsley, 1998)



Source: http://www.tank-net.com/forums/index.php?showtopic=38661

Workload

"Workload represents the cost of accomplishing mission requirements for the human operator. " (Sandra G. Hart, 2006)

Source: https://upload.wikimedia.org/wikipedia/commons/1/1f/CBP_unmanned_aerial_vehicle_control.jpg

Source: https://www.tes.com/sites/default/files/styles/news_article_hero/public/news_article_images/istock_meldown_5.jpg?itok=ASS2LQTE

Change Blindness

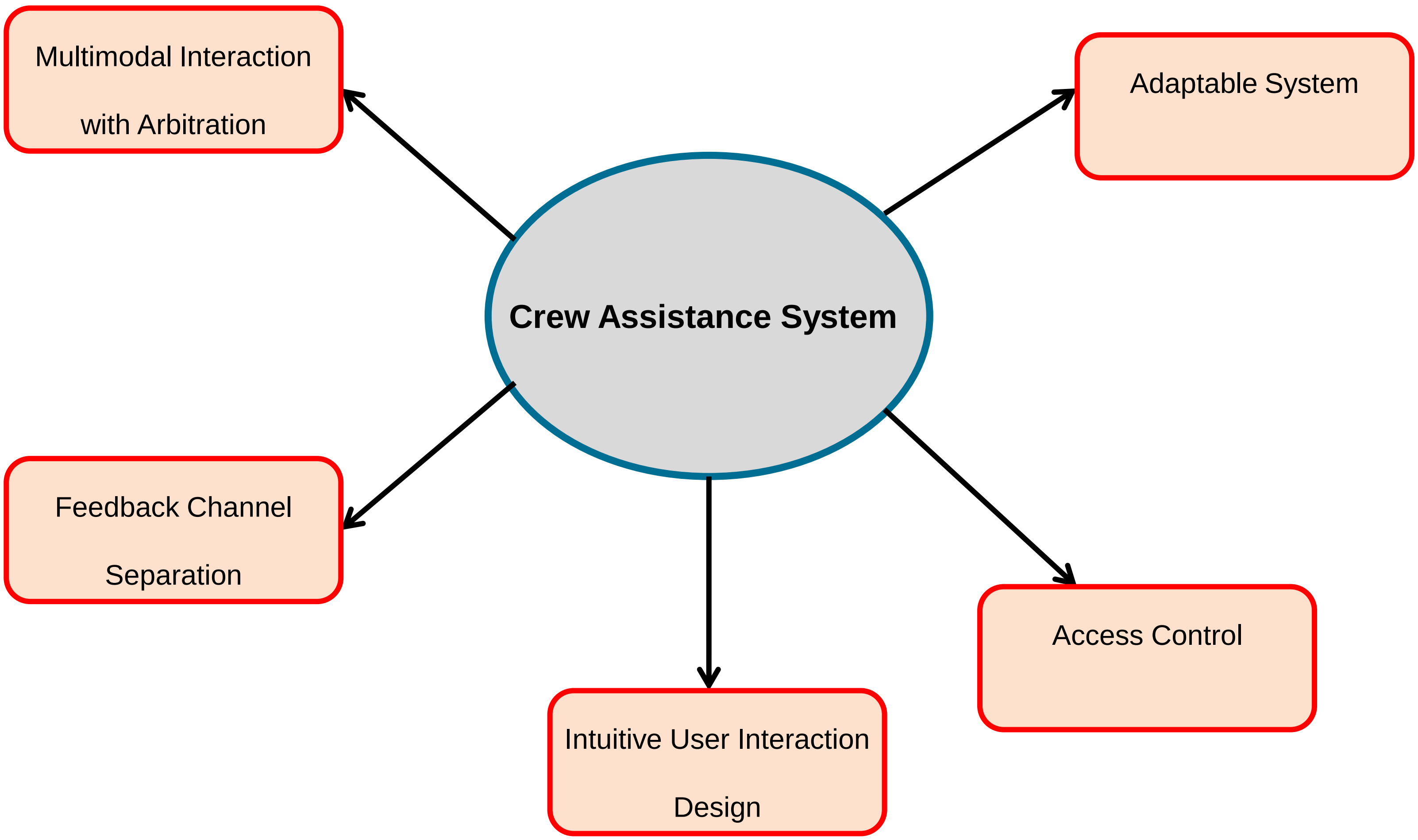
“Operators who work with visual displays fail to detect the changes that happen on the displays.“ (Christopher D. Wickens, 2015)

Source: https://www.cis.rit.edu/research/thesis/bs/2001/so/proposal/tv.jpg

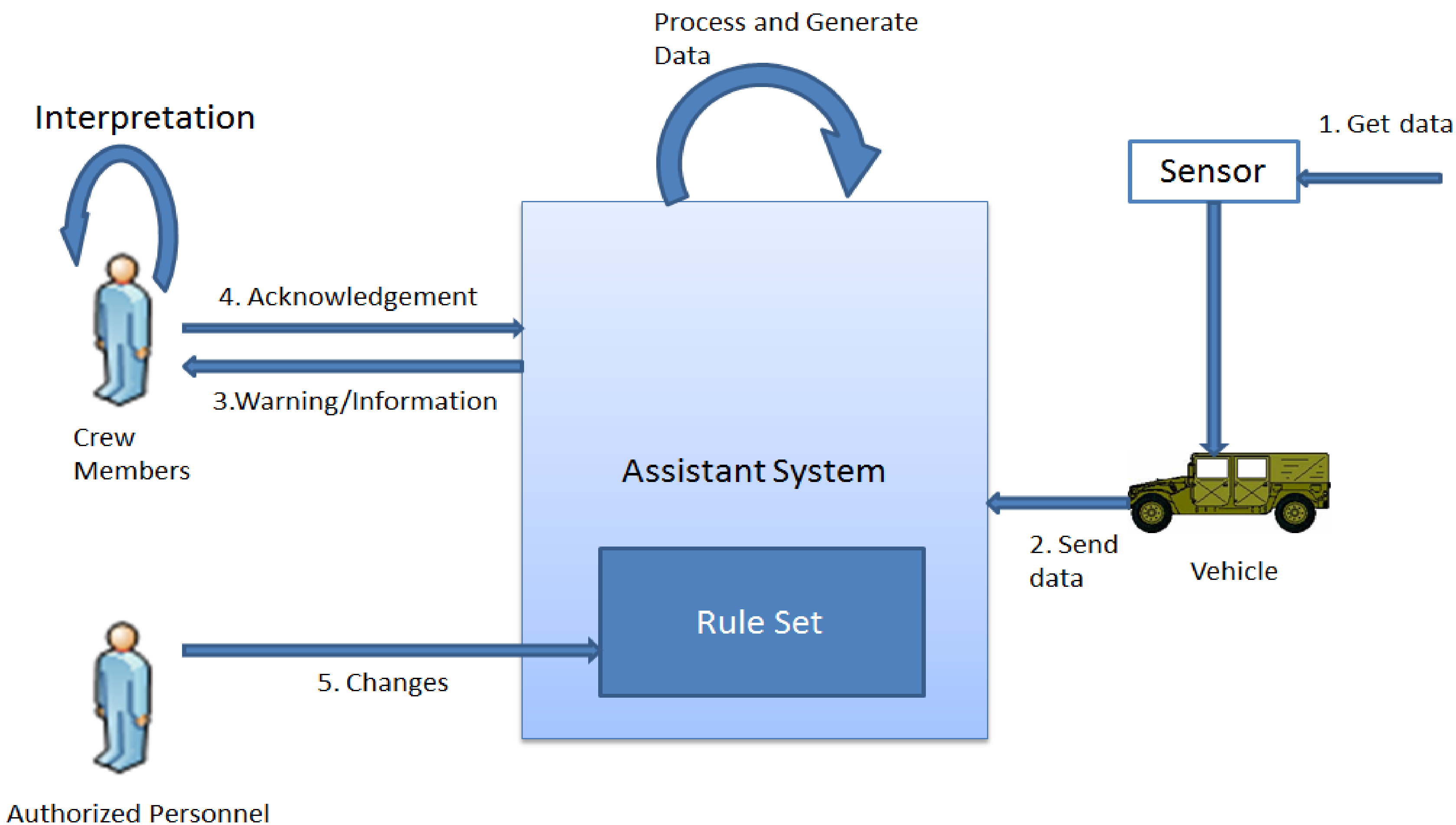
Feedback Mechanisms

- Enhance human cognition abilities.
- Human-Computer Interaction depends on building an interactive system.
- Modes available:
  - Visual
  - Haptic
  - Auditory
- Arbitration between feedback modes.

System Objectives



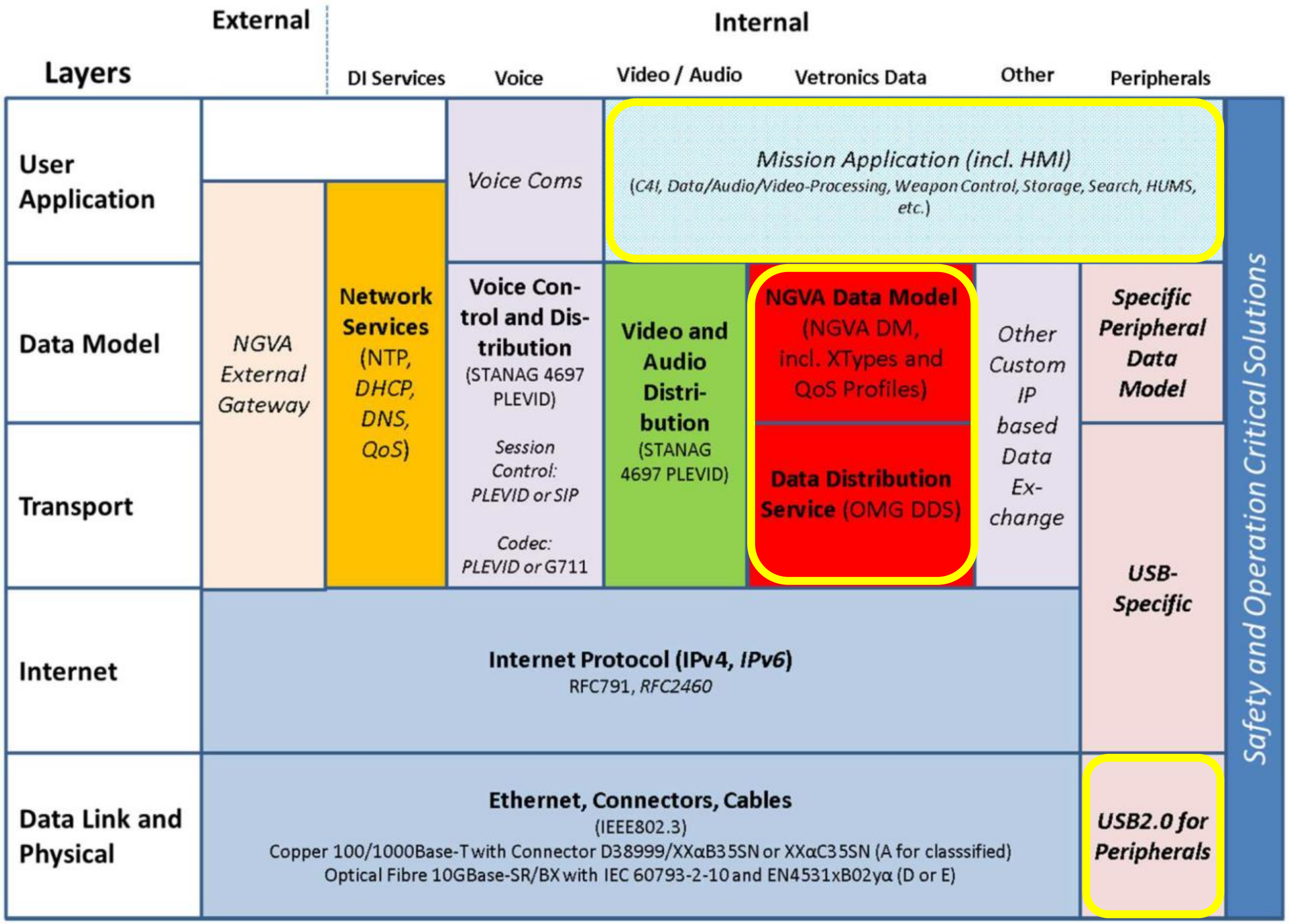
Human Factors View



NATO GVA Standard

- Standardisation of interfaces and protocols for systems integration.
- Specification of internal data exchange among vehicle sub-systems.
- SIP based protocol and codecs for communication (internal and external).
- Doesn’t specify:
  - Action based on sub-system data.
  - Level of automation allowed.
  - User Interaction Design and evaluation methodology.
  - Feedback mechanisms to be used.

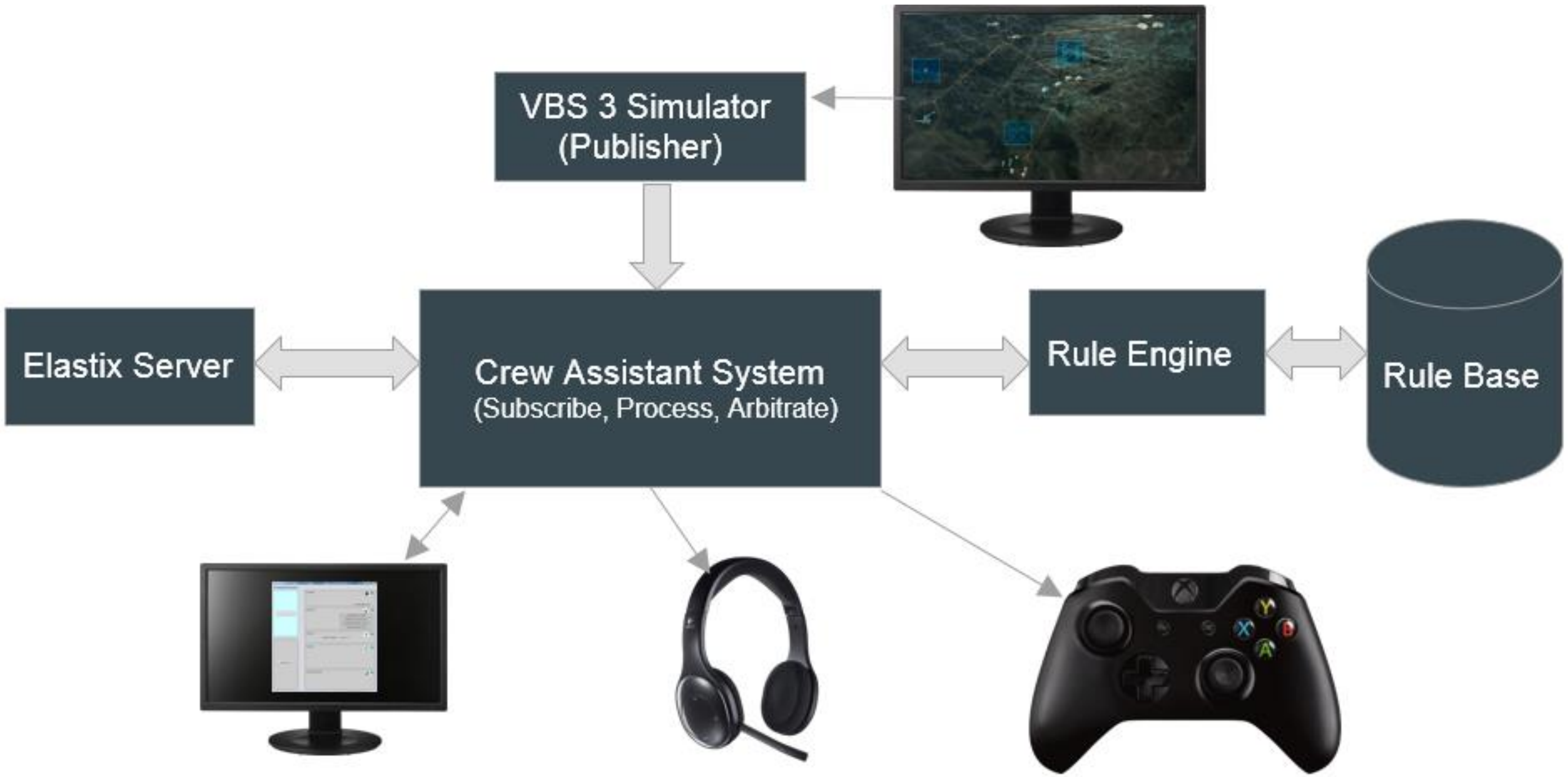
NATO GVA Standard



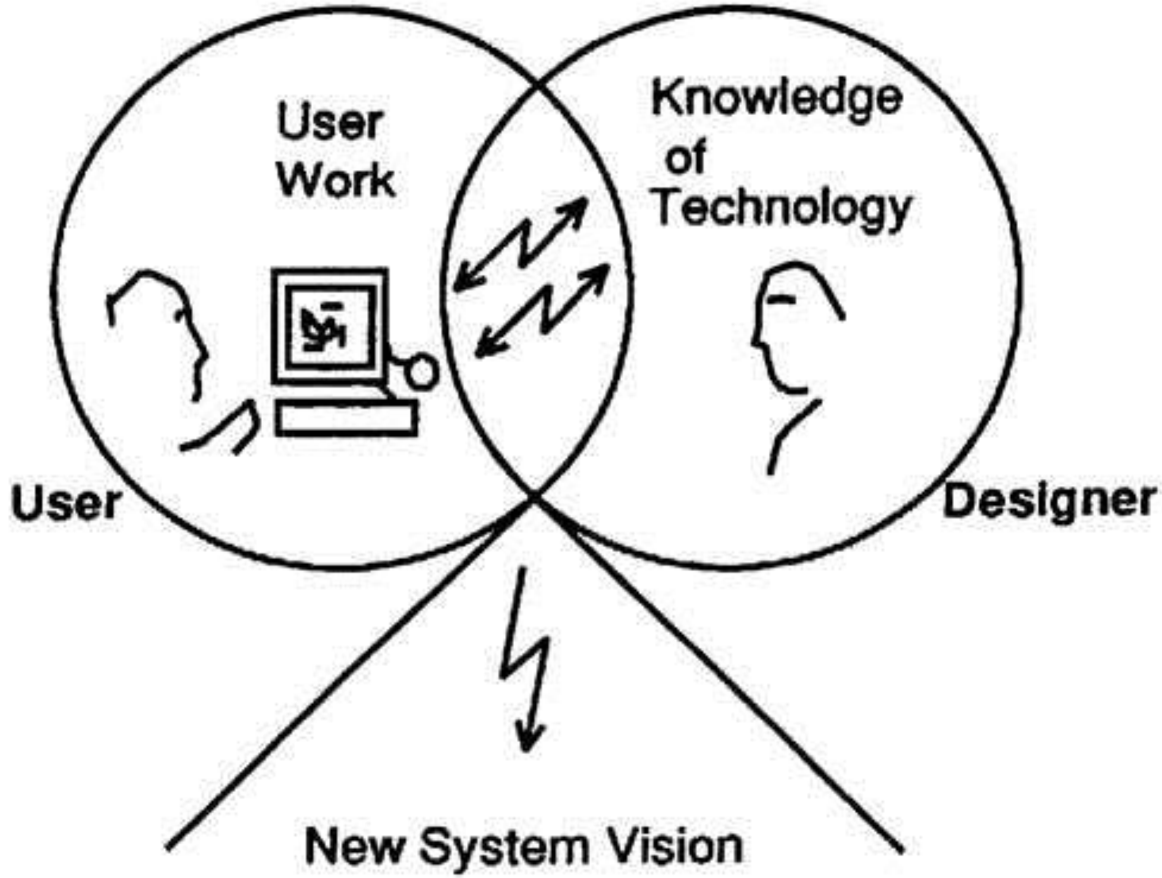
NGVA Data Infrastructure Layer View

Source: NATO, AEP-4754 Volume 5, NGVA Data Model, Edition A, Version 1, Ratification draft, August 2015

Test-Bed Set-Up



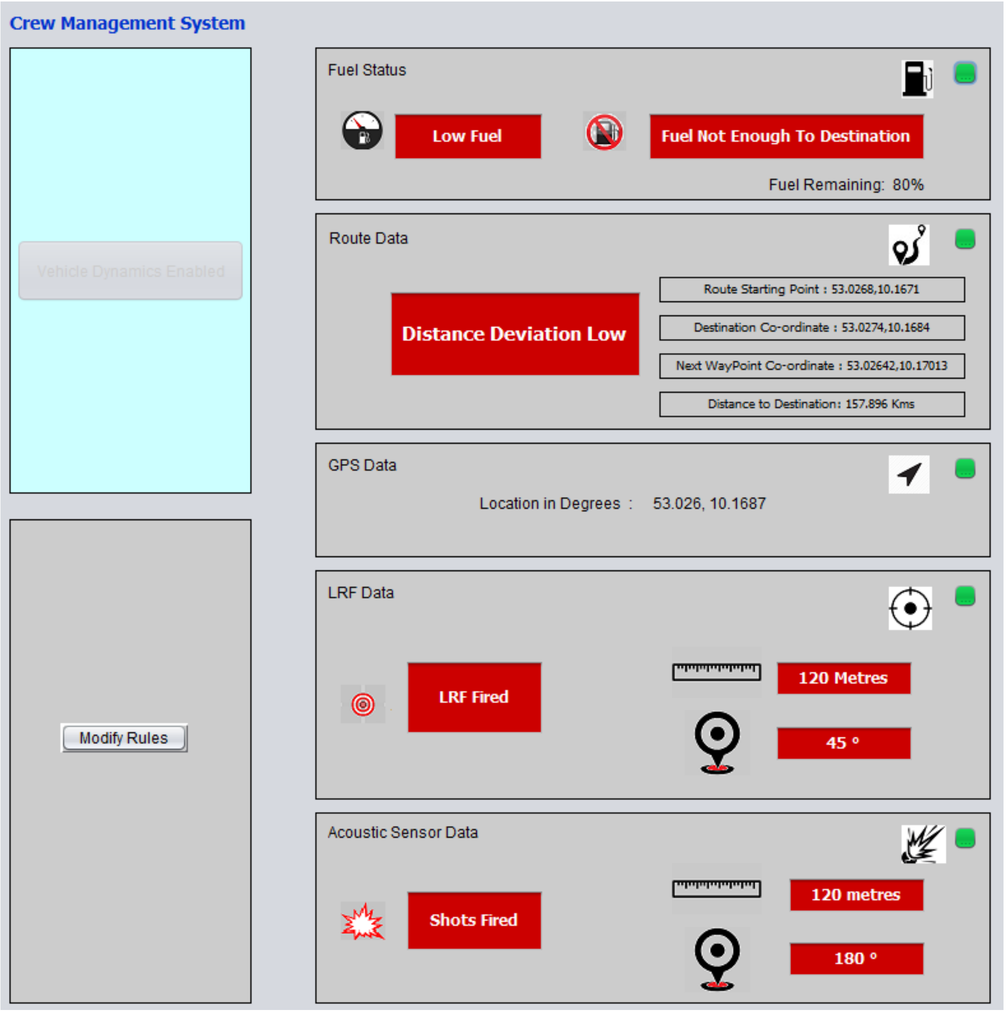
User Interaction Design



Participatory Method

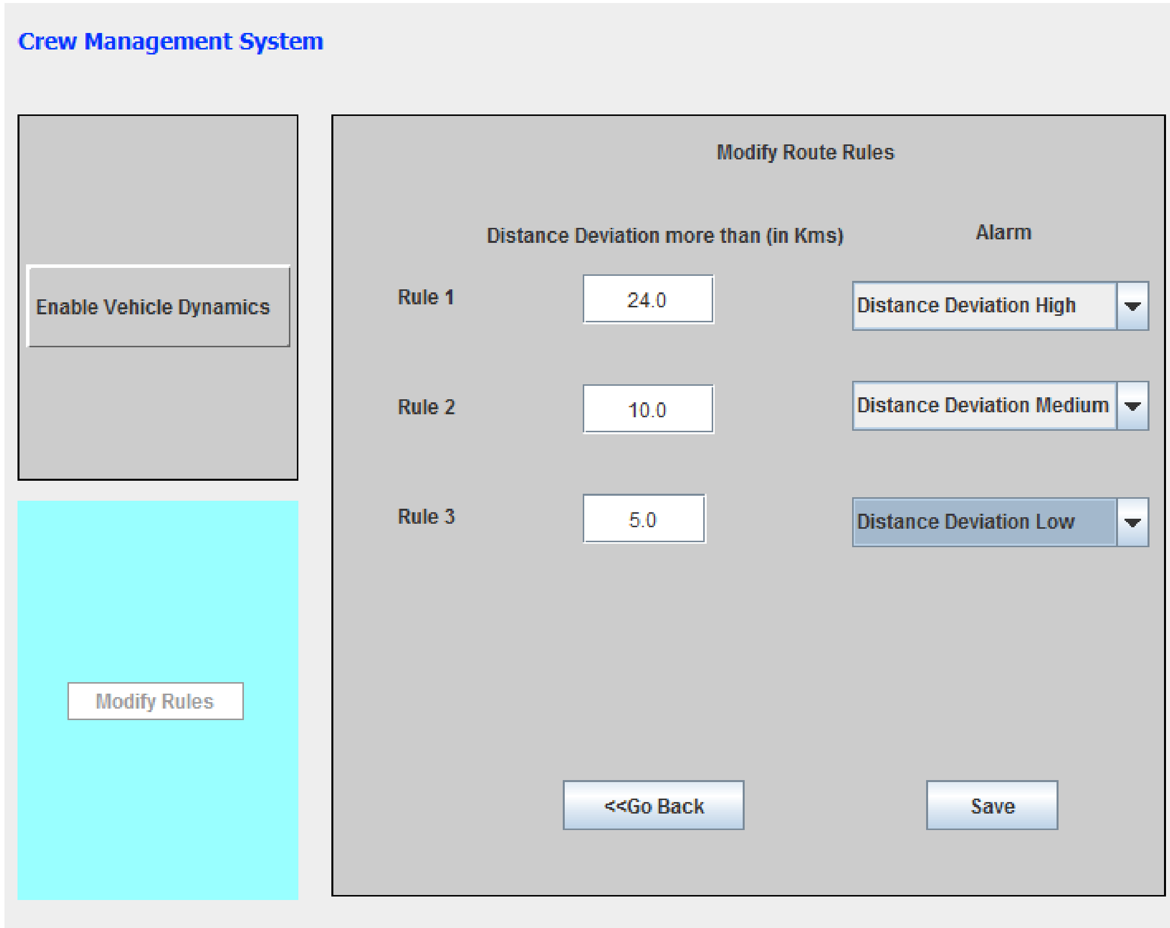
Source: http://michaelgood.info/wp-content/uploads/2010/09/chi92fig1.jpg

UI Design



Crew Management System
Vehicle Dynamics Enabled
Modify Rules
Fuel Status
Low Fuel
Fuel Not Enough To Destination
Fuel Remaining: 80%
Route Data
Distance Deviation Low
Route Starting Point : 53.0268,10.1671
Destination Co-ordinate : 53.0274,10.1684
Next WayPoint Co-ordinate : 53.02642,10.17013
Distance to Destination: 157.896 Kms
GPS Data
Location in Degrees : 53.026, 10.1687
LRF Data
LRF Fired
120 Metres
45 °
Acoustic Sensor Data
Shots Fired
120 metres
180 °

UI Design



Route Deviation Rules

Audio and Haptic Interaction Design

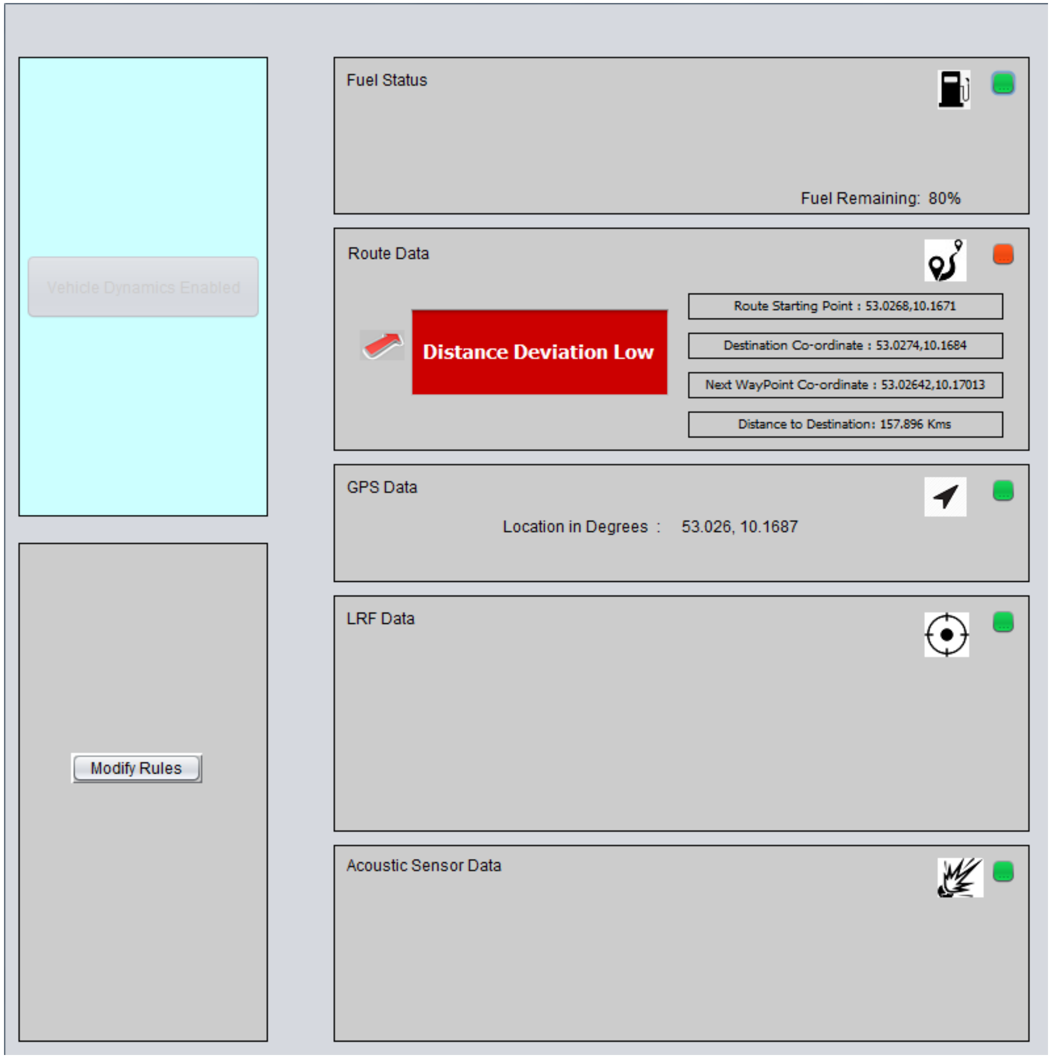
Use Case	Audio File
Route Deviation	“Warning Route Deviation”

Route Deviation By	Length of Vibration	Intensity of Vibration
>5 Km	2 seconds	30000
>10 Km	3.5 seconds	45000
>15 Km	5 seconds	65535

Sample Use Case

- GPS Data for current location.
- Route Data updated constantly.
- Calculate distance.
- Send distance to Rule Engine.
- Comparison of the rules w.r.t computed distance.
- Here Warning ”Route Deviation Low”.
- Audio Feedback to driver sent via VOIP.
- Haptic Feedback on the steering of the driver.

Sample Use Case



Sample Use Case extended with Arbitration

If during the event, enemy shots are fired then -

- Shot Fired event given priority.
- Warning for Shot Fired -
  - Displayed on GUI: “Shots Fired”, Distance, Location of shot
  - Haptic Feedback to all Crew Members.
  - Audio Alert to all Crew Members.

User Evaluation

- SAGAT (Situational Awareness Based Global Assessment) Technique
  - Assesses Situation Awareness.
  - Simulation is frozen at randomly selected times.
  - Subjects are queried for their perception of the situation at the time.

- NASA TLX (National Aeronautics and Space Administration Task Load Index) Method
  - Multi-dimensional rating procedure to measure workload.
  - Sub-scales include Mental, Physical and Temporal demands, Performance, Effort and Frustration.

Modified SAGAT Technique

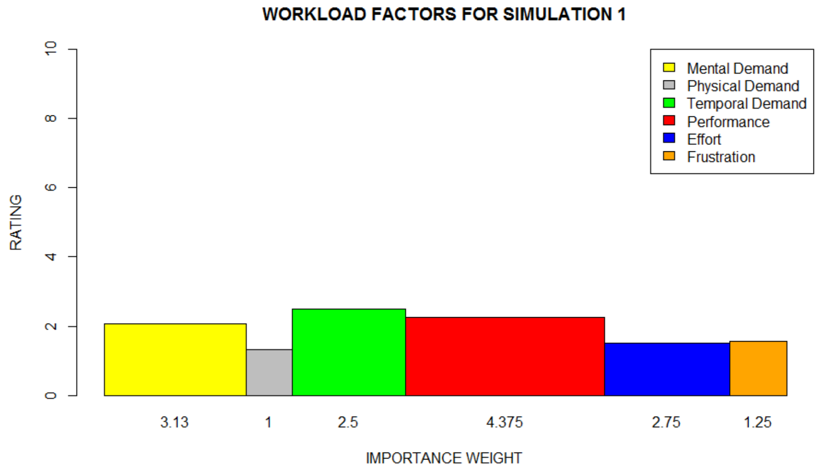
- The participants were asked questions as the simulation was going on in real time.
- The system needs to be assessed as the users would perceive the system in a real-world and real-time situation i.e. users get informed about the events without the system stalling or pausing.
- Impacts of freezing are negligible since it does not impact the results of the test. If the tests are frozen at predictable times then the users are able to prepare and/or improve their SA. (Gregory Bew, 2015)
- The knowledge of the system state or SA is based on the times individuals are exposed to information. As stated by Endsley, "a person's knowledge of the environment is highly temporal in nature". (Mica R. Endsley, 1995)

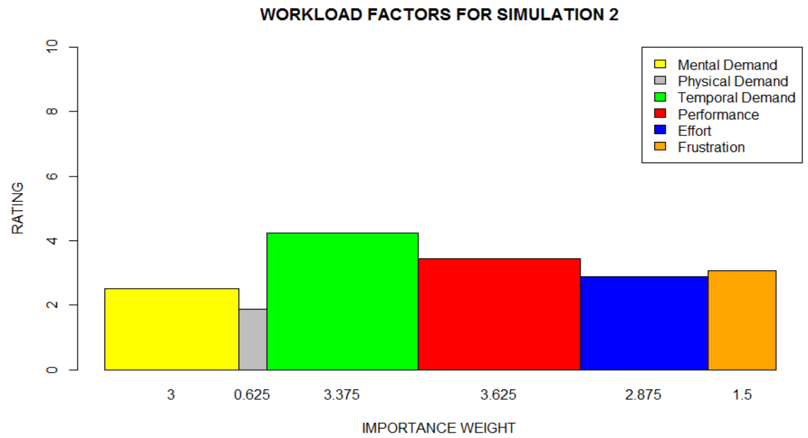
User Evaluating

SAGAT Results

Simulation	Mean Score (%)	Standard Deviation	T-Test
1	93.56	1.66	8.83776E-07
2	83.21	2.16	

NASA TLX Results





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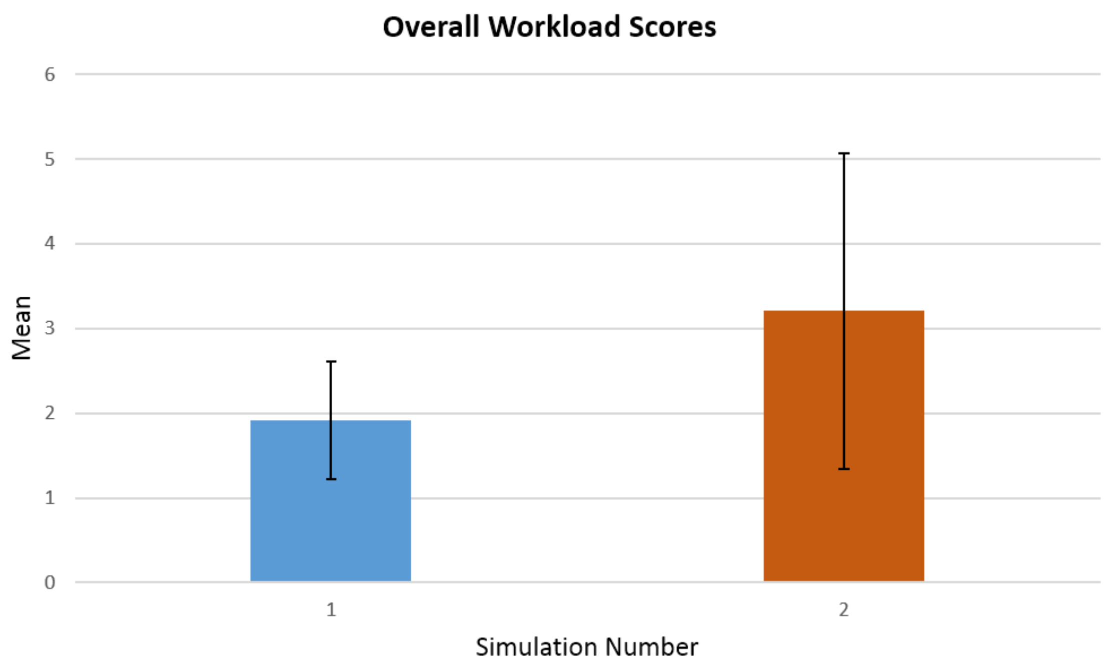
NASA TLX Results



Simulation	Standard Deviation	T-Test
1	0.694	0.044952
2	1.86	

User Evaluation Conclusions

- Modified SAGAT method measures SA of the CAS by giving real-time data about the users' perception of the alarms.
- The multimodal feedback mechanism is able to deliver crucial information successfully to increase the SA of users.
- There is a significant but small difference in situational awareness scores and workload levels when there is a big increase in frequency and type of alarms being conveyed with various feedback modes by the CAS.
- Increase in workload levels directly correlate to decrease in SA levels.
- The SD and paired comparison T-test for SA and workload show a very minimum difference between the perception of users for the two simulation environments.

Conclusion

- Presentation of a Crew Assistance System:
  - Multimodal Feedback Design with arbitration based on NGVA.
  - Concept of System Awareness and means to achieve it.
  - Use of Participatory Design Process for User Interface design.
  - System Awareness and workload assessment techniques.
  - Proof-of-Concept for Human Ergonomics framework.

Future Work

- Adoption to NGVA Crew Terminal Software Architecture Specification.
- Field user study and evaluation using SAGAT and NASA's TLX.
- Further research into modified SAGAT techniques.
- Concepts to be applied to commercial C2IS application.

Thank You
for Your Attention!

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