NIST Virtual Reality Heads-Up-Display Navigation Challenge

VR FIRST (Firefighter Integrated Recovery and Survival Technology)

Team: ENGRdynamics

Business POC: David Kaniss Dave@engrdynamics.com

Technical POC: Tim Kaniss Tim@engrdynamics.com

Abstract:

This concept paper explores utilizing a virtual reality (VR) heads-up display (HUD) to increase the situational awareness of firefighters, and to provide operationally relevant information in a timely and non-distracting manner. This project will be implemented for the HTC Vive headset within the Unreal game engine.

The proposed HUD concept will synthesize raw data streams into operationally relevant alerts and insights. While important and urgent alerts need to be presented clearly, the HUD should not degrade situational awareness in the simulated environment. In support of this, the display will be customizable and dynamic, allowing relevant information to be displayed in the most effective manner possible.

Developing and refining an effective first responder capability will involve combining user experience principles with operator feedback. Survey instruments and user interviews will allow characteristics of the display to be qualitatively and quantitatively measured.

Unique team perspective composed of Computer Science, Systems Engineering, and Sociology backgrounds. Major focus areas include Integration, Human Factor Design, Sustainability, and Modeling & Simulation.

Review of Literature

The Next Generation First Responder (NGFR) program is a Department of Homeland Security initiative intended to equip first responders with sophisticated sensors, data links, and information displays, in addition to enhanced physical protection[1]. The Wearable Alert and Monitoring System (WAMS) is targeted to support the NGFR by providing data like atmospheric oxygen or operator heart rate to AUDREY agents.[2] Assistant for Understanding Data through Reasoning, Extraction and Synthesis (AUDREY) is a platform designed to synthesize actionable insights and alerts from diverse sources of data through machine learning. AUDREY is intended to process varied, high-rate data in realtime to eliminate distractions while delivering operationally relevant information.[3]

A 2016 Department of Energy analysis explored the capabilities of NGFR information concepts and their effect on situational awareness.[4] Head-mounted wearables provide additional data, but can negatively affect operator performance. Heads-Up Displays (HUDs) have demonstrated issues involving the display capturing visual or attentional focus, at the expense of situational awareness. Situational awareness includes awareness of data like operator locations and nearby hazards, but also involves undistracted cognitive processing. Dangerous, chaotic scenarios with multiple sources of data present a challenging information environment. Firefighting decision-making involves data sharing, protocol, and local command, and demands a high degree of coordination and focus.

Head-mounted displays have, however, had proven benefits in areas like targeting and wayfinding. Integrating existing sources of information into a head-mounted display can provide a more efficient approach to supplying relevant information. While adding new sources of information may be able support better awareness, it is often a source of distraction or information overload.

[1]https://www.dhs.gov/sites/default/files/publications/Apex%20Program-Next%20Generation%20First%20Responder-508_0.pdf

[2]https://www.dhs.gov/sites/default/files/publications/OIC_NGFR_WAMS-FactSheet_170706-r1-508.pdf

[3]https://www.dhs.gov/sites/default/files/publications/Audrey2-fact-sheet-508.pdf

[4]https://nwrtc.pnnl.gov/PDFs/RTAs/RTA_Situational_Awareness.pdf

Concept Description

This project is a virtual reality (VR) heads-up display designed to demonstrate the presentation of operationally relevant information to firefighters. This project will be implemented for the HTC Vive headset within the Unreal game engine.

Information will be provided based on spatial characteristics including operator location and gaze direction. The display will provide interactive capabilities that allow extensive customization and dynamic querying of information through speech and gaze. Other interactive mechanisms, such as gestures, may be possible, but pose additional difficulties when trying to generalize the solution to include actual operating environments; gesture-detection is commonly performed through stationary sensors, which would restrict operational use. A very limited selection of gestures than can be unambiguously performed with a full loadout may be appropriate.

Detailed information can be displayed through an unobtrusive heads-up-display, but auditory and haptic feedback may be valuable to communicate additional context or time-critical alerts. Operational parameters will include oxygen levels, temperatures, victim location, and the locations of known hazards. Customizable information like maps and routes will be provided. These will display current operator position and nearby environmental features.

Standard HUD customization functions will be implemented, such as color and font size selection. Additionally, options for dynamic adjustment will be provided (such as selecting colors that maximize contrast with the background). Dynamic, interactive controls will help to allow the implementation to provide detailed information without distracting the operator. For example, a gesture or voice command could be used to temporarily display a bread crumb trail over the environment.

The final solution must provide relevant information in a non-distracting manner. Human factors will be taken into account to ensure that situational awareness will not be affected by the presentation of critical information. Simultaneously, urgent alerts must be prominent enough that they are fully noticeable in a chaotic operating environment.

Technological maturation will involve planning to incorporate operator feedback. Surveys will allow the usability, information relevance, and distraction potential to be accurately assessed and made available for future VR or AR applications.

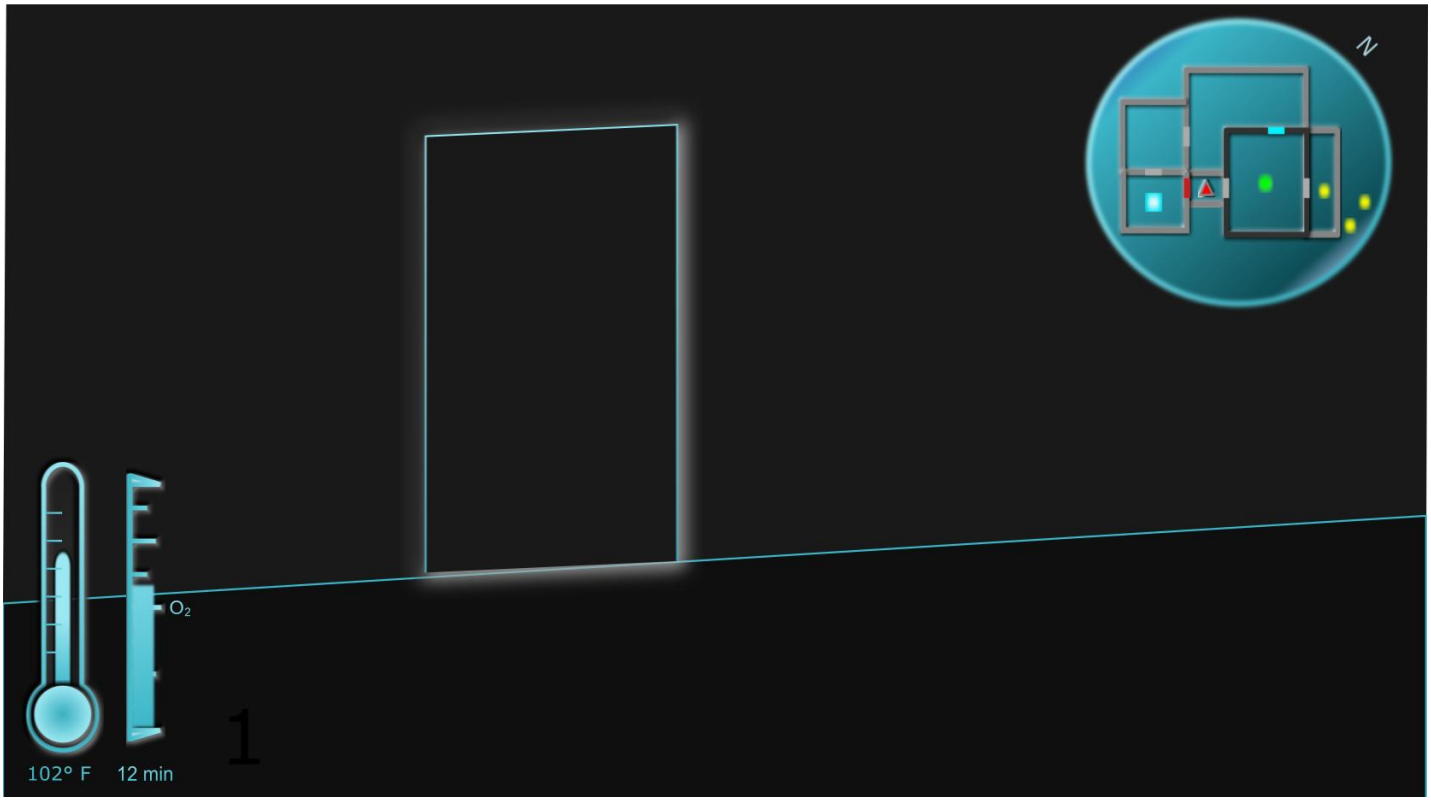


Figure 1: HUD Concept

Metrics:

The design of the VR FIRST system is primarily driven by human factors, so the majority of the metrics generated will be qualitative rather than quantitative. As such, the primary research methodology will consist of tools such as surveys and interviews, which will be supplemented as appropriate with key performance parameters. Several examples of the metrics intended for use are included below.

1. Practicality
    a. Does the system reduce scenario complexity for the user?
    b. Is the right level of information displayed at any given time to avoid information overload?
    c. Does the system provide a clear, concise view of the following:
        i. Hazards
        ii. Route/Navigation
        iii. Personal Status
    d. Does the system induce motion sickness?
    e. Is relevant data, such as operator location, seamlessly integrated?
    f. Does the operator have to manually perform tasks that can be automated?
    g. What is the process to load the system with navigation data?
2. Usability
    a. How much training time does the average user require to gain basic/experienced familiarity with the system?
    b. How intuitive is the HUD?
    c. How intuitive are the HUD controls?
    d. Does the system maintain easily readable elements in different environments/backgrounds?
    e. How reliable is the system?
3. Safety
    a. How does the system impact situational awareness?
    b. How do alerts, whether routine or urgent, impact situational awareness?
    c. Does the system reduce the user's mobility/ ability to navigate around hazards?
4. Affordability
    a. How modular is the system?
    b. What is the upgrade process for the system?
    c. What are the long-term costs of the system (including maintenance)?

Project Team / About Us:

Our team combines a unique set of skills and experiences, which is well-suited to solving a technical problem of such critical importance. We blend the complimentary aspects of Sociology and Systems Engineering to thoroughly understand the overall goals of the product, along with the constraints and complexities faced over the lifespan of the product. System development utilizes both time-tested concepts (such as designing for sustainability), along with a technologically advanced toolset to explore alternatives and create a mature product. We believe that the following are the most important aspects of good design, and are required to produce designs that we can be proud of:

1. Our focus will always be on the end users, and how we can help them. Solutions should fix problems, not create new ones.
2. Simplicity of Design: Unnecessary complexity leads to operational problems. Solutions should be technically capable enough to meet the user's needs, without being complex for complexity's sake.
3. Usability: How easy is the solution to use on a daily basis? Solutions should be inherently intuitive to learn and use.
4. Practicality: Does the solution meet the actual underlying need? Have all underlying needs been met?
5. Modularity: Upgrades and Modifications should be easy and cost-effective.
6. Affordability: Long-term expenses and maintenance account for the vast majority of a product's total costs, and should be minimized wherever possible.

Key Team Members:

Dave Kaniss is a Systems Engineer specializing in seamless integration and long-term sustainability. He has over 8 years of experience, spanning both test & evaluation and program management activities. He is well versed in providing safe, cost-effective products that are both reliable and extremely usable.

Tim Kaniss is a Computer Scientist with over 3 years in modelling and simulation, focused on interoperability and cyber test and evaluation. He has extensive experience in cross-platform development, distributed simulation protocols, and GNU Radio.

Dr. Julie Fennell is a qualitative Sociologist with over a decade of experience, skilled in both research and statistical analysis. She has presented for a wide range of conferences and groups, ranging from academia to the general public. She has won numerous speaking awards, and provided multiple media interviews.

DAVID A. KANISS

SUMMARY: Systems Engineer specializing in integration and sustainability. Over 8 years of DoD acquisition experience, spanning test & evaluation and program management. Demonstrated ability to provide safe, cost-effective products that are both reliable and extremely usable.

PROFESSIONAL EXPERIENCE

Systems Engineer; Department of Defense 2009-Present

- Define requirements from customer feedback, and ensure correct product is being designed. Provide deliverables that meet customers' current use cases, while still providing cost-effective flexibility for future capabilities. Design for reliability and sustainability, which includes minimizing long-term usage expenses.
- Manage development of collaborative management software designed for ease of use and future flexibility. Solicit feedback from end users to ensure maturity and usefulness.
- Manage development of critical technical documentation. Decreased turnaround time by 60%; incorporated 99% of backlogged content; and actively prevented additional backlog via a modernized process, focusing on collaboration and efficiency.
- Lead formal technical reviews and ensure appropriate technical experts have conducted a thorough review.
- Utilize rapid prototyping/manufacturing to develop and deploy high-priority capabilities.

KEY SKILLS

- Program Management
- Systems Engineering
- Systems Integration
- Test & Evaluation
- Technical Publications
- Modeling & Simulation
- Configuration Management
- Rapid Prototyping/Manufacturing

EDUCATION

Naval Postgraduate School (NPS); Monterrey, CA

- **Certificate of Lead Systems Integration (LSI)** Mar 2017
- **Master of Science in Systems Engineering (MSSE)** Sep 2014
- **Certificate of Systems Engineering (SE)** Dec 2013

Capitol Technology University**;** Laurel, MD

- **Bachelor of Science in Electrical Engineering (BSEE),** *summa cum laude* Dec 2011

TIMOTHY R. KANISS

SUMMARY OF QUALIFICATIONS

Computer Scientist with over 3 years in modelling and simulation, focused on interoperability and cyber test and evaluation. Extensive experience in cross-platform development with C++ and Qt. Familiar with distributed simulation protocols, GNU Radio.

PROFESSIONAL EXPERIENCE

Software Developer; Department of Defense 2014-Present

- Developed tools and supporting APIs that enable interoperability between independently-designed distributed simulations.
- Created automated test framework to verify syntactic and behavioral protocol compliance.
- Found and removed over 300 bugs in existing code, reducing end-user discrepancy reports by a factor of ten.
- Designed and implemented data visualization tools for conceptual design that introduced support for high-performance computing datasets over 1,000 times as large as previous solutions.
- Developed tools to simulate cyber attacks against embedded systems.

EDUCATION

Capitol Technology University; Laurel, MD

- **Bachelor of Science in Information Assurance (BSIA),** *summa cum laude* Dec 2011

Old Dominion University; Norfolk, VA

- **Master of Science in Modelling and Simulation** Aug 2017

Naval Postgraduate School (NPS); Monterey, CA

- **Master of Science in Engineering Systems**

Sep 2017

Julie L. Fennell, PhD

EDUCATION

Ph.D. Sociology Brown University, 2009 (completed Sept. 2008)
M.A. Sociology, Brown University, 2005
B.A. Sociology and Literature, *summa cum laude,* University of North Carolina, 2003

ACADEMIC POSITIONS

2014-present Associate Professor of Sociology (tenured), Gallaudet University
2009-14 Assistant Professor of Sociology, Gallaudet University
2008-9 Assistant Professor of Sociology (non-tenure track), Central Connecticut State University
2006 Visiting Instructor, Connecticut College

NOTABLE ACHIEVEMENTS:

- Presented at 30+ academic conferences, and roughly 80 workshops for the general public
- 8 peer reviewed articles
- Taught 70+ undergraduate classes
- Extensively profiled in 5 major media interviews, and a featured guest on multiple podcasts.

KEY SKILLS:

- Highly sophisticated ability to understand the connection between individual experiences and larger social contexts
- Strong expertise in qualitative research skills including, but not limited to: in-depth interviewing, participant observation, content analysis, and data analysis (qualitative coding)
- Highly skilled at presentation, especially translating complex ideas from one audience to another.
- Highly skilled writer, both for academic audiences and general audiences
- Quantitative research skills, especially survey design, and statistical analysis
- Extensive background in understanding and analyzing complex social issues

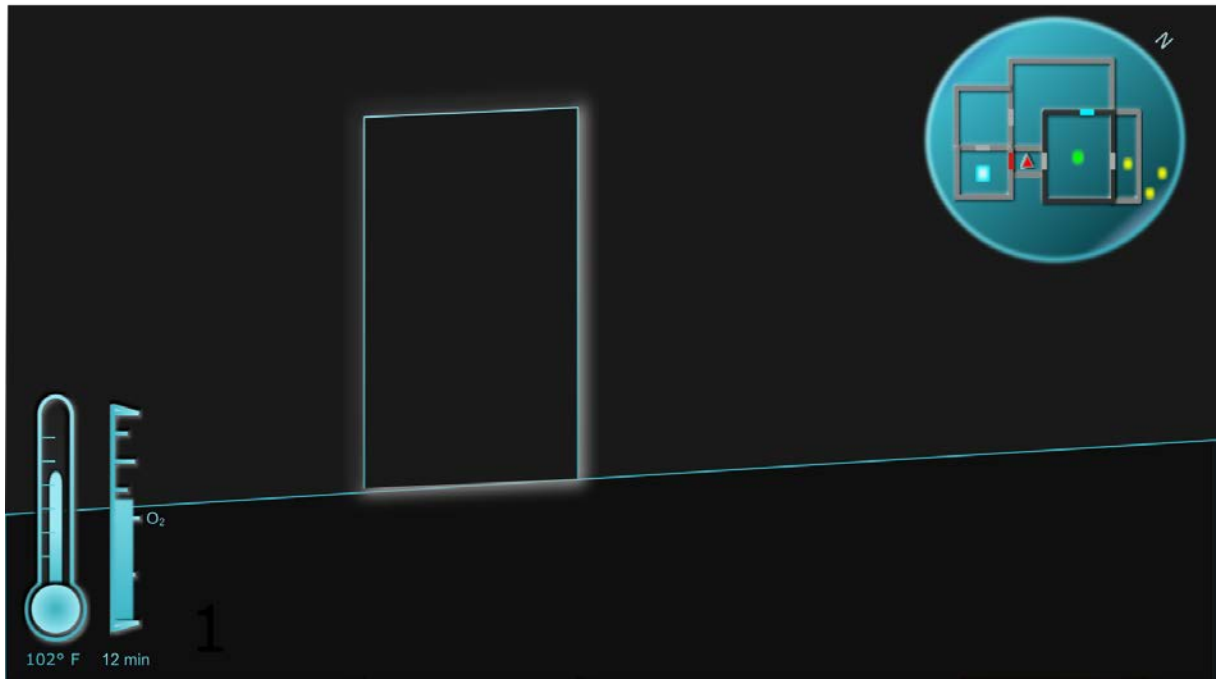
VR FIRST (Firefighter Integrated Recovery and Survival Technology)
Engineering Dynamics

Project Summary:

The VR FIRST Prototype is an HTC Vive-based Unreal Engine demonstration of data link integration into a heads-up display (HUD) for first responders.

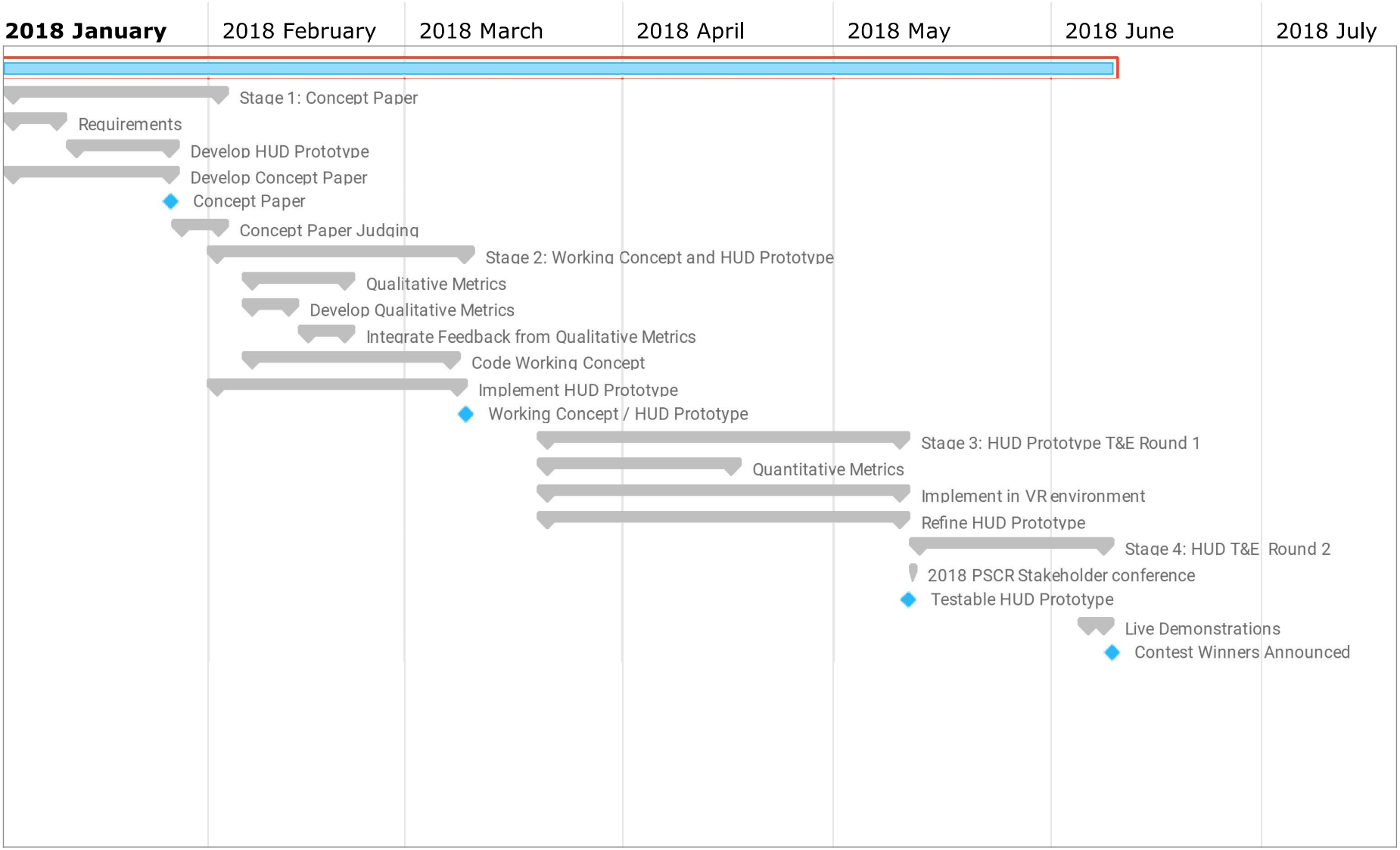
Participant Summary:

- Unique perspective composed of Computer Science, Systems Engineering, and Sociology backgrounds.
- Expertise in both quantitative and qualitative analysis.
- Major focus areas: Integration, Human Factor Design, Sustainability, Modeling & Simulation,



Technical Outcomes:

- Increase end user safety via enhanced situational awareness, and monitored personal safety metrics.
- Decrease mission complexity by providing real-time navigational and communication assistance.
- Provide cost-effective solution, with modular upgrades.



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