2020 PUBLIC SAFETY BROADBAND STAKEHOLDER MEETING

NIST

#PSCR2020

PSCR

Prototyping 3D User Interfaces for First Responders

Katelynn A. Kapalo

NIST

PSCR

DISCLAIMER

Certain commercial entities, equipment, or materials may be identified in this document in order to describe an experimental procedure or concept adequately.

Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the entities, materials, or equipment are necessarily the best available for the purpose.

*** Please note, unless mentioned in reference to a NIST Publication, all information and data presented is preliminary/in-progress and subject to change**

Speaker Bio

Katelynn A. Kapalo

Current Role: **NIST UI/UX Portfolio Team**
Research Associate, Brown School of Engineering
Ph.D. Candidate, University of Central Florida

Usability Studies, Human Performance, Prototyping Augmented and Virtual Reality (AR/VR) User Interfaces

Professional Background:

- Former Research Statistician for Orange County Fire Rescue in Winter Park, Florida
- Former Research Psychologist for DoD/U.S. Navy
- Former Intern with the East Central Florida Regional Planning Council, developed CAMEO files and modeled chemical plumes for HazMat response in four large Central Florida counties

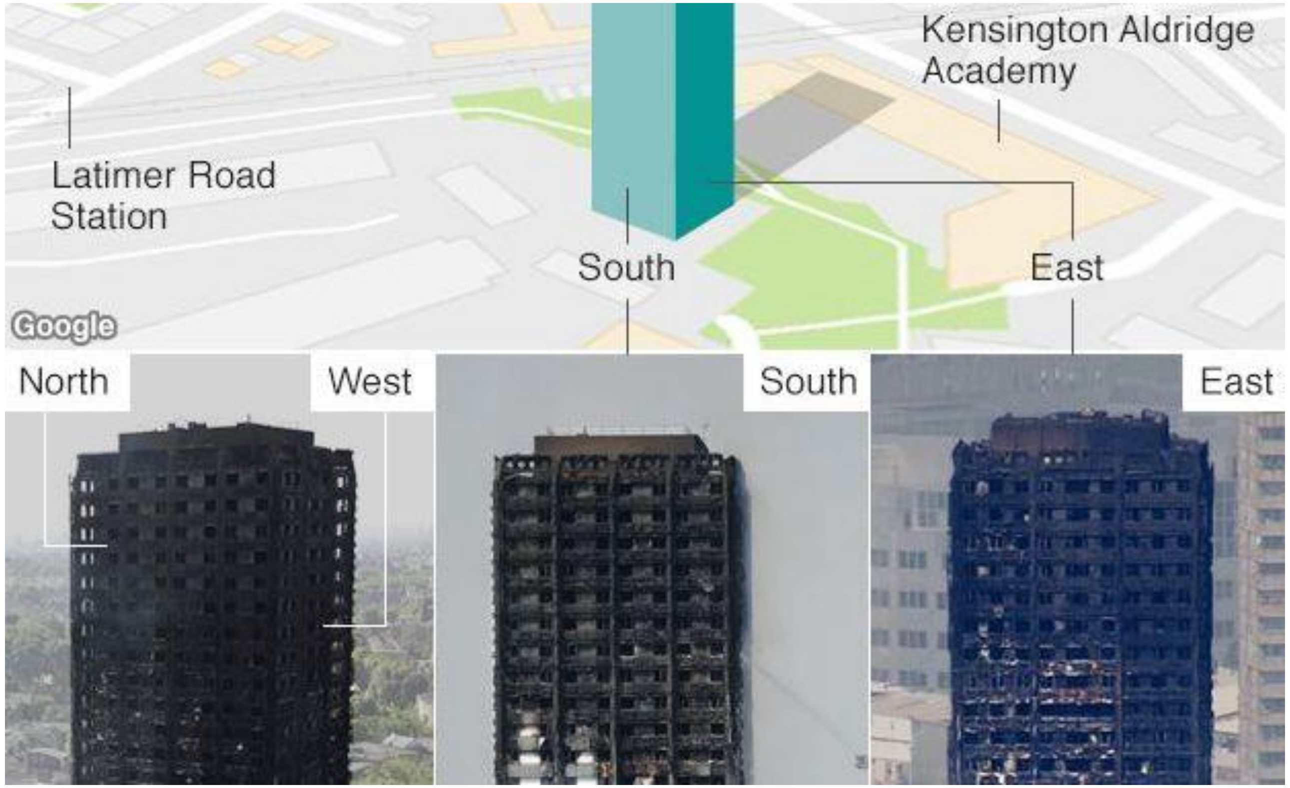
Agenda

- Introduction
- Understanding Public Safety End Users
- Visualizing the Future of Technology
- NIST Past, Present, and Future Directions
- Benefits and Challenges of Prototyping 3D User Interfaces

Understanding Public Safety End Users

Grenfell Tower

To design effective 3D user interfaces that better support first responders, we need to understand the ***operational environment*** and their ***technology needs***



Structure Fires in the United States

499,000

Number of Reported Structure Fires

112,000

Number of Reported Nonresidential Structure Fires

1,100

Number of Civilian Injuries (non-residential)

22, 975

Number of Firefighters Injured on the Fireground

National Fire Protection Association (2018)

How Do We Address These Challenges?

Technological Innovation

Due to rapid advances in technology, first responders will eventually have access to building information, sensor data, and fire protection system data in real-time

Perception & Performance

The presentation and display of this information has not been fully evaluated from the *human performance* perspective

Public Safety User Interface R&D Summit Report

Prioritization of Needs

1. **Augmented Reality (highest priority User Interface Capability)**
2. Voice Command / Audio Intake
3. Unmanned Vehicles / Human-Machine Interaction
4. Biometrics / Wearables / Smart Suit
5. Haptic
6. Virtual Reality
7. Gesture Recognition / Eye-Gaze (lowest priority User Interface Capability)

Full Report Available: Click Here

Benefits of Enhanced User Interfaces

Communication

Different communication modalities (avoiding *over-reliance* and increased workload)

Situation Awareness

Increased situation awareness and enhanced decision making

Collaboration

Increased efficiency of collaboration

Information Quality

Enhanced accuracy and availability of information

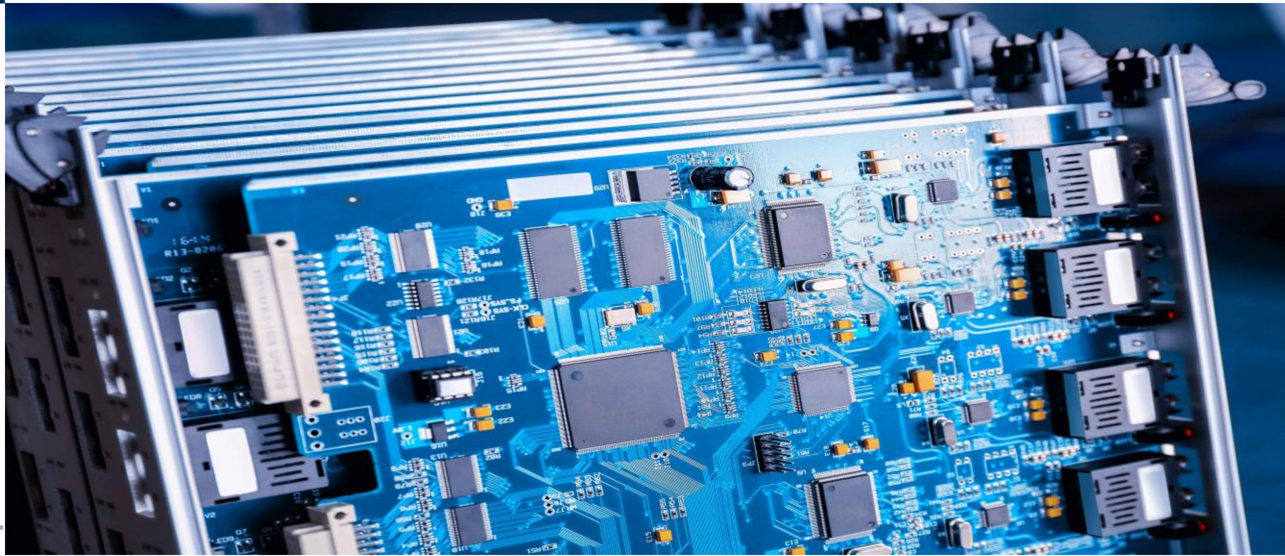
Ubiquitous Computing

Theoretical Background

"Anytime, anywhere computing" (Weiser, 1991)

Examples of Ubiquitous Computing

- Natural User Interfaces
- Context-Aware Applications
- Automated Capture & Access



Situated Computing

Embedded Tools

Computers to be conceptualized as “embedded tools”

Embodied Cognition

- Exploits our physical skills
- Emphasizes the relationship between the ***environment and the task***

Situated Visualization

What is Situated Visualization?

Leverages real world environment to make it relevant to the situation, task, or user (White & Feiner, 2009)

What is important about Situated Visualization?

- Visualizations that are **related to and displayed in their environment**
- Significance: combination of *visualization and the relationship it has with the environment* is supposed to *support* the user

Visualizing the Future of Technology

AR for Visualization

To design effective 3D user interfaces that better support first responders, we must explore and investigate multiple interface paradigms and configurations (while *mitigating human performance issues*) in their **context of use**

AR is a powerful paradigm because it offers *relevance* to the situation

Reduce Distractions

Potential to reduce distracting information, such as unnecessary radio traffic

Attention

Reduces shift of attention between interface and physical objects (Liu et al., 2012)

Memory

Reduces the need to remember multiple sources of information

Situational Awareness

Potential to enhance SA (BARS; Yohan et al., 2000)

Interaction

Medium of interaction is more fluid, creating a better user experience (Billinghurst, Clark, & Lee, 2015)

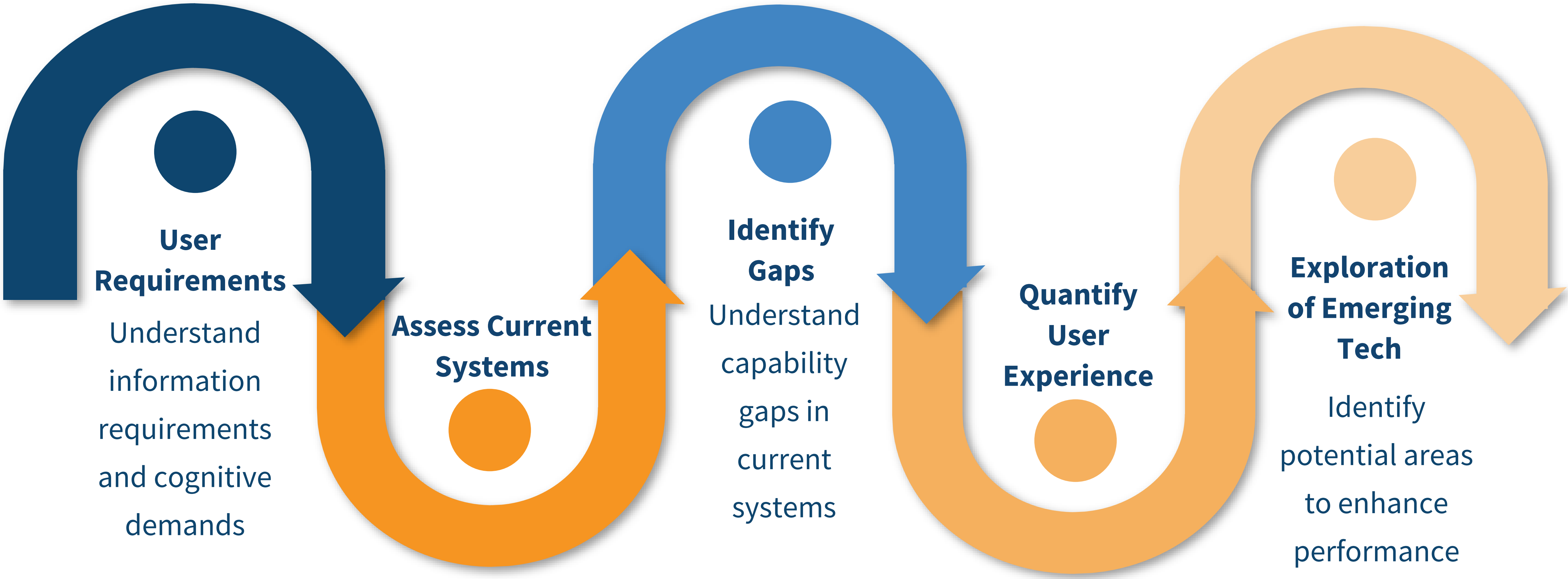
Why Augmented Reality?

CHARIoT Prize Challenge

Developers have the opportunity to leverage augmented reality (AR) technology, such as ***heads-up display and holographic interfaces***, to convey actionable information to first responders without *distractions* or *cognitive overload*

CHARIoT CHALLENGE
Advancing First Responder Communications

Research Goals



UCF

DISCLAIMER

The following slides, 20-29, are based on research completed by the presenter at the University of Central Florida (UCF). This research was not funded by the National Institute of Standards and Technology. The contents of these slides do not necessarily reflect the views or policies of NIST or the U.S. Government.

The UCF Institutional Review Board reviewed the protocol for this project and determined it meets the criteria for "exempt human subjects research."

Requirements Analysis

- Needs Assessment/Cognitive Work Analysis
  - Conducted with an entire Fire Battalion in Florida
  - $n = 35$ (32 male, 3 female)
    - Focus Groups
    - Field Study (Ride-Along)
    - Observational Data

Lessons Derived from Case Studies

First Arriving Needs

First arriving firefighters found visual information to *create overload*, primarily due to their specific ***roles and tasks***

Company Officer Needs

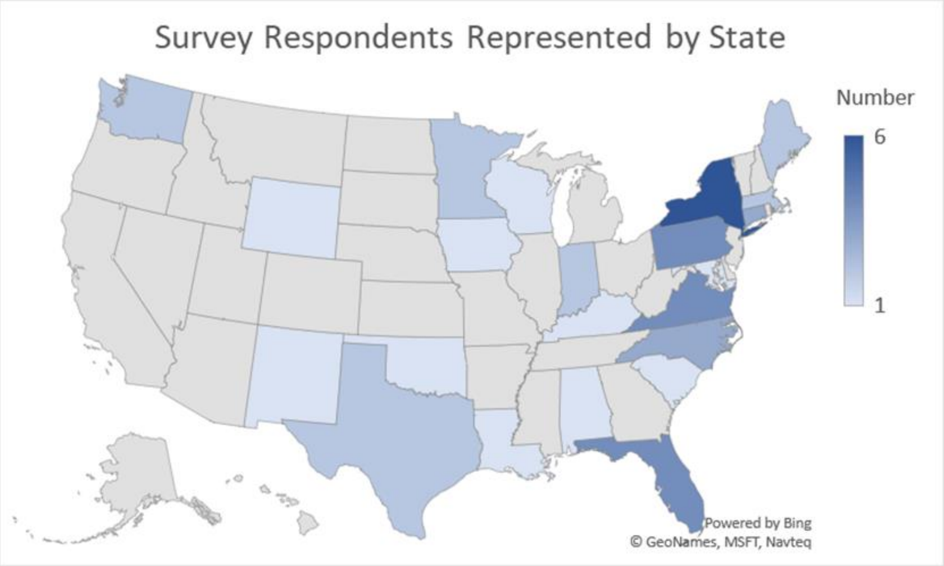
Company and command officers (Lieutenants and higher ranked officers) expressed a ***need for summarized visual information***, without too much clutter

Sociotechnical Challenges

The ***technology used*** in this fire department *does not reflect* **the values and expectations** of firefighters (people) and their **main job functions** (incident response). This creates a strain on both the users and the technical systems supporting them

Pre-Incident Planning (PIP) Practices and Policies

- Nationwide survey about Pre-Incident Planning (PIP) practices and policies
    - Survey Data
    - *n*= 50 firefighters



RANK	NUMBER OF PARTICIPANTS
FIRE MARSHAL/INSPECTOR	2
CHIEF	10
CAPTAIN	8
LIEUTENANT	3
SENIOR FIREFIGHTER	3
FIREFIGHTER	21
OTHER (1 DID NOT REPORT RANK)	3

Results: Time to Retrieve Plan Information*

	Find Plan	Hazardous Materials	Building Occupancy	Auxiliary Appliances
10-30 SECONDS	10	15	14	16
30-60 SECONDS	13	**16**	**17**	9
>60 SECONDS	**16**	11	9	**17**
OTHER	4	1	1	1
DID NOT USE	7	7	9	7

n = 50

*Based on self-reported measures

Key Findings

What are the most frequently reported barriers to successful information capture and retrieval?

- Time
- Type of Facility
- Staffing & Administration
- **User Interface & Technology Limitations**
- Attitudes

Key Findings

What information do firefighters need on the fireground?

- 76% reported using PIPs for structure fires
- 90% reported using PIPs for hazmat incidents
- Only 10 reported using pre-incident plans for *size up* (initial incident assessment), mostly due to ***data accessibility issues or barriers***

Lessons Derived from PIP Survey

Inadequate User Interfaces

Inaccessible information due to inadequate user interfaces/disparate systems

Static vs. Dynamic Information

Conflicting information needs based upon factors such as role and type of facility

Organizational Challenges

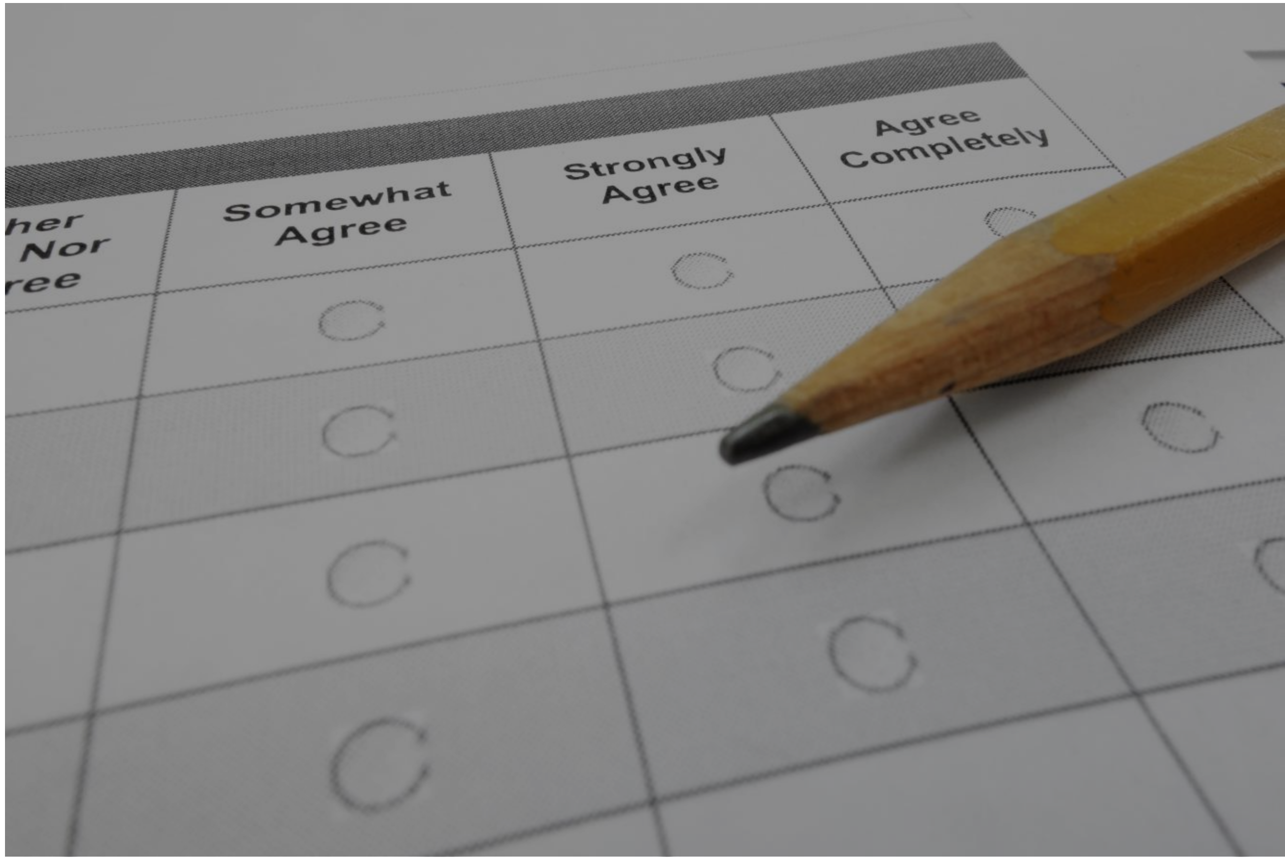
Sociotechnical barriers to adoption identified and classified by type

Study Limitations

Ecological validity: We cannot ask participants to complete these tasks at the scene of a real emergency

Limitations of Sampling: Cannot directly manipulate level of expertise (novice vs. more experience incident commanders)

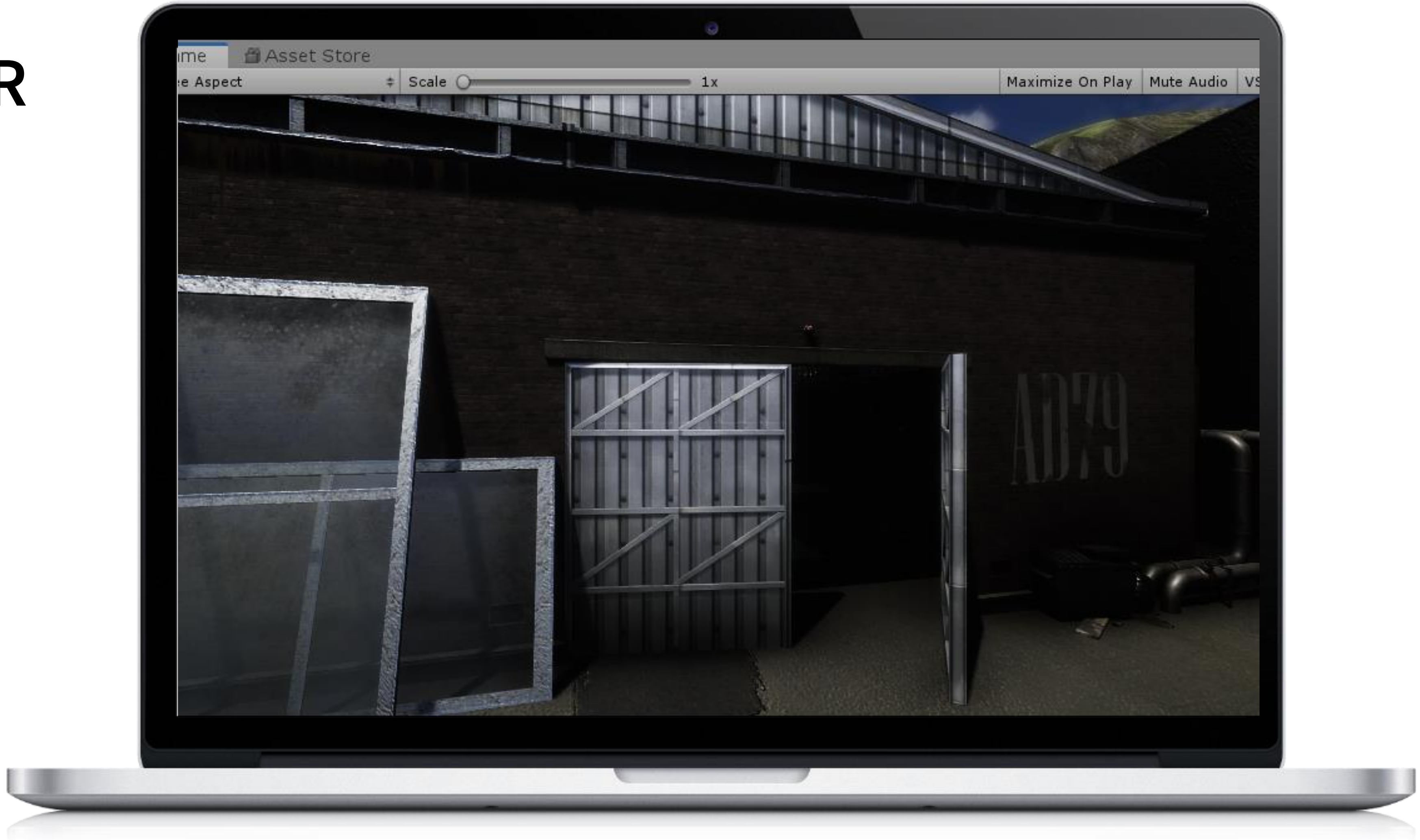
Limitations of Measures: Self-reported measures may be biased



Prototyping AR User Interfaces
Structure Fire Use Case

Structure without AR

- Pre-Incident Planning Use Case
- Structure Fire in Warehouse



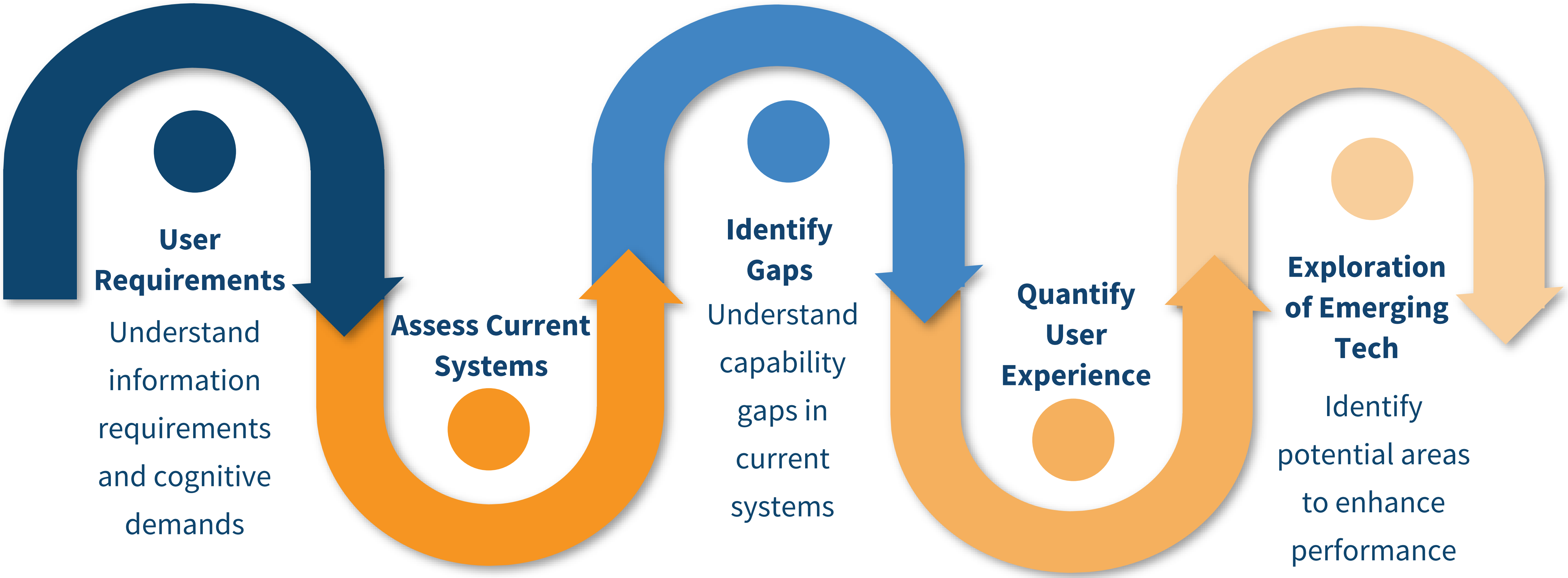
Prototyping AR User Interfaces
Structure Fire Use Case

Structure with AR UI

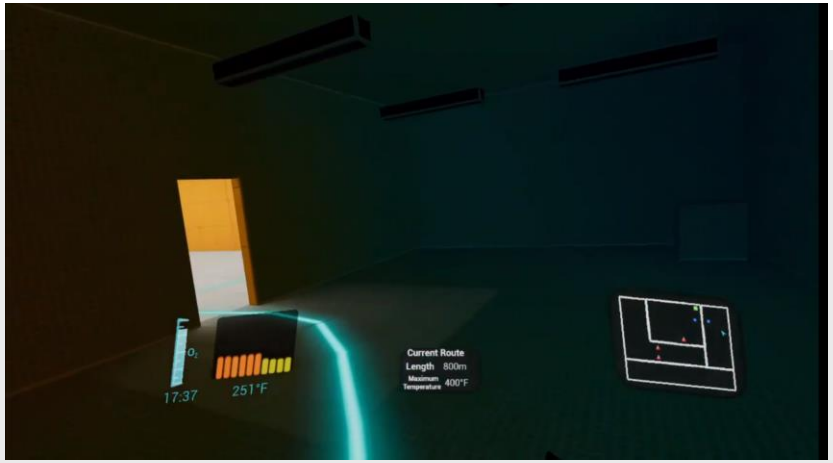
- Pre-Incident Planning Use Case
- Structure Fire in Warehouse
- Can toggle interface to show important features of the facility (e.g., Fire Department Connections (FDCs), water mains, etc.)

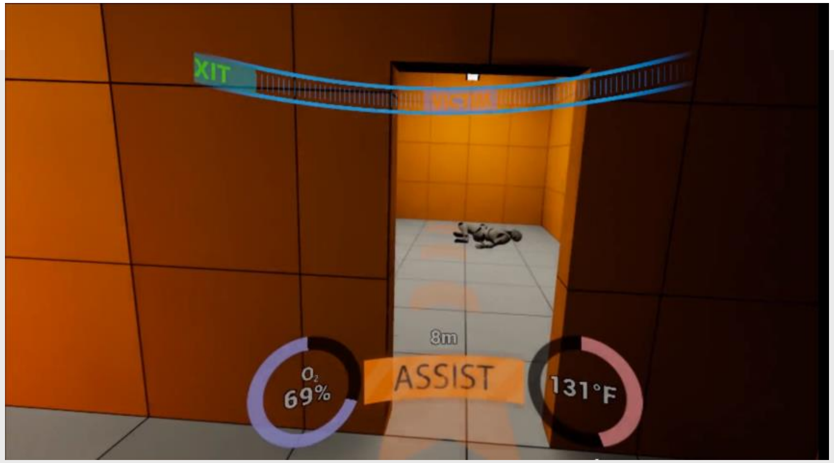
Past, Present, and Future Research Directions at NIST

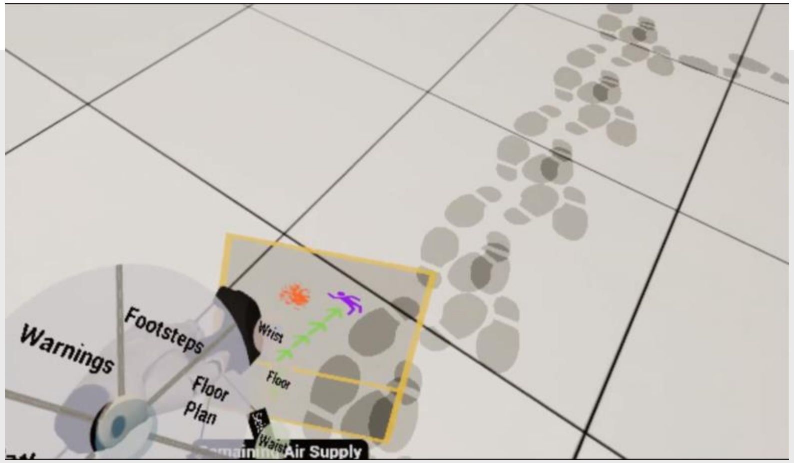
Research Goals



2018 - Heads-up Display Navigation Challenge Finalists







2019 Haptic Interfaces for Public Safety Challenge

Relevancy of Haptic Interfaces for Public Safety Tasks

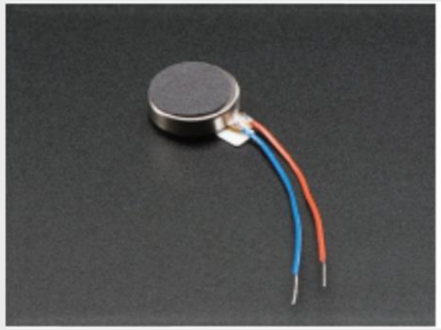
Can Haptic Interfaces assist First Responders?

3 Virtual Scenarios
1 Live Test

$425,000 awarded

Two Different Contestant Types

- Haptic Providers
- Haptic Development Teams



2020 CHARIoT Challenge

4 Emergency Scenarios

- Active Shooter
- Flood
- Wildfire
- Mass Transit

Prototyping AR in VR: Challenges and Opportunities

Visualizing the Future of Technology

Testing for hazardous scenarios is expensive

- $40 - $60K for testing in hazardous scenarios
- $10K - $30K for consumer testing firms for single-phase, uncomplex testing
- $12K - $20K for full service testing services from third party firms offering outsourced testing for consumer products (ex. Mediabarn and MeasuringU)
- ~$50K for the rental of controlled burn facilities for fire testing typically required for a single day of testing

Visualizing the Future of Technology

Limit the hazard to study participants

- Eliminate exposure to unnecessary hazards
- Allow for the rehearsal of dangerous incident types without the risk of injury
- Create the opportunity to train for low-frequency, high-risk events ethically

Visualizing the Future of Technology

UI/UX best practice is to test usability as often as possible

- Involve stakeholders early and often
- Iterative design cycles
- The opportunity to create technology with tangible improvements and impact

Visualizing the Future of Technology

In summary, VR prototyping can potentially:

- Save costs
- Increase the efficiency of the design and development time
- Decrease the complexity of testing

Contact Us

321-276-8330

Katelynn.Kapalo@nist.gov

NIST References and Publications

Links to

Publications:

R & D Summit Report

Voices of First Responders

UI/UX Resource Library

Challenge Information:

2018 VR HUD Navigation Challenge

2019 Haptic Interfaces Challenge

2020 CHARIoT Challenge

Presentation References

Billinghurst, M., Clark, A., & Lee, G. (2015). A survey of augmented reality. Foundations and Trends® in Human–Computer Interaction, 8(2-3), 73-
272.

Gorse, C., & Sturges, J. (2017). Not what anyone wanted: Observations on regulations, standards, quality and experience in the wake of Grenfell. Construction Research and Innovation, 8(3), 72-75.

Liu, C., Huot, S., Diehl, J., Mackay, W., & Beaudouin-Lafon, M. (2012, May). Evaluating the benefits of real-time feedback in mobile augmented reality with hand-held devices. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2973-2976).

Yohan, S. J., Julier, S., Baillot, Y., Lanzagorta, M., Brown, D., & Rosenblum, L. (2000). Bars: Battlefield augmented reality system. In In NATO Symposium on Information Processing Techniques for Military Systems.

Relevant UCF Publications*

Kapalo, K. A., & LaViola Jr, J. J. (2019, November). Failing to Plan is Planning to Fail: Capturing the Pre-incident Planning Needs of Firefighters. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 63, No. 1, pp. 612-616). Sage CA: Los Angeles, CA: SAGE Publications.

Kapalo, K. A., Wisniewski, P., & LaViola Jr, J. J. (2019). First in, left out: Current technological limitations from the perspective of fire engine companies. Information Systems for Crisis Response and Management, 16, 1286-1299.

Kapalo, K. A., Bockelman, P., & LaViola Jr, J. J. (2018, September). "Sizing Up" Emerging Technology for Firefighting: Augmented Reality for Incident Assessment. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 62, No. 1, pp. 1464-1468). Sage CA: Los Angeles, CA: SAGE Publications.

*These views are the authors' alone and do not represent the official views of NIST, NIST PSCR, or any other government agency

THANK YOU

NIST

#PSCR2020

PSCR