

Conceptualizing the Design and Use of Augmented Reality Within a Common Operating Picture for Incident Command Systems

Final Report

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For **Indiana University Crisis Technologies Innovation Lab**
and **Director of User Experience, Sonny Kirkley**

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Executive Summary

The Indiana University Crisis Technologies Innovation Lab (IUCTIL) is developing an augmented reality (AR) system to assist incident commanders and first responders in resolving emergency situations. We are aiding in that effort by discovering what data is necessary for incident commanders to see, demonstrating where AR technology can be best utilized in incident command workflows, generating user interface and experience design criteria and requirements, and recommending a standardized interface from requirements set by incident commanders and first responders. Our efforts were broken into four primary phases.

Phase 1

The first phase of the project included several information sessions in which the team got acquainted with the lead sponsor of the project, Director of User Experience, Sonny Kirkley. During these sessions project objectives and scope were also determined. The team wrote and submitted an initial draft of the Project Definition and Scope document.

The project sponsor introduced the team to an expert stakeholder, Dale Rolfson, Chief Technology Officer of the Indianapolis Fire Department. An initial interview was conducted on February 11th, 2022. This interview was a conjunctive effort including questions developed from both active augmented reality teams.

Feedback received from the project sponsor informed significant revisions to the Project Definition and Scope Document. These revisions were guided by ongoing team research and information obtained during the interview. Specific attention was given to the development of expected project activities and deliverables. The focus of this phase was primarily organizing project scope, learning more about the previous work completed in the AR incident command space, and collecting resources for future phases.

Phase 2

In the second phase of the project, Dale Rolfson invited the team to a tour of the Indianapolis Metro Police Department's incident command center. The tour provided insights, allowing researchers to place themselves in the same environment as their users and gave a new perspective on their workflows.

An interview took place on March 8th, 2022, with Kirk McKinzie, a retired firefighter and smart technology consultant. Kirk answered the team's questions with a focus on current location-based technologies and handed over an immense number of resources. Due to the interview being shared with other research groups, the team's time with Kirk was limited but another interview was set up for Phase 3 for the team to gain more specific information.

A second Interim Report was written and delivered to the project client demonstrating continued progress towards project objectives. The focus of the second phase was to gain a greater understanding of the users, such as the different personalities of incident commanders

as well as their goals, values and needs. An affinity map, empathy map, and two personas were created, helping to tighten the focus of the project. These artifacts are expected to guide the effort going forward by providing future design teams information about their users.

Phase 3

The third phase of the project began with an interview with Kirk Mackenzie. Kirk provided the team with insights into current products related to incident command and control, situational awareness, and future technology adoption. The team learned that situational awareness is the biggest challenge faced in incident command situations to date and that tracking capabilities would offload current complexities significantly.

The team conducted an interview with Chief Jacob Spence in which Spence described pain points of the Civil Unrest of 2020. This was an emergency that he deemed particularly difficult to manage. Based on the interview, the first storyboard and scenario set were created to visualize the use case for AR Incident Command technology. These deliverables serve to highlight problem areas Incident Commanders deal with because of communication issues. The team also created a Project Update Presentation which captured their key successes, key issues, and next steps.

The first draft of the dynamic prototype was then completed. This prototype served as conceptualization of past research and designs to get an idea of what an augmented reality interface would need for incident commanders. The team conducted an additional interview with Chief Spence to review the current prototype and receive feedback on data he would like to see. These insights culminated into 2 additional scenarios and storyboards.

The group had previously planned to create an experience map to demonstrate their findings towards the end of this phase. The group decided to instead create a Journey Map because they felt it would better highlight their findings. This deliverable was moved to the next phase as its timeline positioning made it difficult to adjust to before the next interim report.

All other deliverables were completed successfully with the overall focus of the third phase being to gain enough knowledge from subject matter experts to highlight the use cases for the AR technology within incident command. A third Interim Report was written and delivered to the project client demonstrating continued progress towards project objectives.

Phase 4

The fourth phase of the project began with a focus on creating a journey map to properly visualize the experience of what incident commanders will go through as they perform tasks while using AR technology. This exercise was valuable as it easily illustrated how the technology and design impact the user's experience. It can be used to help the future UX designers of this project empathize with the users. This journey map was split into two sections, the old system journey map without AR technology, and the new system journey map including AR technology.

In addition to the journey map, the team also worked on their dynamic prototype. The prototype is based on the culmination of research collected throughout the project term and data collected through interviews and feedback from subject matter experts. Prototype screens were mocked up to influence the design of the prototype and many meetings were conducted to discuss their development. Other deliverables that were previously planned during this 4th phase had to be canceled as discussed below, so the team decided to expand upon the original plan for this prototype.

The group had previously planned to prepare a tree test to help find any usability issues within the interface of the dynamic prototype. After some reflection, the group decided to not create the deliverable because as the focus of this project is to discover UX requirements for implementing AR technology in Incident Command, there is not enough of a finalized prototype to properly layout full information architecture as tree-testing requires.

The group had also planned to conduct another interview with Chief Jacob Spence to go over the status of the dynamic prototype and get his feedback on anything that needed to be changed. Chief Spence did not respond to the team's communications however and as a result, the team had to move forward without his feedback. They conducted additional internal feedback sessions to address as many potential concerns as possible based on their knowledge.

To conclude this phase and overall research process, a presentation was created in addition to this final report to wrap up the team's involvement in the project. All the deliverables completed throughout this process will serve to inform the client on the project as a whole, as well as work as a handoff to the future team who will continue the project in its next steps.

Introduction

The Indiana University Crisis Technologies Innovation Lab (IU CTIL) is exploring the design of an augmented reality system that will enhance the workflows of incident commanders as well as other first responders. The team was tasked to research current design systems of similar nature, discuss current pain points with key stakeholders, demonstrate their findings through project deliverables, and establish requirements for a future system.

The goal for this project's future is to implement a system that improves the current incident command workflow. Current research has already proven that augmented reality is a viable asset in specific industries. The team utilized research and insights gained through interviews while incorporating best practice user experience methods.

The goal was to uncover what incident command operators would want to see in a futuristic and augmented reality-based environment. The team defines the value of real-time location tracking and asset management during emergency incidents by utilizing interviews and secondary research to empathize and understand current systems in place.

This report features a detailed overview of their project goals, a description of the methods used, key findings, and recommendations for future teams moving forward with this work. All of these efforts culminated in the creation of a robust and dynamic hi-fidelity prototype to prove various concepts and design system feasibility.

The Project Goals

The overarching goal of the project was to accurately conceptualize and recognize the user experience in augmented reality for incident commanders in order to:

1. Understand the current workflow of incident commanders in emergencies

- a. Focusing on the current toolsets being used, the steps taken to accomplish tasks, finding the data and information necessary to achieve goals, and other potential cognitive processes involved
- b. Understanding AR is secondary—this is not our focus when receiving user feedback
- c. Attempt to identify and fix pain points that incident commanders currently experience when responding to emergencies

2. Learn what smart-tracking or indoor location-tracking interfaces and ideas would benefit incident commanders

- a. Investigate the data that is useful to the incident commander and determine how detailed it needs to be
- b. Discover the usefulness of their current toolset and how future effort can iterate and improve upon the incident commander's productivity and flow
- c. Explore what information is currently available for an incident commander during an emergency and uncover any unknown data points that would be beneficial

3. Investigate the use of location-tracking and other techniques to assist in workflow enhancement

- a. Demonstrate the value of highly accurate location-tracking in workflows
- b. Validate the use of AR in these settings to assist with situational awareness and decision making
- c. Research if AR can assist current incident commander workflow regarding role assignment, asset management, and resource allocation with a heavy emphasis on location-tracking

4. Research the benefits of augmented reality interfaces and controls when creating common operational pictures (COP)

- a. Identify current processes, designs, and tasks that COP applications utilize
- b. Explore tools that handle COP workflows and understand why or how they deliver experiences for their users
- c. Investigate the addition of AR within these interfaces and tools to verify advantages and disadvantages
- d. Discover if modern AR concepts have enhanced experiences for their userbases, particularly for indoor location-tracking, command and control, and other similar situations, such as emergency response

5. Gather enough ideas and concepts to easily hand-off user interface requirements to an external development team

- a. Prepare UX design criteria with AR techniques at the forefront
- b. Create workflows for designers and developers to build and materialize
- c. Deeply understand user workflows and how AR would best fit within them
- d. Design AR specific features and functionality at a prototyping level
- e. Find the high-value tasks in incident command workflows and capture them accurately for AR experience purposes

Description of Methods

For each of our project goal's success, we completed multiple activities and deliverables. The efforts ranged from collecting various sets of data and research, conducting interviews with multiple subject matter experts, developing documents that will help the next team understand what users will require in their workflows and tasks, and creating a hi-fidelity and interactive prototype to help conceptualize the proposed AR design system.

1. Interviews with subject matter experts

- a. Conducted seven (7) interviews
- b. Initial interview was used to gain a high level understanding of the problem space and gain further insights that helped clarify the scope of the project (Appendix A)
- c. Goal of the second interview was to define specific traits of Incident Commanders such as their approach to work, their values, their needs, and their workflows so as to gather enough qualitative data that could be used for persona development down the line. (Appendix B)
- d. Third interview was a tour of the IMPD Incident Command center which gave a real-world example of current IC workflows and communication patterns. (Appendix C)
- e. Fourth and fifth interviews helped to obtain information about current technologies being used by first responders, as well as how AR can improve the work of future firefighters. (Appendix E and Appendix I)
- f. Sixth interview focused on scenario and storyboard creation. The SME gave us an in-depth description of a real-life scenario which helped with identifying a key scenario for the design team to pinpoint areas of opportunity for the AR tool to assist. (Appendix J)
- g. Final interview was a walkthrough with a SME of the current progress of the dynamic prototype. We received feedback and identified further key features the AR tool would need. (Appendix M)

2. Affinity map

- a. The affinity map helped to organize findings, ideas, and pursue concepts uncovered throughout the project (Appendix D)
- b. Assisted in defining common themes through qualitative data gathered from the informal interviews conducted. This data was used to help create personas that will enable designers to greater empathize with the future end users

3. Empathy map

- a. Served to gain further insight into Incident Commanders and what they may be thinking or feeling while performing their job. (Appendix F)
- b. Also worked as a stepping stone for creating and fleshing out two personas

4. Persona development

- a. Two (2) unique personas were developed (Appendix G and Appendix H)

- b. Established two main user groups: younger Incident Commanders who are willing to learn and use advanced technologies (“The New Guy”), and seasoned Incident Commanders who are competent in their current workflows and more reluctant to use new and advanced technologies (“The Old Dog”).
- c. These personas will help future developers understand the types of users that are envisioned to use this technology and help guide their team in the right direction

5. Scenarios and storyboards

- a. To help designers visualize the use cases for the system additional scenarios and storyboards were created.
- b. The second and third scenarios (Appendix L and Appendix N) highlighted the use cases of AR Incident Command technology and how it addresses communication issues in the workflow of incident commanders. One scenario showcases a civil unrest incident, and the second showcases a large fire incident that requires indoor location tracking of personnel.

6. Journey Map

- a. Two (2) journey maps were created (Appendix O and Appendix P)
- b. Created for the purpose of helping designers visualize and empathize with the Incident Commanders’ journey of performing tasks while using the AR tool.
- c. The first journey map illustrates the current commander workflow and emphasizes the pain points in the current process, as well as emphasizes areas of opportunity for the AR technology to improve the workflow.
- d. The second journey map illustrates a new workflow using the AR technology. It serves to show how it addresses plainly identified pain points.

7. Concept Art

- a. Conceptualized design layout in an easy to understand format for less tech savvy users. (Appendix Q)
- b. Provided additional design direction for prototype development in a quick and flexible manner.
- c. Initial direction was focused on creating the most major aspects of the design as that was initially all the team had planned to do, but with the cancellation of a few other deliverables during this phase, the team was able to continue into more minor aspects of the design.

8. High Fidelity and Interactive Prototype

- a. Helped to conceptualize a design system for AR in Incident Command based on the cumulative research. (Appendix R)
- b. Uses 3D models to add a level of detail beyond basic 2D symbology.
- c. Showcases a potential design for collaboration, resource management and live location tracking addressing major pain points.
- d. Can act as a step towards the development of an actual product thanks to realistic user interactivity and feedback.

The Key Findings

One of our research goals was to define the value of **real-time location tracking** and **asset management**. To understand the value, we first needed to understand the current landscape of incident command. Through our research, we learned that situational data changes rapidly and current technologies, such as radios and telephones, cannot adequately support incident commanders in forming an up-to-date and accurate mental model of a given scenario. The data they receive is often difficult to translate and can even be contradictory. For example, when interviewing Chief Spence about his account of a Civil Unrest Incident in Indianapolis in 2020, he described receiving early data from boots-on-the-ground field workers about the size of crowds, with some describing groups of 50 people, while others describing groups as large as 250 people. Synthesizing contradictory audio data impedes significant cognitive load in Incident Commanders and most importantly, often cannot depict a scene perfectly.

Another research goal of ours was to **discover how augmented reality could improve situational awareness and decision making**. Fundamentally, augmented reality could enable commanders to access a clear vision that is representative of the current scenario at hand for which they are commanding. Data could be visualized in a way that represents the real world, and therefore require less time be spent cognitively processing the information, thus facilitating the faster generation of contingency plans and increased responsiveness to unexpected variables in incidents. Most importantly, displaying visual data in a way that reflects the real world with augmented reality reduces the opportunity for miscommunication among collaborators and truly facilitates the formation of a common operating picture in the most efficient manner. Augmented reality tools could potentially facilitate remote collaboration, which we learned has recently become more common among large-scale incident command operations as a result of COVID. The current technologies commanders utilize are outdated and limited in what they can show; a visual depiction of data gathered at an incident would improve collaborative efforts through reduced time spent conversing to form a common operating picture.

Pain Points in Current Landscape of Incident Command

1. **Situational awareness** is one of the biggest problems in current incident command systems. There is a gap between what commanders know and what is happening. Lives and property are lost in a flash because of this time difference.
2. The ability to track **triage status, civilian and responder health**, as well as calling in **additional resources** are activities that are extremely complex currently but would benefit from being offloaded to technology that is intuitive.
 - a. There are **opponents to this technology** being added to workflows that have remained constant over the years. However, this “**technical revolution**” will be happening no matter what as these technologies and applications become commonplace among **civilians and responders** alike. What matters is how we

can frame the experience to bridge that gap while also incrementally adding features along the way.

Augmented Reality Tool Feature Requirements

1. By focusing on **3D models**, the product can add a level of detail unmatched with standard 2D **symbology**. All actionable resources, structures, and areas of operation are represented in three dimensions to improve situational awareness
2. To properly allow **collaboration** among multiple levels of the incident command system, tools that each user can manipulate should be added. These features could allow commanders and other personnel to **draw out planning ideas, shapes, and even place symbols** detailing updates from on-the-ground personnel.
3. Controls to allow users to **focus** on certain parts of each structure should be added to help commanders achieve their ultimate objective: **know where all their resources are at all times**, especially in a multi-level structure. This feature was pleaded for when interviewing every subject matter as it was one of their top problems that needed a solution.
4. Each interactable unit, vehicle, and structure will tap into **camera feeds** that will eventually be accessible by public organizations. With this functionality, the commander can get an idea of what's happening in front of these resources and plan accordingly. This will also allow commanders to **work in remote posts** but understand what's happening through **video**.
5. **Resource management** was another highly requested feature. This feature will allow users to easily find **assets and resources on the map**, no matter how large the area of operation is. The goal with creating controls like this will be to provide a **common operating picture** for those who need it when providing emergency services.
6. Visually display a **3D map** of a small area to demonstrate the distribution of threats, field workers, resources, civilians, and areas of operation across the **X, Y, and Z-axis** to provide the operators with a situational awareness of the incident
7. Standards should be pushed that are **agnostic and ubiquitous** to allow for all devices, sensors, and software to easily combine and work together. This concept (and a long road ahead) will help users **adopt and become acquainted** with software and devices that are familiar to them, both in design and experience.
8. Facilitate the display of available resources and assets, along with their status and other important information
 - a. Provide details about **resources**, such as individual **units**,

- vehicles**, and even air assets like **helicopters** or **drones**
 - b. If available, **streaming cameras** attached to a unit can help the incident commanders place themselves at the scene
9. Reflect updates **real-time** from data gathered at the incident
10. Provide a **thermal imaging** setting to visually show **thermal mapping**
11. Display **weather data**
- a. Wind direction
 - b. Precipitation patterns
 - c. Humidity
12. Provide **indoor-location data**
- a. Identify where resources are located
 - b. Identify collapsed areas or threats within an area
13. Enable **remote collaboration**
- a. Multiple users can collaborate in the same environment without needing to be in the same room
 - b. Users must have the ability to see exactly what another user is seeing from their perspective to facilitate a **common operating picture**
14. Support users in **mapping out plans** before executing
- a. Placing staging areas, barricades, and placement of task forces and resource
 - b. Allow multiple users to collaborate on the same plan
 - c. Add drawing capabilities, using lines, points, and polygonal graphics
 - d. Support users in **executing a contingency plan**
 - e. Make updates to plan real-time in response to scenario
15. Provide **direct messaging** and **group messaging**
- a. Can avoid overloading audio communication by adding chat communication
 - b. Support **benchmarking** during operation execution
 - i. Visually signify completed and pending benchmarks within the interface
 - ii. Maintain a clutter-free, simple, and easy to read interface
 - iii. **Filtering views** may be necessary to achieve this, so all data isn't visible at one time
16. Visually display
- a. **Crowd** placement and volume

- b. Where **911 calls** are coming in from
 - c. Where **critical infrastructure** is
 - d. Where **resources** already placed / need to be placed
 - e. Data about incoming and current **weather**
 - f. Traffic patterns
17. Provide the **ability to place waypoints / incident markers** in the interface and map out a plan before executing it.
18. Utilize **standardized iconography** that is recognized and used by multiple federal agencies, we can help bring multiple agencies together with recognizable symbolism.

Recommendations & Next Steps

We believe that future teams moving forward with this project should:

1. Consider Iterative Progress

- a. First and foremost, the team found that big jumps in technology in this space have often proven unsuccessful.
- b. As a result, smaller steps should be incrementally introduced through the design system instead of huge leaps in technology.

2. Witness the Incident Command Process In-person

- a. The team did not have the opportunity to witness incident commanders or an emergency situation in person due to the COVID-19 pandemic.
- b. They do believe that this would be beneficial to future teams to witness and would encourage them to participate in such activities.

3. Continue to Utilize Standardized Iconography

- a. Using this iconography can help bring these agencies together with recognizable symbolism.
- b. It also makes the learning barrier lower for more seasoned incident commanders.
- c. The iconography used by the team has been developed by the [National Alliance for Public Safety GIS Foundation](#)

4. Maintain Focus on Using 3D Models

- a. 3D models add a level of detail unmatched by standard 2D symbology.
- b. They insure all actionable resources, structures, and areas of operation are represented more accurately and improve situational awareness

5. Augment Users Capabilities by Providing Additional System Tools

- a. To properly allow collaboration among multiple levels of the incident command system, tools that each user can manipulate need to be added.
- b. These features should allow commanders and other personnel to draw out planning ideas, shapes, and even place symbols detailing updates from on-the-ground personnel.
- c. This allows commanders to constantly be updating the system and communicate to other commanders what is going on during a situation

6. Provide Users Building Controls

- a. Controls to allow users to focus on certain parts of each structure should be added to help commanders achieve their ultimate objective: know where all of their resources are at all times, especially in a multi-level structure.
- b. This feature was pleaded for when interviewing every subject matter as it was one of their top problems that needed a solution.

7. Supply Resource Management Capabilities

- a. The prototype should continue to demonstrate the use of this functionality after researching external competition that use similar interfaces and experiences.
- b. This feature should allow users to easily find assets and resources on the map, no matter how large the area of operation is.
- c. The ultimate goal with creating controls like this will be to provide a common operating picture

8. Tap into Live Video Feeds

- a. Each interactable unit, vehicle, and structure should tap into camera feeds that will eventually be accessible by public organizations.
- b. With this functionality, the commander can get an idea of what's happening in front of these resources and plan accordingly.
- c. This will also allow commanders to work in remote posts, but understand what's actually happening through the eyes of their commanders and other Internet of Things Devices.

9. Cross Department Connection and Collaboration

- a. To best facilitate the organization process of first responders, incident commanders across different firefighter, police, and medical departments should be able to access the information input by different departments.
- b. This collaboration would augment the communication necessary for incident commanders to do their jobs even further.

10. Identify Competition Offerings that Target Civilian-based Industries

- a. Currently, there isn't much being offered to the public regarding augmented reality and its role in command and control systems.
- b. The line of software named "ATAK" has provided an excellent entry for civilian and public service organizations to receive a common operating picture across all levels of leadership due to a low-cost barrier of entry
- c. Another product, named "ARTAK", is also being demoed and offered to military groups within the United States and could provide a clearer picture of how augmented reality concepts fit within the incident commander role
- d. Our team recommends to follow, listen, and learn from influencers and leaders on social media that are involved with geographical information systems, 3D mapping technologies, and smart technologies involved with public service

Conclusion

The team learned through their journey that first responders, especially those in the incident command space, have heavy workloads. The workflows and systems currently in place are rich with information and communication, but aren't without errors. They found through their research that incident commanders incorporate many different technologies in their workflow, all of which lack adequate communication pathways.

These insufficient methods of communication often make it difficult to form an accurate understanding of the overall picture of an incident. As a result, commanders lack the ability to make quick and informed decisions which in the worst situations, can cost lives. Augmented reality provides a solution to this problem space by providing effective communication pathways. This results in incident commanders being able to utilize the best possible strategies for resolving an incident each and every time.

Incident command currently operates with limited and dated technology. It is imperative going forward that technological advancements are made to support their workflows. Future technology improvements, especially augmented reality, can be developed to improve the accuracy of commander situational awareness with a real-time visual presentation of time-sensitive data.

Augmented reality can be used to decrease the time spent communicating with audio devices and systems by shortening information processing through the use of a visual-spatial interface. This technology can provide real-time data, thereby increasing the efficiency of generating contingency plans. Remote collaboration can be facilitated with augmented reality to form a common operating picture among correspondents by enabling commanders to view the same data concurrently.

Our belief is that augmented reality interfaces and controls can assist in streamlining emergency responses. The use of innovative technology and modern concepts creates a future system that's both effective and vigorous. First responders and other emergency personnel place their own lives on the line every day to assist the general public. We hope the future of this work results in saving the lives of many people and supports those who keep us well protected.

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Appendix A: 1st Interview with Dale Rolfson

[Dale Rolfson Interview 1, Full Video - 02_11_2022](#)

[Dale Rolfson Interview 1, Protocol - 02_11_2022](#)

[Dale Rolfson Interview 1, Notes - 02_11_2022](#)

[Dale Rolfson Interview 1, Additional Discussion Video - 02_11_2022](#)

Appendix B: 2nd Interview with Dale Rolfson

[Dale Rolfson Interview 2, Full Video - 02_25_2022](#)

[Dale Rolfson Interview 2, Protocol - 02_25_2022](#)

[Dale Rolfson Interview 2, Notes - 02_25_2022](#)

Appendix C: IMPD Tour and Interview, Dale Rolfson & Jacob Spence

[IMPD Tour and Interview, Audio Recording - 03_02_2022](#)

[IMPD Tour and Interview, Audio Transcription - 03_02_2022](#)

Appendix D: Incident Commander Affinity Map

Incident Commander Affinity Map - 03_03_2022

Personality	Values	Goals	Approach to Work	Needs
Calm and collected disposition  To avoid a mess by being external	Respect for seniority and heirarchy  Highest ranking chief  chain of command  "rookie"  25+ years of experience	Commanders aim to minimize harm as quickly as possible  save more lives and property  faster mitigation of incident  better survival  Saving AT&T Same here	They use various tools that support collaboration and shared awareness  Laptop / tablet  Command board  What's inside our pouch  Social media websites for sharing information	There is a need to form a unified mental model among remote commanders and field workers
Prefers consistency in workflow structure  They prefer consistent workflow structure	Polarized affect towards technology  Computer monitor with multiple windows  Smart phone with multiple notifications  Laptop with multiple tabs open	They seek to gather as much situational awareness as possible  Situational Awareness  Don't know exactly what's going on	They are very process oriented  tactical decisions  managing personnel  get on the defensive  increase of risks associated with increased complexity  implement strict protocols and procedures  Two in two out rule	Communication - there must always be an open line to communicate efficiently
Needs are not often recognized  Incident commander not often recognized  Being the last to receive recognition	  large-scale incidents  managing multiple resources simultaneously	They are responsible for supporting large events  managing multiple resources simultaneously  large-scale incidents  managing multiple resources simultaneously	They collaborate with their team to coordinate and distribute resources  coordinate resources  considering outcomes  ensure that all the resources are available  managing multiple resources simultaneously	Time - time is a valuable resource. Actions should be completed as soon as humanly possible  try to prioritize tasks  radio traffic  communicate with others  expressive language  target event of the day immediately  prioritize tasks  communicate with others  expressive language  target event of the day immediately  time is key  prioritize tasks  communicate with others  expressive language  target event of the day immediately

Affinity Map - March 3rd, 2022

Appendix E: 1st Interview with Kirk McKinzie

[Kirk McKinzie Interview 1, Full Video - 03_08_2022](#)

[Kirk McKinzie Interview 1, Protocol & Notes - 03_08_2022](#)

[Kirk McKinzie Interview 1, Zoom Chat - 03_08_2022](#)

Appendix F: Incident Commander Empathy Map

Incident Commander Empathy Map - 03_10_2022



Appendix G: Incident Commander Persona, “The New Guy”

Incident Commander Persona, “The New Guy” - 03_13_2022

Norm The “New Guy”



“How can we save lives if we don’t use the best technology? We need to update our systems!”

Age: 25 years old
Job Title: Incident Commander
Education: Bachelor's Degree
Experience: 6 months

Personality:

- Level-headed
- Lively
- Alert
- Serious
- Approachable
- Kind
- Innovative

Goals:

- Minimize harm among civilians
- Communicate effectively across departments
- Acquire optimum situational awareness
- Use resources as efficiently and effectively as possible

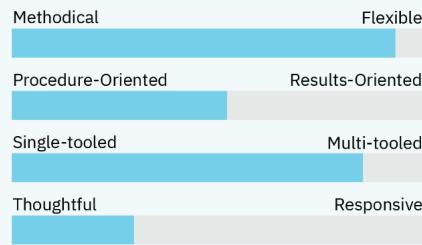
Motivations:

- Desires to grow their skills and advance in their career
- Wants to acquire advanced tools and technologies to better response time
- Using any means possible to save as many lives as possible

Frustrations:

- Does not always feel listened to by higher-ups
- Relies on radio communication to gain a clear picture of an emergency scenario
- Delays in communication hinder situational awareness

Approach to Work:



Needs:

- Advanced Technology - tools that utilize the latest technology to enhance situational awareness
- Open Communication - seconds wasted by an occupied radio can cost lives
- Responsiveness - optimize response times

Values:

- Respect those with greater tenure but wants to push them to achieve higher standards through technology
- Wants to have confidence in the fact that he is doing absolutely everything he can for the people he is trying to help

Appendix H: Incident Commander Persona, “The Old Dog”

Incident Commander Persona, “The Old Dog” - 03_13_2022

Oliver The “Old Dog”



“Technology reliance only causes problems. We’re better without it in the end”

Age: 57 years old
Job Title: Lead Commander
Education: High School
Experience: 27 years

Personality:

- Composed
- Stoic
- Decisive
- Parental
- Honest to a fault
- Reliable
- Respectful

Goals:

- Doesn’t want to be phased out before retirement
- Maintain confidence so they can continue to lead their team
- Passionate about saving lives and property

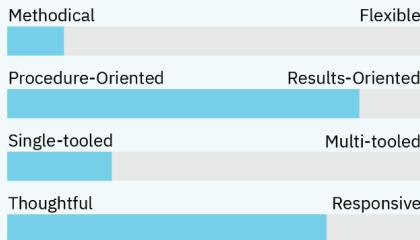
Motivations:

- Wants to ensure the safety of their team as they respond to incidents
- Wants their team to trust them and to appear as a strong confident leader
- Cares about saving lives and property within the community he serves

Frustrations:

- Thinks learning a new computer system will slow them down or cause harm if they make mistakes
- Doesn’t like new technology. Is not convinced it is accurate, stable, or reliable
- Worried that rookie commanders will not know how to function should the new technology crash

Approach to Work:



Needs:

- Intuitive usability – needs a system that works as quickly and reliably as their brain
- Education – learning how a new system works
- Comprehension – needs proof of improve outcomes
- Confidence – lack of system failure

Values:

- Proud of their past accomplishments, but never forgets the result of a poor call
- Honors the well-established procedures as they’ve proven successful
- Doing things the easy way versus trying to fix what isn’t broken

Appendix I: 2nd Interview with Kirk McKinzie

[**Kirk McKinzie Interview 2, Full Video - 03_22_2022**](#)

[**Kirk McKinzie Interview 2, Protocol & Notes - 03_22_2022**](#)

Appendix J: 1st Interview with Jacob Spence

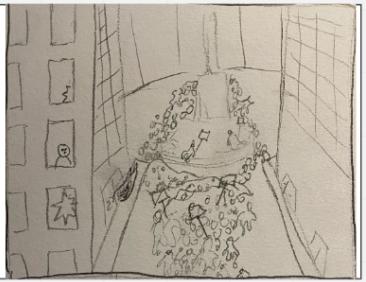
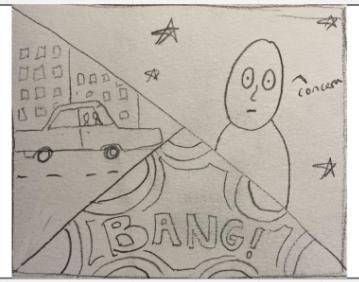
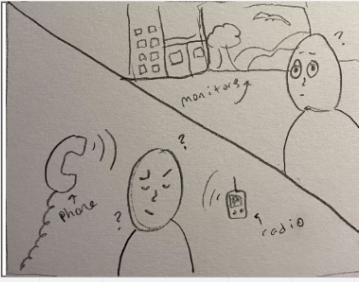
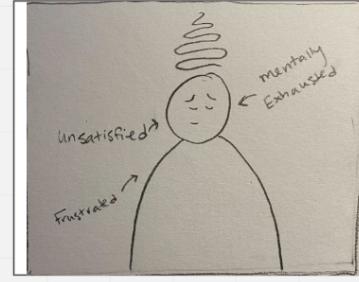
[Jacob Spence Interview 1, Full Video - 03_25_2022](#)

[Jacob Spence Interview 1, Protocol & Notes - 03_25_2022](#)

Appendix K: “Civil Unrest” Scenario and Storyboard

[Civil Unrest Scenario - 03_29_2022](#)

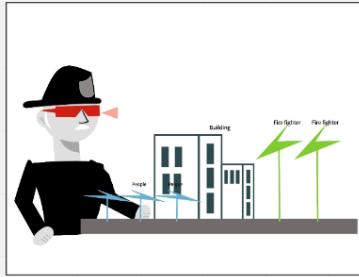
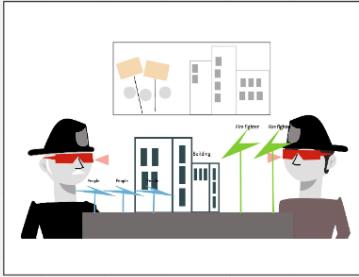
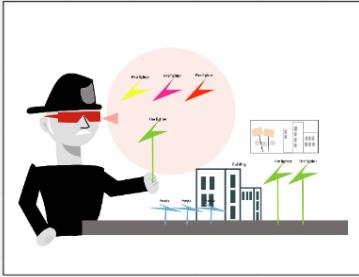
[Civil Unrest Storyboard - 03_29_2022](#)

				
Trigger Action Reports of large crowds and property damage come in	Discovery Looking for Inspiration Discovers danger and relocates	Journey Step Action Gathering contradictory audio data/limited visual Data	Journey Step Action Time wasted conversing with other Commanders to form COP	Conclusion Less than Satisfactory Ending Civil unrest mitigated but operation execution was high-stress and likely non-optimal
Who Emergency Management Division at the Metropolitan Emergency Services Agency	Who Chief Jones and Deputy Meijers	Who Chief Jones	Who Chief Jones and IC's and IFD, IMPD, and EMS	Who Chief Jones and IC's and IFD, IMPD, and EMS
Where Indianapolis	Where On the scene downtown	Where Incident Command Center	Where Incident Command Center and remote calls	Where IC Center and Indianapolis
What The EMD is made aware there are large crowds amassing downtown and property damage has begun to accrue	What Chief Jones attempted to size up the scenario but quickly realized the unsafe nature of it. He is shot at and immediately leaves the scenario.	What Back at the Incident Command Center, Chief Jones attempts to form a clear mental picture of how the scenario is developing by listening to radios and receiving limited visual data from drones.	What Chief Jones wastes time conversing with fellow commanders when trying to form a common operating picture before they can create a contingency plan. They experience technical difficulties over zoom due to poor internet connections.	What Though the civil unrest was mitigated, the commanders experienced many communication errors through the operation that they anticipate could have

Appendix L: “Civil Unrest with ICAR Tool” Scenario and Storyboard

[Civil Unrest with ICAR Tool Scenario - 04_03_2022](#)

[Civil Unrest with ICAR Tool Storyboard - 04_03_2022](#)

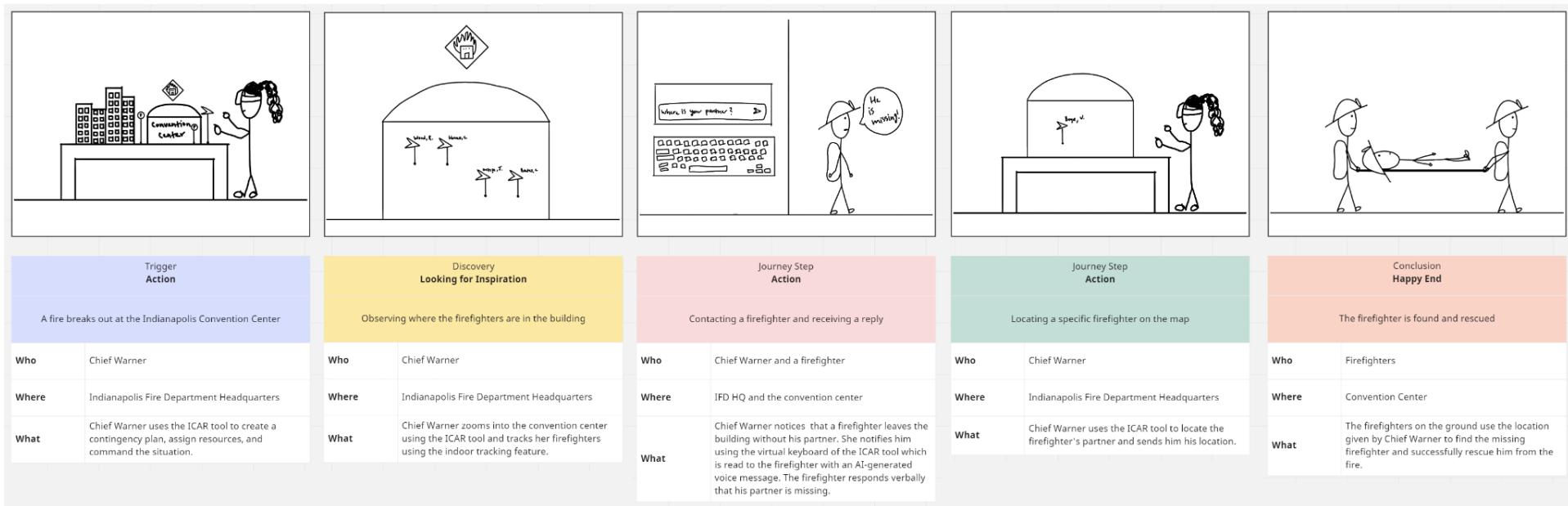
				
Trigger Action "A crowd is forming, and Robert needs to assess the situation"	Discovery Looking for Inspiration "In an instant, he is able to see a 3D rendering of the city of Indianapolis"	Journey Step Action "Fellow commanders are able to see the same map with the same real-time data live"	Journey Step Action "Placing virtual symbolic components that represent task forces"	Conclusion Happy End "Robert is able to collaborate with fellow commanders"
Who Chief Robert Jones Where Night Downtown Indianapolis What Places his ICAR (Incident Command Augmented Reality) Tool over his eyes and slips the corresponding haptic feedback gloves over his fingers	Who Chief Robert Jones Where In the command center What Zooms in using his fingers to identify where the crowds of people are beginning to amass	Who Chief Robert Jones with other commanders Where In the command center What Connects with other commanders to establish resources	Who Chief Robert Jones with other commanders Where In the command center What Add resources on the map and creates a plan	Who Chief Robert Jones with other commanders Where In the command center What The fellow commanders collaborate with Jones in this effort

Appendix M: 2nd Interview with Jacob Spence

Jacob Spence Interview 2, Protocol & Notes - 04_01_2022

Appendix N: “Managing the Civil Unrest and Unexpected Fire Emergency with ICAR Tool” Scenario and Storyboard

[Managing the Civil Unrest and Unexpected Fire Emergency with ICAR Tool Scenario - 04_03_2022](#)
[Managing the Civil Unrest and Unexpected Fire Emergency with ICAR Tool Storyboard - 04_03_2022](#)



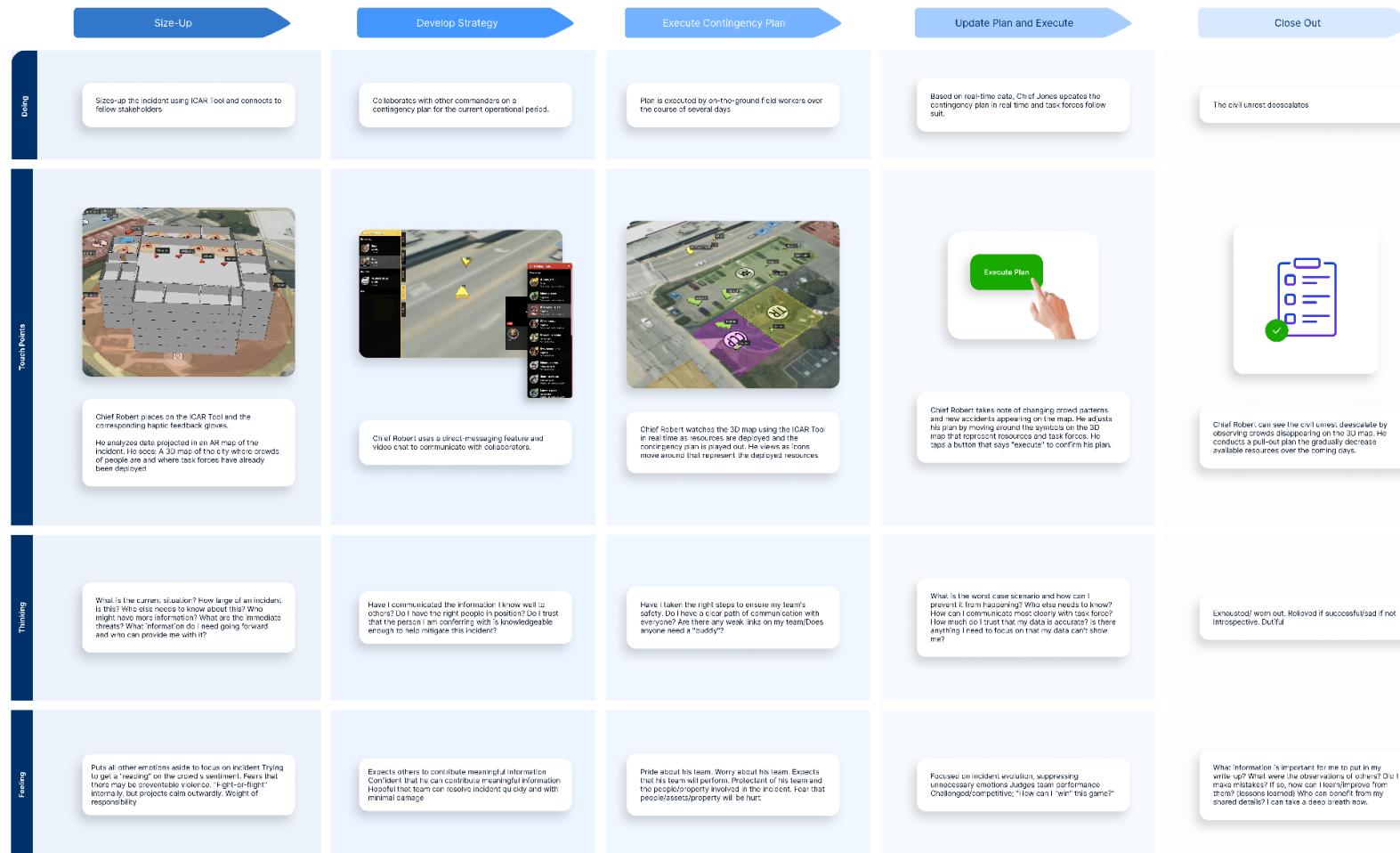
Appendix O: Incident Commander “Old System” Journey Map

Incident Commander "Old System" Journey Map - 04_24_2022

Civil Unrest		Expectations			
Stages	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Doing					
Doing	hears about situation	asks for crowd info	collaborating with other commanders	communicating with resources on the ground	A command system is set in place for on-going communication. After so many days, the incident is under control.
Touch Points	Chief Robert receives info from a situation. <ul style="list-style-type: none"> Radio Sometimes Police scanner 	Chief Robert goes to command center. Now has access to <ul style="list-style-type: none"> Computers Phones TV (News feeds) 	Chief Robert collaborates with other officers in office and onsite. <ul style="list-style-type: none"> Phones Computers TV (News feeds) Cell phones 	Chief Robert collaborates with first responders onsite <ul style="list-style-type: none"> Phones Radios Computers TV (News feeds) Cell phones 	Chief Robert maintains the situation using. <ul style="list-style-type: none"> Phones Computers TV (News feeds) Cell phones
Thinking	<ul style="list-style-type: none"> What is the situation right now? Where are crowds forming? What resources are currently out in the field? 	<ul style="list-style-type: none"> Are crowds getting out of control? Where are the crowds forming? Where do we need to position our resources? 	<ul style="list-style-type: none"> What information do other departments have that I don't yet? Am I not seeing the full picture? What can we do to best protect people? 	<ul style="list-style-type: none"> Where are my trucks at? What are my people on the ground doing? Has crowd control been working? 	<ul style="list-style-type: none"> How can we have better communication in the future? I wish I had known all of the information sooner
Feeling	<ul style="list-style-type: none"> Questioning - don't know all the facts yet Worried - don't want the situation to get out of hand Determined - ready to get to work 	<ul style="list-style-type: none"> Unsure - can't make a decision without all the facts first Apprehensive - hoping things don't get worse 	<ul style="list-style-type: none"> Tense - reports coming in are not looking good On Edge - don't have the full picture yet Unsure - want to make the best decisions possible 	<ul style="list-style-type: none"> Weary - this incident is accelerating too quickly Nervous - worried about the people in the field Frustrated - want to make sure this goes in a good direction 	<ul style="list-style-type: none"> Relieved - glad the incident has ended Encouraged - everyone did their best in managing the incident

Appendix P: Incident Commander “New System” Journey Map

Incident Command "New System" Journey Map - 04_29_2022



Appendix Q: Prototype Concept Art

[Prototype Concept Art 1 - 04 24 2022](#)

[Prototype Concept Art 2 - 04 24 2022](#)

[Prototype Concept Art 3 - 05 02 2022](#)

[Prototype Concept Figma File - 05 02 2022](#)

The image shows a prototype concept art for a mobile application or dashboard. On the left, a sidebar lists 'Officers' (Allison, K. Captain, Landmark Center - Floor 5; John, D. Captain, Landmark Center - Floor 5), 'Vehicles' (LD14 Ladder Truck, Fire Staging Zone; LD23 Fire Truck, Landmark Center - Main Entrance), and 'Other' (DR100 Video Drone, The Landmark Center). The main area has tabs for FIRE, POLICE, MEDICAL, and PUBLIC WORKS, with FIRE selected. The FIRE tab displays an aerial view of a building on fire with a 'LIVE' feed from DR100. Below the feed are status indicators for the DR100 drone: 100% ping, 56% battery, 1 gallon water, and signal strength. It also shows status for LD14: 88% full O₂ Oxygen, 25 gallons gas, and 100 gallons water. At the bottom, there's a 'FIRE EMERGENCY' alert for Allison, Kenneth's body temperature is getting dangerously high, with a 'click to view' link. A legend on the right shows icons for Search, Add Marker, and Draw Zone. An inset map shows the layout of 'The Landmark Center' with various emergency points marked.

Appendix R: Dynamic Prototype

[Web-based Dynamic Prototype \(Recommend Google Chrome\)](#)



Appendix S: Interim Report #1

Interim Report #1 - 02_23_2022

Appendix T: Interim Report #2

Interim Report #2 - 03_14_2022

Appendix U: Interim Report #3

Interim Report #3 - 04_04_2022

Appendix V: Interim Report #4

Interim Report #4 - 04_25_2022

Appendix W: Project Definition and Scope

Project Definition and Scope - 05_03_2022

Summary of Project

The Indiana University Crisis Technologies Innovation Lab (IUCTIL) is in the process of developing an augmented reality (AR) design system that assists both incident commanders and first responders in resolving emergency situations in an efficient manner. The future innovations and use of AR within heads-up displays (HUDs) have already proven to be a viable asset in many hands-on industries. Utilizing research and data from interviews, cognitive analysis, and other user experience design techniques, we are looking to uncover what most incident command operators are wanting in a futuristic environment that incorporates the use of AR. Features, workflows, client requirements, and proper contextual user-centered design will be at the forefront of recommendations to a design and development team that will create prototypes. The anticipated research and work from this project will impact the following:

- Demonstrate the value of precise location-tracking, asset management, and other necessary data within incident commander workflows
- Demonstrate the value of using AR in emergency scenarios to assist with situational awareness and decision making while saving more lives compared to conventional measures
- Generate user interface and experience design criteria and requirements for an augmented reality interface
- Recommend a standardized interface and design restraints from requirements set by incident commanders and first responders

Incident command personnel will be the focus of this project; specifically, commanders that work directly with first responders. Understanding their workflows, problems, and goals will be paramount to our research on using augmented reality when performing duties.

The Project Goals

To accurately conceptualize and recognize the user experience in augmented reality for incident commanders, five (5) main goals have been defined:

1. Understand the current workflow of incident commanders in emergencies

- a. The current toolsets being used, the steps taken to accomplish tasks, finding the data and information necessary to achieve goals, and other potential cognitive processes involved
- b. Understanding AR is secondary—this is not our focus when receiving user feedback
- c. Attempt to fix problems that incident commanders have when responding to emergencies and propose solutions

2. Learn what smart-tracking or indoor location-tracking interfaces and ideas would benefit incident commanders

- a. Investigate the data that is useful to the incident commander and determine how detailed it needs to be
- b. Discover the usefulness of their current toolset and how future effort can iterate and improve upon the incident commander's productivity and flow
- c. Explore what information is currently available for an incident commander during an emergency and uncover any unknown data points that would be beneficial

3. Investigate the use of location-tracking and other techniques to assist in workflow enhancement

- a. Demonstrate the value of highly accurate location-tracking in workflows
- b. Validate the use of AR in these settings to assist with situational awareness and decision making
- c. Research if AR can assist current incident commander workflow regarding role assignment, asset management, and resource allocation with a heavy emphasis on location-tracking

4. Research the benefits of augmented reality interfaces and controls when creating common operational pictures (COP)

- a. Identify current processes, designs, and tasks that COP applications utilize
- b. Explore tools that handle COP workflows and understand why or how they deliver experiences for their users
- c. Investigate the addition of AR within these interfaces and tools to verify advantages and disadvantages
- d. Discover if modern AR concepts have enhanced experiences for their userbases, particularly for indoor location-tracking, command and control, and other similar situations, such as emergency response

5. Gather enough ideas and concepts to easily hand-off user interface requirements to an external development team

- a. Prepare UX design criteria with AR techniques at the forefront
- b. Create workflows for designers and developers to build and materialize
- c. Deeply understand user workflows and how AR would best fit within them
- d. Design AR specific features and functionality at a prototyping level
- e. Find the high-value tasks in incident command workflows and capture them accurately for AR experience purposes

These outlined goals will keep our focus and priorities on client requirements while delivering detailed recommendations about our target user base.

Expected Activities and Deliverables

For each of our project goal's success, multiple activities and deliverables have been identified. The efforts will range from collecting various sets of data and research, conducting interviews with multiple subject matter experts, and developing documents that will help the next team understand what users will require in their workflows and tasks.

1. Interviews with subject matter experts

- a. Conduct seven (7) or more interviews
- b. Initial interview will assist in further defining the scope of the project
- c. Second interview will target our users' workflows and understanding their wants, needs, and problems
- d. Third interview will help define persona attributes, needs, wants, and problems
- e. Fourth interview will be explicitly about task-analysis and investigating what works well, what doesn't work well, and what can be improved
- f. The fifth interview will be about reviewing all effort completed with an expert and assist with creating suitable scenarios and storyboards
- g. Two (2) interviews will be conducted with a subject matter expert who is involved in the augmented reality space and has an understanding of how AR can help ICS; may also get more industry connections from these interviews as well
- h. All interviews will attempt to help understand workflows of emergency personnel, information that is necessary or beneficial for the actual user, and conceptualize modern interfaces that can use AR to enhance experiences
- i. Visit in-person the various facilities that today's incident commanders will use when responding to emergency situations or large events

2. Persona development

- a. Three (3) unique personas will be developed
- b. Each persona will be idealized as personnel on different command levels in an incident command system hierarchy
- c. These personas will help future developers understand the types of users that are envisioned to use this technology and help guide their team in the right direction

3. Affinity map

- a. Using an affinity map will help organize findings, ideas, and pursue concepts uncovered throughout the project
- b. The affinity map will assist in defining common themes through qualitative data gathered from the informal interviews conducted. This data will be used to help create personas that will enable designers to greater empathize with the future end users

4. Empathy map

- a. An empathy map will guide us through visualizing our target users' behaviors and create a deeper understanding of their mindset

- b. An empathy map will facilitate a shared understanding of the users' needs and perspectives among the design team and client

5. Experience/journey map

- a. The experience of what the user goes through when accomplishing tasks and goals will need to be properly visualized through the use of an experience map
- b. The experience map will serve to illustrate the user's journey through an emergency scenario using AR technology. The map will be used by future designers to empathize with the users and recognize the key parts in the user's journey that are impacted by the design

6. Scenarios and storyboards

- a. Scenarios will help with predictions on user behavior while delivering potential experiences and interactions
- b. To help properly explain a journey (story) the user participates in, storyboards can give a visual representation. The story boards will be used to demonstrate the value of using AR technology to enhance situational awareness

7. Secondary literature review

- a. Reviewing previous research will uncover solutions and problems that other research teams have encountered. Some examples of this research include:
 - A framework for AR Usability Evaluation in the public safety communication research realm ([PSCR 2021: Augmented-Reality \(AR\) Usability Evaluation Framework for PSCR](#))
 - Presents grants and funding opportunities for AR in public safety communications research, as well as descriptions of ongoing projects ([PSIAP Augmented Reality \(AR\) Funding Opportunity](#))
 - Research portfolio for User Interface / User Experience work with the public safety community ([NIST User Interface/User Experience Research Portfolio](#))
 - Description of the CHARIoT Challenge in which participants built AR interfaces or IoT data emulators for first responder communications ([2020 CHARIoT Challenge: Advancing First Responder Communications](#))
 - A roadmap for planning public safety communications research ([Public Safety User Interface R&D Roadmap](#))

8. User Interface Requirements Document

- a. After analyzing tasks, feedback, and other requirements, a document will be created to help guide future development teams
- b. Various user interface designs that are proven necessary for the user will be recommended
- c. The document will contain research artifacts, such as the personas, empathy map, experience map, and more, to enable future designers to grasp the context for which they will be designing.

9. Dynamic Prototype

- a. Take previous researched design ideas, concepts, and interfaces to build out a prototype that can help incident commanders visualize a system
- b. The prototype would utilize feedback from subject matter experts and current design flows
- c. The prototype would also act as an “incremental” step towards a software solution that was built with incident command and emergency response in mind

The expected activities and deliverables will assist in developing a better understanding and thought process for the design and development team in their effort on creating viable features and prototypes.

The Project Timeline

Four Phases, January 31 – May 5

The expected timeline has been outlined for the next four months and broken out into individual phases. All actions and deliverables are tentative. If any changes or updates happen, the timeline will be refreshed accordingly.

PHASE 1 <i>January 31 – February 21</i>	
ACTIONS	DELIVERABLES
<ul style="list-style-type: none">● Continue reviewing secondary literature and researching applicable material● Perform interview with subject matter expert utilizing a developed protocol in collaboration with a different team● Update the project definition and scope from feedback given within interview and from client● Create the first interim report on success and failures for the project	<ul style="list-style-type: none">● January 31<ul style="list-style-type: none">○ Initial draft of Project Definition and Scope● February 11<ul style="list-style-type: none">○ Complete interview with Subject Matter Expert● February 21<ul style="list-style-type: none">○ Revised Project Definition and Scope● February 23<ul style="list-style-type: none">○ 1st Interim Report

PHASE 2

February 22 – March 15

ACTIONS	DELIVERABLES
<ul style="list-style-type: none">● Pursue a second interview with a knowledgeable candidate that can help define our future persona attributes, wants, goals, and problems● Invited to a tour of the IMPD's incident command center to get a better understanding of our user's environment● Develop an affinity map based off research and interview feedback● Connect with and interview with a leading expert in AR tech with an emphasis in incident command systems● Develop two (2) unique personas that are representations of users within an incident command structure● Develop an empathy map for each persona that targets four main areas: what things they are saying, thinking, doing, and feeling● Produce a second interim report and potentially update project definition and scope	<ul style="list-style-type: none">● February 25<ul style="list-style-type: none">○ Complete interview with focus on building personas● March 2<ul style="list-style-type: none">○ Tour of Incident Command Center● March 5<ul style="list-style-type: none">○ Affinity Map● March 8<ul style="list-style-type: none">○ Interview with AR subject matter expert● March 10<ul style="list-style-type: none">○ Empathy Map● March 13<ul style="list-style-type: none">○ Personas Document● March 14<ul style="list-style-type: none">○ 2nd Interim Report

PHASE 3

March 16 – April 6

ACTIONS	DELIVERABLES
<ul style="list-style-type: none">• Complete the second interview with the AR subject matter expert on more specifics with what is being fielded today• Complete interview to help develop scenarios and storyboards based on real incidents• Implement past research and development of augmented reality design systems in a rough dynamic prototype• Based off interviews and research completed this phase, produce scenarios and storyboards that help conceptualize the incident command workflow in AR• Create a presentation detailing key success, key issues, and next steps for peers to present feedback• Produce a third interim report and potentially update project definition and scope	<ul style="list-style-type: none">• March 22<ul style="list-style-type: none">◦ Complete second interview with AR subject matter expert• March 25<ul style="list-style-type: none">◦ Complete interview focused on building scenarios and storyboards with ICS subject matter expert• March 29<ul style="list-style-type: none">◦ First Scenario◦ First Storyboard• March 30<ul style="list-style-type: none">◦ First draft of dynamic prototype• March 31<ul style="list-style-type: none">◦ Project update presentation to get feedback from UX peers• April 1<ul style="list-style-type: none">◦ Complete second interview with ICS subject matter expert focusing on dynamic prototype and features• April 3<ul style="list-style-type: none">◦ Two more scenarios, focused on AR tooling◦ Two more storyboards, focused on AR tooling• April 4<ul style="list-style-type: none">◦ 3rd Interim Report

PHASE 4

April 7 – May 5

ACTIONS	DELIVERABLES
<ul style="list-style-type: none">• Demonstrate the experiences and issues an Incident Commander will have while responding to an emergency situation with a journey/experience map• Address any overlooked problem areas and ensure the best deliverable for future teams• Since this research is being handed off to an external team, develop user interface requirements that will explain all visual and interactive experiences necessary for the incident commander. This effort will build on previous research and create/innovate where there are gaps• Present all the research, findings, and ideas in one final report and presentation• To end the research effort, our team will debrief the client about all of our efforts and recommend the next steps to take in the near future	<ul style="list-style-type: none">• April 29<ul style="list-style-type: none">◦ Journey/Experience map• April 29<ul style="list-style-type: none">◦ User Interface Requirements Document• May 1<ul style="list-style-type: none">◦ Final Report• May 2<ul style="list-style-type: none">◦ Dynamic Prototype• May 3<ul style="list-style-type: none">◦ Final Presentation• May 5<ul style="list-style-type: none">◦ Client Debriefing

Conclusion

Our team is excited to explore the first responder's cognitive work flow during times of crisis to analyze how many enhancements can be completed regarding their situational awareness. First responders and other emergency personnel place their own lives on the line every day to assist the general public. Our belief is that augmented reality interfaces and controls can assist in streamlining their processes with innovative technology and utilizing modern concepts. We hope the future of our work results in saving the lives of many for generations to come.

Appendix X: Annotated Bibliography

Annotated Bibliography - 05_03_2022

Data Collected

Recorded Interview with Dale Rolfson - February 11th, 2022:

Dale Rolfson is the Chief Technology Officer for Indy Fire Department. He's been employed with the Indianapolis Fire Department for 34 years. The interview addressed his career working for the Indianapolis Fire Department and his responsibilities. Many of the questions targeted situational awareness and technology related to his day to day activities.

- [Watch on Kaltura](#)
- [Download Dale Rolfson Interview 1 - 02_11_2022.mp4](#)

Discussion with Sonny Kirkley - February 11th, 2022:

Follow-up discussion to review notes and insights obtained from the Dale Rolfson interview. Key points discussed were the project focus and the gathering of new information based on new findings.

- [Watch on Kaltura](#)
- [Download Dale Rolfson Interview 1 - Additional Discussion - 02_11_2022.mp4](#)

Recorded Interview with Dale Rolfson - February 25th, 2022:

Dale Rolfson is the Chief Technology Officer for Indy Fire Department. This interview included questions that focused on walking through incident command scenarios with Dale and attempted to capture the details of those experiences from thoughts, feelings, and motivations. This was done to assist in creating an affinity map, develop an empathy map, and ultimately, generate two unique personas that capture the necessary users. A bonus to this interview was witnessing the current software the IFD uses daily when responding to incidents.

- [Watch on Kaltura](#)
- [Download Dale Rolfson Interview 2 - 02_25_2022.mp4](#)

Recorded Interview and Tour with Dale Rolfson and Jacob Spence at Indianapolis Metro Police Department Command Center - March 2nd, 2022:

Dale Rolfson is the Chief Technology Officer for Indy Fire Department and Jacob Spence is an active Battalion Chief for the Indy Fire Department. This interview included a direct placement of researchers in the same room and seats that the users are in. Dale was also able to include Jacob Spence, an active incident commander, who provided valuable insights from his career, including recent events such as the NCAA tournament in 2021. Our researchers were able to capture critical information and take photos of the command center the incident commanders have been using when responding to larger scale emergencies and events.

- [View Images](#)
- [Download IMPD Tour and Interview - Dale Rolfson & Jacob Spence - 03_02_2022.m4a](#)

Recorded Interview with Kirk McKinzie - March 8th, 2022:

Kirk McKenzie is a retired firefighter and is currently the president of McKinzie Smart Technologies LLC. This interview was a group effort of four different teams and the time was shared between all. Kirk explained the history, issues, and concerns of firefighters in different areas. He recounted his experience as an active firefighter and expectations for the future of first responders.

- [Watch on Kaltura](#)
- [Download Kirk McKinzie Interview 1 - 03_08_2022.mp4](#)

Wide Area Search Waypoint Data Directory Documentation - March 4th, 2022

A document containing information about visual icons and universal images that is used in emergency situations. The document also contains definitions about their use and when the images are implemented. The information contained within is also used internationally with other civilian service organizations. Dale passed this documentation to us as it dealt with common visualizations that should apply to all incident commanders.

- [Download USAR Data Dictionary.pdf](#)

Indianapolis Fire Department Standard Operating Procedure Documentation - March 4th, 2022

The document contains how certain first responders are required to account for their responsibilities depending on their role. These responsibilities include addressing immediate situations and the occupancy of other people's roles. Dale Rolfson provided this document and it allowed us to accurately picture responsibilities of our users in their roles.

- [Download IFD Accountability SOP.pdf](#)

Indianapolis Fire Department Tactical Worksheet - March 4th, 2022

Provided by Dale Rolfson, this worksheet details some of the things the incident commander in an emergency situation would cover and update. The document also represents the workflows incident commanders may encounter.

- [Download Tactical Worksheet - IFD - Version 4.31.xlsx](#)

Kirk McKinzie's Next Gen Curriculum Resource - March 8th, 2022

Kirk has graciously shared this with us and it contains a plethora of resources and links to continue investigating for research and inspiration.

- [Download McKinzie's Next Gen Curriculum 2021.pdf](#)

i-Axis Best Practices Guide - March 9th, 2022

An excellent resource detailing some best practices on navigational visuals for indoor mapping and tracking.

- [Download i-Axis Best Practices Guide to Indoor Mapping, Tracking, & Navigation.pdf](#)

Augmented Reality Device for First Response Scenarios - March 16th, 2022:

This paper discusses a prototype of a wearable computer system that allows for access to location-specific information about an environment, and the capability for user tracking. Its applicability is primarily discussed for use in first response scenarios.

- [Download Augmented Reality Device for First Response Scenarios.pdf](#)

NIST Delivering Building Intelligence to First Responders - March 16th, 2022:

This paper discusses the challenges of delivering building intelligence information to firefighters. It also presents a summary of current state-of-the-art technology in this area and provides insight into how to address these challenges.

- [Download NIST Delivering Building Intelligence to First Responders.pdf](#)

HPHSCC - 2017 Active Shooter Planning and Response in a Healthcare Setting - March 16th, 2022:

This booklet discusses basic information and difficult to answer questions when it comes to safety in an active shooter situation occurring in a healthcare setting. This information is based on expert review and specifically covers patient, visitor, and personal safety, duty to act, and abandonment.

- [Download HP HSCC - 2017 Active Shooter Planning and Response in a Healthcare Setting.pdf](#)

Intelligent Dashboard for Augmented Reality Based Incident Command Response Co-ordination - March 16th, 2022:

This paper describes an Intelligent Dashboard for incident commanders that provides augmented reality benefits with minimal human communication through IoT devices. These devices include such as heads-up displays, virtual beacons, QR-code cards, and wireless mesh network elements. Usability evaluations are conducted to show the ease-of-use and effectiveness of the dashboard.

- [Download Intelligent Dashboard for Augmented Reality Based Incident Command Response Co-ordination.pdf](#)

Recorded Interview with Kirk McKinzie - March 22nd, 2022:

Kirk McKinzie provided answers as our team explored some questions detailing his experience and knowledge of any products related to incident command and control, situational awareness, and future technology adoption

- [Watch on Kaltura](#)
- [Download Kirk McKinzie Interview 2 - 03_22_2022.mp4](#)

Recorded Interview with Jacob Spence - March 25th, 2022:

Chief Spence described an incident situation in-depth that he felt was unusually complicated and overwhelming. The incident described was the Civil Unrest of 2020.

- [Watch on Kaltura](#)
- [Download Jacob Spence Interview 1 - 03_25_2022.mp4](#)

ARTAK Informational Brief - March 30th, 2022:

An informational brief on the Augmented Reality Tactical Assault Kit which helps soldiers to plan missions. The presentation shows detailed images of the process and its capabilities.

- [Download ARTAK Informational Brief.pdf](#)

Project Update and Next Steps - April 2nd, 2022:

The teams Video Presentation and Slides which served to update the class on the project scope, the steps they have completed since beginning the project and intended plans as they move forward. Includes the deliverables they have created thus far, and the key issues the team is facing.

- [Download Project Update and Next Steps - 04_02_2022.mp4](#)
- [Download Project Update and Next Steps - 04_02_2022.pdf](#)

ICS 100 - Incident Command System - USDA.gov - April 3rd, 2022:

This report serves as an overview of the Incident Command System (ICS). It details what the ICS is, its history, applications, its interdisciplinary and organizational flexibility and how it serves as the standard for emergency management across the country.

- [Download ICS 100 - Incident Command System - USDA.gov.pdf](#)

US Department of Transportation - ARC-IT Architecture Overview - April 9th, 2022:

An overview of the USDOT's ARC-IT architecture which can help influence how a public organization organizes objects and views.

- [Download US DOT - ARC-IT V8 Architecture Overview - 04_09_2022.pdf](#)

Chris K. Bailey - Finav Process Book - April 10th, 2022:

A book detailing the process that Team Ember took to accomplish objectives in creating Finav: a firefighter management system that crosses some of the same paths our research takes.

- [Download Finav Process Book - Chris K. Bailey - 04_10_2022.pdf](#)

Edgybees - GeoRegistration Checklist eBook - April 11th, 2022:

An eBook describing the benefits and requirements to find a solution to accomplish situational awareness by use of “GeoRegistration” and other related concepts.

[Download GeoRegistration Checklist eBook - Edgybees.com - 04_11_2022.pdf](#)

References

“PSCR 2021: Augmented-Reality (AR) Usability Evaluation Framework for PSCR”, NIST, https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=932560.

A framework for AR Usability Evaluation in the public safety communication research realm. The document contains examples of Usability Evaluation test scripts targeting specific metrics such as behavioral and performance. Further detail includes how the framework is implemented and the measurement of task performance.

- [Direct Web Link](#)
- [Download PSCR 2021 Digital Experience.pdf](#)

“PSIAP Augmented Reality (AR).” NIST, 21 Oct. 2021,

<https://www.nist.gov/ctl/pscr/funding-opportunities/past-funding-opportunities/psiap-augmented-reality>.

Presents grants and funding opportunities for AR in public safety communications research, as well as descriptions of ongoing projects. The document mentions past participants who have received grants and the importance of research needed for AR technology.

- [Direct Web Link](#)
- [Download PSIAP Augmented Reality \(AR\) _ NIST - 02_23_2022.pdf](#)

“2020 Chariot Challenge: Advancing First Responder Communications.” NIST, 8 Dec. 2021,

<https://www.nist.gov/ctl/pscr/open-innovation-prize-challenges/past-prize-challenges/2020-chariot-challenge>.

Description of the CHARIoT Challenge in which participants built AR interfaces or IoT data emulators for first responder communications. The document mentions specific rewards provided based on success of a category. The challenge is to develop solutions using the latest technology in order to help first responders effectively obtain information.

- [Direct Web Link](#)
- [Download 2020 CHARIoT Challenge _ Advancing First Responder Communications _ NIST - 02_23_2022.pdf](#)

"Enhanced User Interface/User Experience Research Portfolio." NIST, 18 Sept. 2017,
<https://www.nist.gov/ctl/pscr/research-portfolios/user-interfaceuser-experience>

Research portfolio for User Interface / User Experience work within the public safety Community. It contains links to different resources on user experience with AR and VR interfaces.

- [Direct Web Link](#)
- [Download User Interface User Experience NIST - 02 23 2022.pdf](#)

Feldman, Harris, et al. "Public Safety User Interface R&D Roadmap." National Institute of Standards and Technology, April 2017,
<https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1961.pdf>

A roadmap for planning public safety communications research. The report contains detailed information regarding different interface technology that can enhance a user experience. Details and explanations on current technology and possible usage is discussed. It explores how specific interfaces can enhance, evolve and expand current public safety operations and the capabilities of users.

- [Direct Web Link](#)
- [Download Public Safety User Interface R&D Roadmap.pdf](#)

Motorola Solutions. "Consensus For Change Transforming Safety Through Technology." n.d. Motorola Solutions.
https://www.motorolasolutions.com/content/dam/msi/docs/dt/consensusforchange/Consensus_for_Change_Report_V13.pdf

A document containing information on a study conducted by University of London detailing how the pandemic affected innovation and attitudes toward technology for public safety. Kirk McKinzie

- [Direct Web Link](#)
- [Download Motorola's Consensus for Change Report V13.pdf](#)

National Institute of Standards and Technology. "NIST Special Publication 1191: Research Roadmap for Smart Fire Fighting Summary Report." n.d.
<https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1191.pdf>

A document detailing how new technologies have allowed for the collection of large amounts of information that can be used to enhance fire fighting and aid in public safety.

- [Direct Web Link](#)
- [Download NIST Research Roadmap for Smart Fire Fighting.pdf](#)

Federal Bureau of Investigation. "Improving Our View of the World: Police and Augmented Reality Technology." n.d.

<https://www.fbi.gov/file-repository/stats-services-publications-police-augmented-reality-technology-pdf/view>

This report serves as an introductory document on Augmented Reality to the policing profession. It discusses principles and components of the technology as well as its newest developments. It also covers potential applications for future use of this technology.

- [Direct Web Link](#)
- [Download FBI.gov - Police and Augmented Reality Technology.pdf](#)

US Fire Administration. "Incident Command System and Resource Management for the Fire Service" n.d.

<https://apps.usfa.fema.gov/nfacourses/catalog/details/10557>

This report serves as a tool to teach about the Incident Command System (ICS) and Resource Management for the Fire Service and their application in both emergency and nonemergency situations. It covers the need for an ICS, an overview of the structure and flexibility of ICS, and an understanding of the command skills necessary to function effectively in an ICS structure and the need to effectively manage your resources.

- [Direct Web Link](#)
- [Download National Fire Academy - Incident Command System and Resource Management for the Fire Service.pdf](#)

California's All Hazards. "Situation Awareness and Collaboration Tool Concept of Operations." n.d.

<https://www.caloes.ca.gov/Cal-OES-Divisions/Regional-Operations/Situation-Awareness-and-Collaboration-Tool>

SCOUT is a web-based tactical and operational response platform that assists in communication, coordination, and collaboration within incident management for all hazards, whether natural or human-made. It was made for the California first responder community and supporting agencies. Authorized users can view, search and add relevant tactical incident information for a variety of incident types, including wildland fires, floods, search & rescue missions, special events, earthquakes, and homeland security incidents.

- [Direct Web Link](#)
- [Download Situation Awareness and Collaboration Tool \(SCOUT\).pdf](#)

NAPSG Foundation. "Symbol Library" n.d.

<https://www.napsgfoundation.org/all-resources/symbology-library/>

The NAPSG Foundation has been working with the Department of Homeland Security to develop a consistent incident symbology framework. These symbols have helped us add commonly accepted and standard iconography for various incidents within the dynamic prototype. This library is a representation of in-use and current symbology that incident commanders should be familiar with and covers a vast range of incident, hazard, and resource iconography.

- [**Direct Web Link**](#)
- [**Download NAPSG Foundation - Symbol Library.pdf**](#)
- [**Download NAPSG Foundation - Symbol Library.zip**](#)

Chris K. Bailey. "Finav: Firefighter Management System." n.d.

<https://www.chriskbailey.com/finav>

Bailey developed a Fire Management System (Finav). The page has a vision video for how this technology is used and provided great reference material for the team's prototype.

- [**Direct Web Link**](#)

Edgybees. "Public Safety & Government - Edgybees." n.d.

<https://edgybees.com/who-we-serve/public-safety-government/>

Geospatial intelligence for aerial and satellite videos and images. This portion of the site details its use for public safety purposes. EdgyBees augments roads, landmarks, and other mission-critical data on top of live video feeds to provide visibility in complex and opaque disaster scenes.

- [**Direct Web Link**](#)

D4H. "Incident Management Software - D4H." n.d.

<https://d4h.com/incident-management>

D4H is a cloud platform for emergency response. The site details the importance of the 3 R's (Readiness, Response and Re-evaluation) as they relate to D4H as well as the full capabilities of the software.

- [**Direct Web Link**](#)

Adashi. "Adashi C&C Incident Command Software." n.d.

<https://www.adashi.com/incident-command-software/>

Adashi C&C is an incident management platform currently being used around the world which is designed to help commanders handle everyday incidents and large-scale disasters. It provides fire and police commanders with enhanced situational awareness, improved interoperability, and detailed accountability tracking to manage incidents effectively and prevent line of duty deaths. The product helps commanders with real-time collaboration, tactical planning, resource management, and incident reporting.

- [**Direct Web Link**](#)

UX Matters. “How to Create Better Alerts and Symbols in Your Designs.” April 6, 2020.

<https://www.uxmatters.com/mt/archives/2020/04/how-to-create-better-alerts-and-symbols-in-your-designs.php>

UX Matters covers standard uses for alerts in symbols in current technology. It discusses the several different types of alerts and how they are typically designed. It also discusses industry standard symbols and how they are interpreted.

- [Direct Web Link](#)

OnPage. “OnPage.com Homepage.” n.d.

<https://www.onpage.com/>

OnPage is an incident alert management system that enables response teams to get the most out of their digital technology investments. Physicians and IT teams use OnPage's rock-solid escalation features, on-call capabilities and persistent notifications to ensure that critical alerts are never missed. Whether to minimize IT infrastructure downtime, or to reduce incident response time for healthcare providers, organizations trust OnPage for all their critical notification needs.

- [Direct Web Link](#)