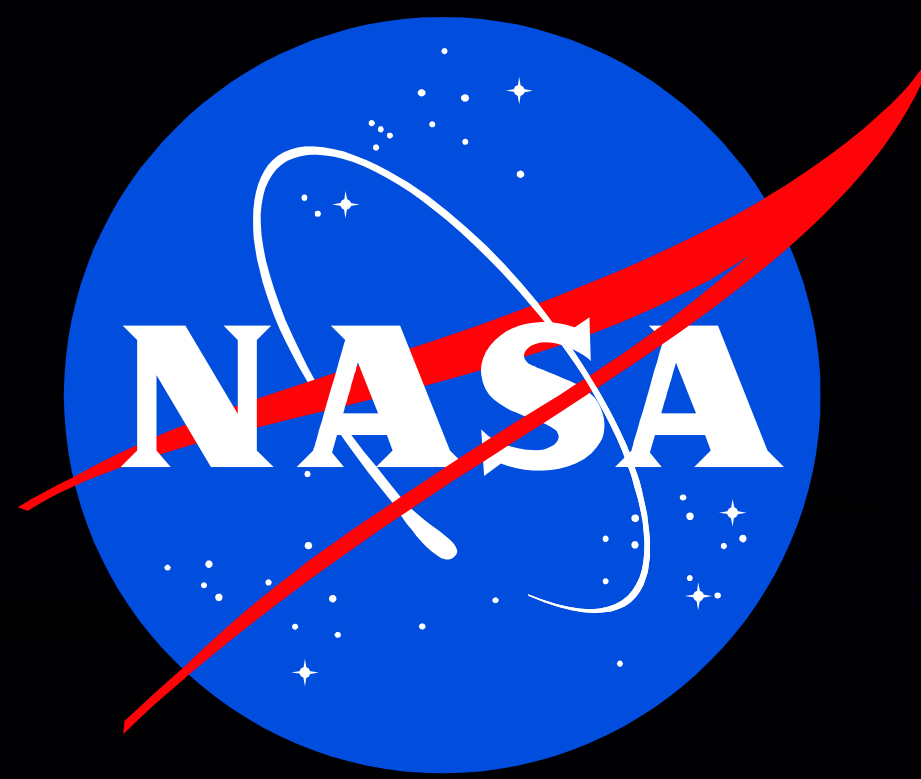




Physiological and Cognitive Exploration Simulation: Assessments of Physiology and Cognition in Hybrid Environment: A novel approach to optimize the future of spacewalk simulations



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Introduction

As NASA plans to return to the Moon in the 2020's, with missions to Mars in the 2030's, extravehicular activities (EVAs) must be optimized due to the inherent 4-22 minute communication latency from Earth to Mars.

Certain control functions previously executed by Mission Control must now be performed by astronauts, leading to a new operational paradigm for the future of mission operations.

Consequently, future mission explorations will be more physically and cognitively demanding on both EV and IV personnel.

Purpose

The development, quantification, and validation of a human in the loop, hybrid-reality platform to simulate physiological, as well as, cognitive demands for spacewalk operations are crucial to mission success with regards to the future of space explorations.

Methods

The lab (a 12 sq. ft. area) contains a HTC Vive Pro Virtual Reality System powered by Unreal Engine, multiple monitor displays, high definition web cameras, and a Tread Metrix treadmill to simulate prolonged ambulation.

The current virtual environment contains a photorealistic terrain, lander vehicle, and unpressurized rover (Figure 1). EV personnel will wear the Vive Pro headset and will be immersed in the lunar environment, with an interactive box.

Various physiological and cognitive parameters will be taken (Figure 2) using devices and programs such as POLAR HR sensor, Oxycon, MATB-II, and NASA-TLX



Figure 1. Virtual environment developed in Unreal Engine.

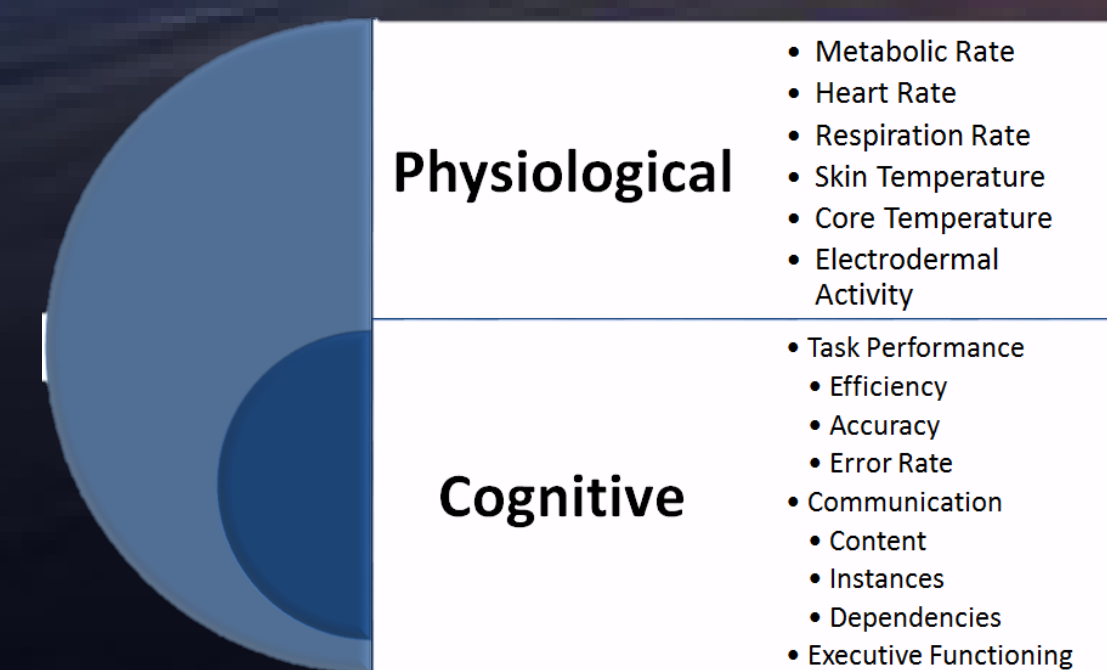


Figure 2. Physiological and cognitive variables and measurements.

Methods Continued



Figure 3. Sensor configuration and data collection.

- Data from physiological sensors were captured by harnessing the emitted BLE signal and then relaying that information to a microcontroller. This information was then piped through an API that communicated in real time with the Database, where data could then be retrieved by navigating to the local host.
- The Database was created through an Amazon Web Server, using Object Relational Mapping, and various Python libraries.
- The API allowed for manipulation and query of the database. The manipulation handled HTTP Requests: POST, DELETE, PUT, allowing for creation, deletion, and updating of the sensors, users, and devices within the database.
- The query component handled HTTP Request: GET, and retrieved the readings from the database organized by date created.



Figure 4. Configuration allowing for real time visual and audio display

- Real time visual display was implemented through Open Broadcasting Software; incorporating the display from the headset and four high definition web cameras that allowed for multiple wireless displays (Figure 5).
- Audio could be sent in real time between the IV and EV personnel. This was achieved using the software Mumble Murmur, using a static IP address with a specific port number that could be accessed on a local server
- Real time visual and audio display are crucial in the APACHE environment, as success of deep space EVAs will be highly contingent exceptional communication between crewmembers.

Results

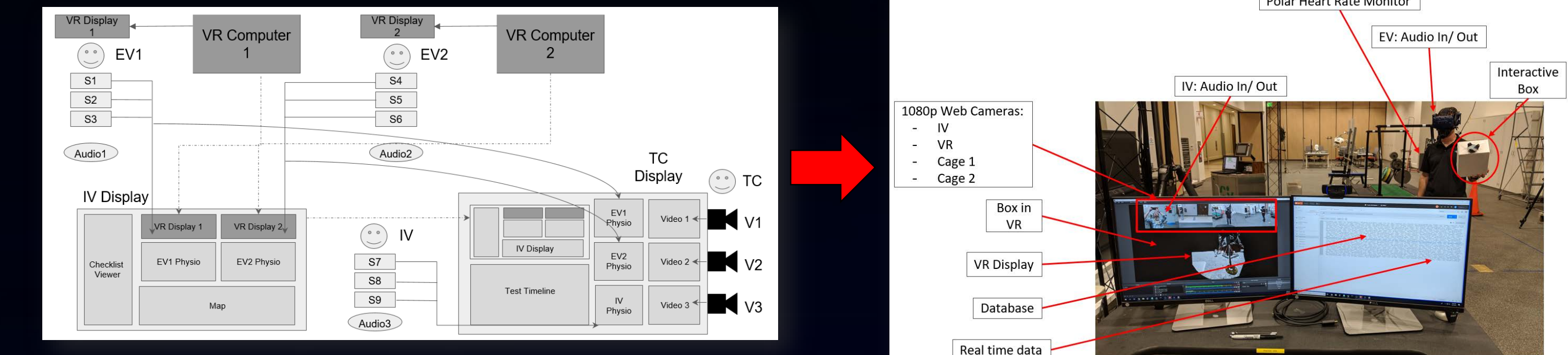


Figure 5. Successful implementation of sensors, database, and real time audio/visual display.

- Figure 5 depicts the overlaying system architecture and its successful implementation within the APACHE environment.
- The APACHE environment can now be used as a platform to assess and explore the challenges associated with EVAs in a way that's never been done before.

Conclusion

- Scientific exploration challenges us to be flexible and inventive with our responses to new information and discoveries, while also maintaining a certain degree of discipline and situational awareness to manage challenging and risky tasks.
- The APACHE environment is a **platform** that provides the capability to effectively simulate high cognitive and physically demanding workloads that can repeatedly measure operational concepts.
- The necessity to practice highly demanding tasks such as spacewalks, is a measure that NASA must take to ensure the safety, mitigate risks, and assure successful performance of mission operations.

Future

- The future of the APACHE environment holds endless possibilities, including a heads-up display, biofeedback algorithms, and features that will be implemented in the new spacesuit such as, decision support systems.
- APACHE can be implemented in environments such as the NBL or xInfo Displays.

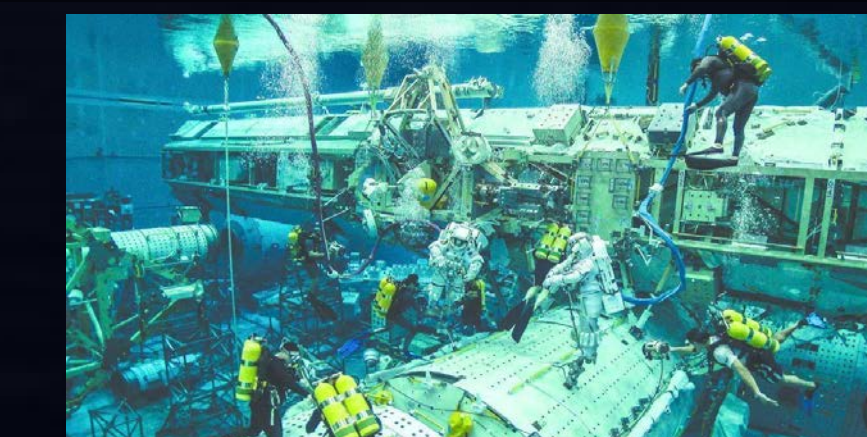


Figure 6. NBL: Neutral Buoyancy Lab.



Figure 7. xInfo display mockup