Hurricane Response and Recovery: Designing an Information System for Social Good

Group 1

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Problem Identification

The effectiveness of hurricane response efforts depends heavily on how well information is managed. In hurricane response situations, information is a primary asset that needs to be produced, retrieved, processed, and distributed. This information and the technology used to take advantage of it represent a crucial dimension of relief efforts (Bharosa, Lee, & Janssen, 2010). However, significant gaps in how data is collected, processed, and shared during emergencies can lead to delays, miscommunication, and inefficient use of resources. These shortcomings can often worsen the impact of hurricanes, hindering the ability to respond quickly and effectively.

Hurricane response involves a complex network of government agencies, non-governmental organizations, first responders, and local communities all of whom must coordinate their efforts under extreme pressure. Real-time information is crucial for understanding the scope of the hurricane, locating the affected populations, identifying available resources, and assessing infrastructure damage. “The occurrence of disasters is unpredictable, so in the disaster response phase, responders including decision makers, rescue organizations and victims will face greater challenges than other disaster phases” (Lu, B., Zhang, X., & Wen, J. 2020). Unfortunately, several key issues complicate the efficient management of this information.

A significant rift in hurricane response is the fragmentation of communication. Many agencies and organizations use incompatible communication systems. This makes it difficult to exchange critical information in real time.

Another problem lies in the use of incompatible data systems. When organizations rely on outdated or proprietary systems that cannot interface easily with others, this can create

barriers to data sharing. As Buckland (1991) pointed out, the “Information retrieval involves communication through time, although not all communication through time involves information retrieval” (p. 62). If multiple organizations collect valuable information on the ground but struggle to share it, efforts would be duplicated, and resources would be wasted.

A further issue is the lack of standardized protocols for sharing data. Even when data is collected efficiently, some organizations do not offer an acceptable way for people to access their information. This would create ethical issues over misuse of user information and put the quality of the system into question. As Davis and Shaw (2013) highlighted about system quality, “What public standards exist to ensure the reliability, and quality of the information in information systems? Issues in this area include the rights of individuals to access and correct information about them and to seek justice if information is lost or misused” (p. 218). Without such protocols in place, responders and users may not be able to access and verify critical information.

Hurricane response also involves managing a vast amount of information in a short time. This creates an additional challenge. The ability to process and analyze large datasets in real time is still limited for many organizations. As Buckland (1991) discussed, "The assembling of materials for use in information systems is often a very large investment in labor, space, and other expenditure and so warrants careful attention” (p. 55). Improved information management is key to overcoming these gaps. First, better communication systems and intercommunication data platforms would allow agencies to exchange real-time information. This would result in sufficiently coordinated and timely responses. As Lester and Koehler (2007) explained, information management is “The capacity of the entities to affect and control information records has changed over time with the evolution of new technologies for creating and managing

information…". What is also changing rapidly now is the degree of separation and independence of the various agencies that function to create, distribute, and manage information…" (p. 112). Addressing fragmented communication due to these changes in management and standardizing data-sharing protocols would allow responders to work more efficiently and reduce the time needed to provide aid.

Conceptual System Design

Due to the recent hurricanes over the past 1-2 months, our group (group one) decided to create a system that better addresses relief for civilians before, during, and after hurricanes, involving concepts like information behavior and management. Some of the systems being used are on the slower slide and are semi-unreliable "making it difficult to exchange critical information in real time" (Lester & Koehler, 2007). Moving forward to what our system is, it's called The Hurricane Response Information System (HRIS). Within our blueprint, there are three main pieces: those being a mobile app, a cloud platform, and government agencies analyzing the data from the cloud platform.

Mobile Apps

Diving into the mobile app portion of our system, there are two different apps, one being the "civilian" app, and the other being the "responder" app. Within the civilian app there is a "Request Help/Send Help" button, a messages button, an evacuation and shelter map based on locations, a news/updates portion, and lastly a weather alerts portion. Within the Request Help/Send Help button, once the civilian clicks on it, it brings them to a form they need to fill out. The form includes various questions such as the civilian's name, location, contact information, what kind of level of hurricane the civilian is in, the urgency level of the situation, and the resources the civilian needs. After the civilian fills out the form described above, the

form is sent directly and immediately to the “responder app.” Within the “responder app,” there are various features such as a disaster zone map, a progress report function, and an inbox with messages. These two apps will significantly improve the management of information during hurricanes.

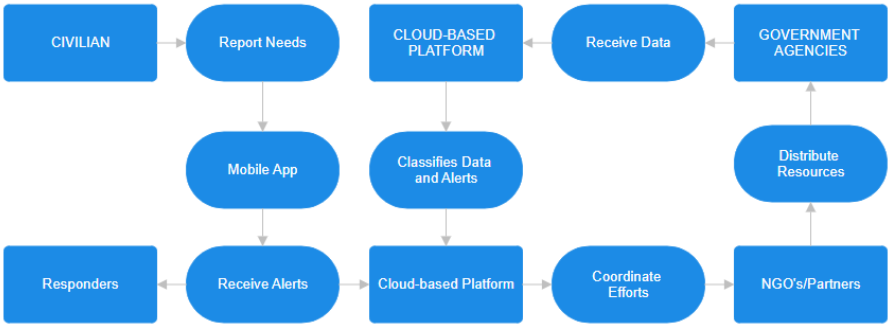
The Cloud

The next portion of our blueprint is the cloud. Over the last 10-20 years the cloud and its use/impact have increased substantially, and that’s why we decided to implement it into our system. The HRIS will rely on a cloud-based platform to store and share data, enabling real-time access for responders, government officials, and civilians (Lewis, 2021). The cloud platform stores and organizes help requests, and pushes out general information/updates/weather alerts/and map updates to the civilian app, while also pushing out disaster map data/progress reports/resource allocation to the responders' app. Without the implementation and use of a cloud platform, our apps wouldn’t be able to function properly.

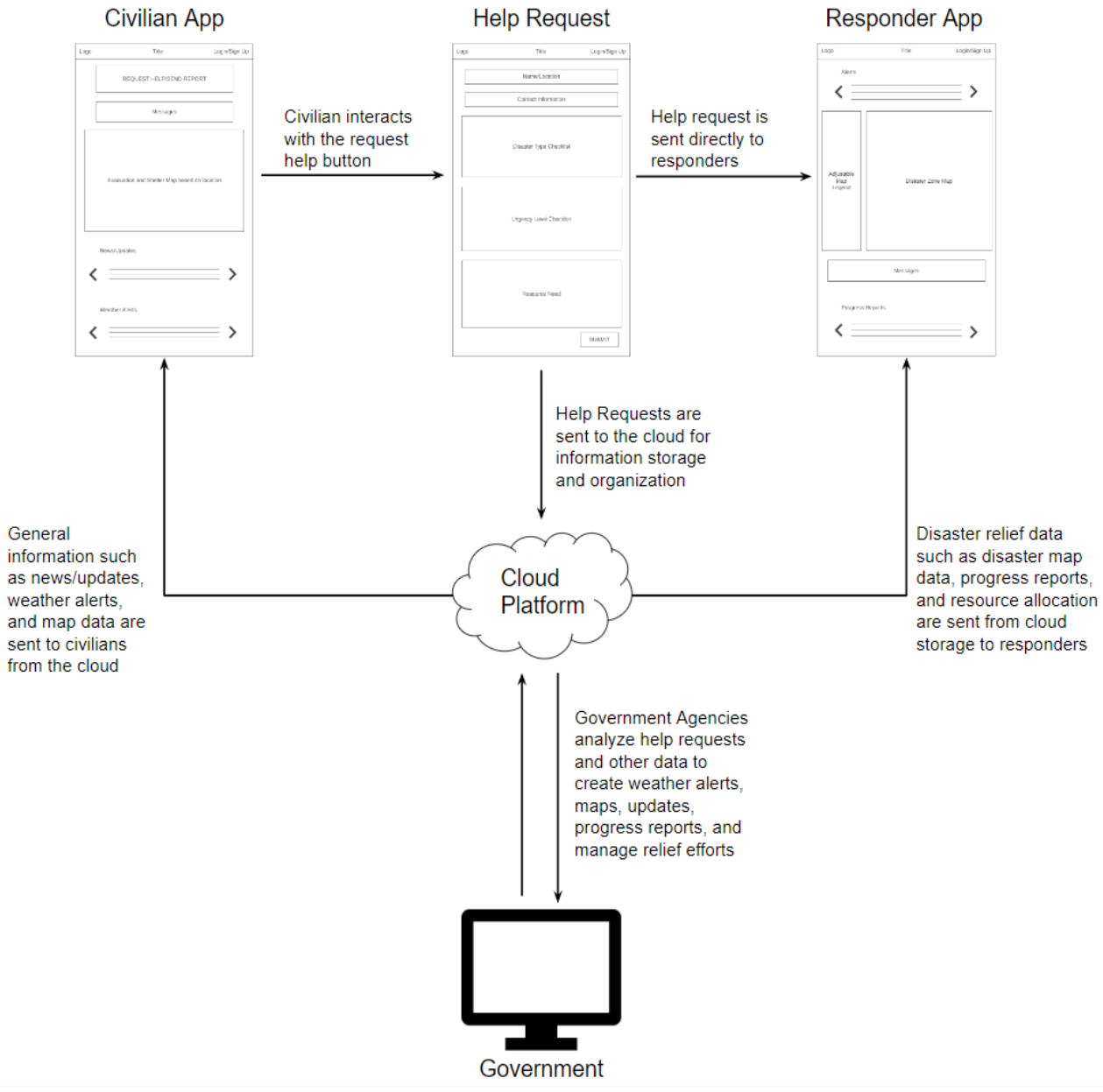
Government Agencies

The last portion of our blueprint is the involvement of government agencies. One of the main challenges in disaster management is coordinating communication and resource allocation among responders, government agencies, and affected communities (Garcia, Turner, & Jones, 2019). The cloud platform keeps track of all the data, but government agencies are the ones who analyze the cloud to make sure everything is running smoothly and efficiently. Wrapping all of this up, our system applies information science to disaster relief by representing how data is created, organized, and used (mobile apps and a cloud platform). While also representing how people interact with data and technology (civilians, respondents, and government agencies).

Diagram of Information Flow



Blueprint



Initial Assessment

Introduction

Hurricanes require quick and well-coordinated responses to reduce damage and loss of life. One of the significant challenges in hurricane management is coordinating communication and resource allocation among responders, government agencies, and affected communities. To address this issue, the proposed Hurricane Response Information System (HRIS) will use cloud-based platforms, mobile apps, and Geographic Information Systems (GIS) to enhance real-time communication and resource management. This system aims to ensure that critical information is efficiently shared between stakeholders, allowing for faster response times and better resource distribution (Goniewicz, Sarker, & Schoch-Spana, 2023).

Technology Infrastructure

Within our system, we will have three main technologies. Those are a cloud-based platform, a mobile application, and GIS mapping. The HRIS will rely on a cloud-based platform to store and share data, enabling real-time access for responders, government officials, and civilians. Cloud technology offers secure, scalable storage that ensures information is always accessible during emergencies (Lagap & Ghaffarian, 2024). A mobile app will allow civilians to report their needs and receive hurricane updates, while responders can track progress and access real-time information on the hurricane zone. This two-way communication system ensures that affected individuals can provide and receive crucial information quickly. GIS technology will provide real-time maps of affected areas, resource distribution, and emergency personnel locations. These maps will guide responders in directing resources efficiently and targeting the area’s most in need (Thomas, 2017).

Information Classification

Information will be organized by hurricane level to ensure proper response protocols are followed. Reports from civilians will be classified based on urgency (immediate, moderate, or long-term) ensuring that the most critical needs are addressed first. The system will categorize resources such as food, medical supplies, and shelter, ensuring efficient allocation to the areas where they are most needed. Finally, information will be filtered based on user roles (e.g., emergency responders, government officials, civilians) to ensure that relevant data is delivered to the appropriate stakeholders.

Information Transfer and Flow

Information will flow will be between the stakeholders through automated alerts, mobile notifications, and direct communication channels. Civilians can report their needs through the mobile app, which will be immediately accessible to responders. The system will also support two-way communication, allowing civilians to report their location and needs while respondents provide updates on evacuation plans, safe zones, and available resources. The HRIS will promote seamless data sharing between government agencies, non-governmental organizations (NGOs), and international aid organizations. Automated alerts will keep all parties informed of changes in the hurricane situation (Goniewicz et al., 2023).

User Interaction and Experience

Civilians can use the app to report their location, request help, and receive updates on evacuation routes and shelter locations. This functionality ensures that those affected by the disaster are always informed (Paul et al., 2021). Emergency personnel will access GIS maps and track resource allocation through the system, ensuring efficient response times and optimized

resource use. Government agencies and NGOs will use the system's dashboards to monitor hurricane zones, manage long-term recovery efforts, and track available resources.

Flow of Information

As soon as a hurricane is detected, the system activates, pulling data from weather services and reports from civilians. This data is immediately accessible to responders through the cloud platform. Civilians then use the app to report their location and needs, which are classified by urgency and resource type. This information is then directed to responders (Paul et al., 2021). Responders access real-time data through GIS maps and deploy resources accordingly. Resource managers use the system to track medical supplies, food, and other essential items. In the background, government agencies and NGOs coordinate efforts through the shared platform, monitoring hurricane zones and distributing resources based on real-time data. Automated alerts ensure that all parties are updated as conditions change (Thomas, 2017). After the initial disaster period, the HRIS will continue to support recovery efforts by tracking rebuilding progress and resource distribution long after the immediate crisis has passed.

Implementation Strategy

Stakeholder Engagement

The first of our three primary stakeholders for the hurricane response system would be the government agencies/organizations who manage the response efforts, such as the Federal Emergency Management Administration (FEMA) or state/local governments. We would plan to approach potential partners or backers with a system pitch and prototype early in the development cycle. Any agency or organization that agreed to back our system or partner with us would then have access to system progress reports and would be able to advise on future

changes. After completion and implementation of the system, the partners or backers would then be able to use and deploy the hurricane response system to help hurricane relief efforts as they deem necessary.

The second primary stakeholder for the hurricane response system would be the responders and disaster relief agencies/organizations who enact the response plans in the areas hit by hurricanes. Once we received the green light on implementation with a major disaster response organization/agency, we would start to reach out to the different responder organizations such as the American Red Cross, the National Guard, and potentially local first responders (police, medical, and fire) to distribute a sample of the system and provide opportunities to learn how it operates. If the agency/organization is not already partnered with or a subordinate entity of our backers or partners, then an opportunity to implement the system into their relief network will be offered.

The third and final primary stakeholder for the hurricane response system would be the victims of a hurricane that use the system. Once the system was fully implemented within hurricane response management organizations/agencies and responder organizations/agencies, an outreach effort would begin to inform the public of the system. Partners, backers, and users of the system would be asked to start sharing the system through advertisements, websites, and other methods that they use to inform the public about hurricanes. Along with that, an internal advertising campaign would be pushed to further the outreach efforts. Engagement would continue through the use of updates from within the hurricane response system.

Technological Requirements

Database(s): A robust database will be essential for storing user account information, including location, name, contact details, and other pertinent data. This database will facilitate

the prompt retrieval of necessary information when users seek relief or aid via our application. It is imperative that this database can accommodate large volumes of data while ensuring easy accessibility; thus, a cloud-based database accessible via an internet connection is most suitable for our application. Furthermore, it is critical that the database is scalable to effectively meet user needs, particularly in the event of a hurricane.

Servers: Our servers will serve as the connective infrastructure between users, our application, and the database in the cloud. They will enable users to share information, allow government officials to review cases, and facilitate communication between first responders and operational teams. It is vital to invest in servers that are capable of managing heavy traffic over extended durations, as the demand for hurricane relief can peak and persist for several weeks. Careful consideration must be given to the construction of these servers to align with the requirements of our application. Additionally, we must establish protocols to reboot the system in case of failure during emergencies, ensuring a swift reset to continue providing assistance to those in need.

Firewall/Proxy: Our system aims to integrate a firewall or proxy to safeguard the databases containing our users' personal information. Given that government agencies may also interact with these databases, it is essential to maintain robust protection during their review of cases and other data. Inadequate protection of this information could lead to catastrophic consequences if it were to fall into the hands of malicious entities.

Cloud Software: We require our application to be readily accessible to any individual with a mobile device or internet connection, thereby maximizing communication across the state. Consequently, the application must function seamlessly on a multitude of devices and platforms, including personal computers, tablets, laptops, and various operating systems such as Android,

Google, and Apple. This multi-platform functionality is integral to achieving our primary objective of accessibility.

Partnerships

The first of our potential partners for our hurricane relief information system would be the Federal Emergency Management Agency (FEMA), which is the federal agency that is responsible for disaster management within the United States. The agency's main responsibility is to work with local and state governments to help manage the aftermath of different types of disasters by providing leadership, financial aid, and technical assistance or by deploying urban search and rescue teams and the U.S Army Corp of Engineers for rebuilding efforts. While FEMA does directly respond to the initial disaster, it primarily focuses on more long-term relief efforts and offers different types of services such as individual or public assistance and future hazard mitigation (FEMA, 2024). Our hurricane response information system would provide them with another method of monitoring hurricane response and managing resources, ensuring that they go to the areas that need it the most. They could also potentially use our system to collect assistance reports to assist in long-term recovery. In return, our system could have access to more robust response data and technical capability through its technology and cloud system (Microsoft Azure). This partnership would also allow our system to be utilized for more long-term assistance that extends past the initial response window.

The second potential partner for our hurricane relief system would be the National Oceanic and Atmospheric Administration (NOAA), which includes the National Weather Service. The National Weather Service is responsible for issuing weather alerts in the United States and surrounding areas. Through a partnership with our system, NOAA could have access to more data relating to hurricanes. This data could be used for news reporting or gauging the

strength of the different contributing factors of hurricane damage, such as wind speeds and flood levels. In return, we could integrate the National Weather Service's weather and alert systems into our hurricane response system. This would allow us to show disaster areas within our built-in map. It will also display weather alerts and include other features such as a working weather radar. This would give responders and victims a way to view upcoming weather that may affect them during the crisis and recovery.

The final potential partner for our hurricane response system would be the local and state governments who manage the relief efforts on a smaller scale such as the state government of North Carolina or the local government of Asheville during Hurricane Helene. Our system would provide these smaller governing bodies with a more centralized and efficient way to monitor and manage hurricane response within their state or local area. The use of our system by local and state governments would open communication channels between all of the responders or responder organizations that are assisting in the area. These could include the American Red Cross, the National Guard, and first responders (police, medical, and fire), who all typically partner with these smaller governments to provide search and rescue, supplies, and aid during disasters. This would improve our system's ability to reach more responders and victims and ensure that response efforts are efficient and centralized towards those who need it most.

Timeline

We intend to seek approval for the development of the application in the late summer to early fall timeframe. This timing is crucial to ensure the relevance of the software during the natural disaster season, with the goal of having a fully operational application prior to the next hurricane season. This takes us approximately one year to realize this objective.

Phase 1: Prototype and Testing (3 – 6 months): The initial phase will consist of prototype development and iterative testing until the application reaches full functionality. This period will also involve raising awareness through targeted advertising and marketing efforts.

Phase 2: Implementation and Distribution (2 – 3 months): In this phase, the application will be publicly released, allowing users to create accounts and input their information into the system in preparation for receiving alerts. Focus will be placed on establishing a reliable system, ensuring a positive user experience, and preparing both staff and users for the first disaster scenario while the system is operational.

Phase 3: Continuous Review and System Improvement: We will engage in ongoing review and enhancement of the system over time, utilizing user feedback, our own analyses, and any identified bugs. Continuous updates and improvements will be made to better serve the needs of all stakeholders involved. During this phase, we will also explore additional features that will enhance preparedness and inform users of potential hurricane risks in their vicinity.

Application of Information Science Topics

Information Retrieval

Information retrieval in the context of our hurricane response system focuses on the ability to access relevant and timely data for decision-making during hurricane relief efforts. Effective information retrieval is essential for identifying urgent needs, tracking available resources, and coordinating responses among multiple agencies. For example, when civilians report their location and resource needs through the mobile app, this data must be efficiently retrieved and categorized to inform responders. Advanced search algorithms and indexing mechanisms integrated into the cloud platform ensure that responders can quickly access real-time data such as evacuation routes, shelter availability, and weather updates. Additionally,

geographic information systems play a critical role in retrieving spatial data to map disaster zones and allocate resources accurately. By streamlining information retrieval, this system helps reduce response times and improve the precision of relief efforts.

Information Behavior

During a disaster, civilians prioritize information that addresses their immediate needs, such as evacuation routes and resource availability. Responders, on the other hand, require aggregated data to make strategic decisions. The dual-app approach of the hurricane response system supports these distinct needs by providing a user-friendly interface for civilians to report their situations and access updates while offering responders tools for data analysis and resource management. Information behavior also varies by demographic factors; for instance, older adults may prefer simpler interfaces, while tech-savvy users might engage more actively with interactive features. Designing this system with diverse information behaviors in mind ensures inclusivity and maximizes the system's usability.

Information Processing and Visualization

Our system uses machine learning and artificial intelligence to process large datasets from sources such as social media, satellite imagery, and IoT sensors. For example, machine learning algorithms can identify patterns in incoming reports to prioritize high-urgency cases, such as those involving medical emergencies or structural collapses. Visualization tools, such as interactive maps and dashboards, enable responders to analyze and interpret data quickly. For instance, GIS-based maps in the responder app can display real-time updates on disaster zones, blocked roads, and resource distribution. Effective visualization not only aids decision-making but also enhances communication among stakeholders by presenting complex data in an easy-to-understand format.

Big Data

When a deadly hurricane hits, due to all the help requests, we have tons of big data coming in at a time so it's important that our cloud software is running properly and smoothly. Not only is it important that our cloud software is running smoothly, but it's also important that government agencies are monitoring the cloud 24/7 to make sure everything is effective and up to date. Our system takes in big data via the cloud, but it also sends out big data via the cloud as well. The government agencies that monitor the help requests coming in are also creating weather alerts, maps, updates, and progress reports, and managing relief efforts. Without big data and an efficient cloud-based platform, our system wouldn't be able to work, leading to lives being at risk.

Privacy, Collection, Transfer, & Storage

To ensure that we handle the responsibility of data privacy throughout all phases of the hurricane response system's use, we will rely on transparency and agency throughout the entire system. Transparency will be addressed within the system by providing an easy-to-reach section that clearly explains what the data is used for and who has access to it. After ensuring transparency within the system, the agency to choose how their personal information is used and shared will be given to the users. However, due to the system being used in times of crisis, it will need to rely on an opt-in system rather than an opt-out system. Most users will not be afforded the time to look through the transparency section and make a decision on their privacy when dealing with a disaster situation. The opt-in system will allow users to recover and receive aid before needing to think about what information they would like to share and how they would like to share it. To ensure proper handling of the data, only approved personnel related to the relief efforts would have access to the data unless a user chose to opt-in to the data collection. If the

user did not opt-in to data collection they would have their information automatically erased after a specified amount of time.

Information Precarity

During a hurricane, the people in need, first responders, and government employees must be on the same page. Hurricanes can last for days and get increasingly detrimental as well. Everybody needs to know what's going on at the current time, the future of the hurricanes, and steps of action moving forward. The beauty of our system is it does exactly so. Within the civilian app there's general information such as news/updates, weather alerts, and map data are sent to civilians from the cloud. Within the first responders' app, there's disaster relief data such as disaster map data, progress reports, and resource allocation are sent from cloud storage to responders. Also, the government agencies who monitor the cloud analyze help requests and other data to create weather alerts, maps, updates, progress reports, and manage relief efforts. With all of that, information scarcity and instability will never be a problem for vulnerable groups as long as they have access to some kind of technology.

Information Inequality

Information inequality poses a significant challenge in disaster response, as access to critical information is not evenly distributed. Vulnerable populations, such as those without smartphones or internet access, may face barriers to using this system. Addressing this requires strategies to reduce digital divides, such as providing offline access or community-based information dissemination through shelters and public broadcasts. Moreover, organizations must ensure that data collected from marginalized communities is not overlooked or deprioritized in decision-making processes. The hurricane response system can address information inequality by incorporating features like multi-language support and accessible design principles, ensuring that

all users, regardless of socio-economic or technological barriers, have equitable access to life-saving information. Additionally, partnerships with local organizations and NGOs can help bridge gaps in information access by leveraging existing community networks.

Information Policy

Within our system, we have set up specific policies to ensure that only data the user, or person in need, is sending over. Due to the nature of our information system (hurricane relief), getting fully informed consent before collecting data from individuals is nearly impossible unless the information system is used before the hurricane occurs. The data collected will only be used for hurricane relief efforts unless the user chooses to opt-in to their data being used externally. If a user decides to opt-in to external data use, they must go through a Terms of Service that clearly explains what the data will be used for past relief efforts. Within our system we also implemented geographic tracking systems to see people's locations, when the user downloads the app, they're prompted to accept these terms and conditions as well and allow first responders to see their location. Locations will only be tracked when help requests are sent out, once the user is safe or given the help they need, their location is done being tracked.

Unintended Consequences

Our system relies heavily on technology, but in today's day and age, if you have any experience, technology doesn't always work. The main consequence of using a system like this is if the cloud goes down or an app doesn't work, then there's no way for first responders to be able to successfully help and rescue. Another consequence of heavily relying on technology is running into a situation where people don't have technology. You won't be able to locate them specifically and give them the help they need. So how do you work around that? Technology is great, our system is really well put together, but the systems in place currently for hurricane

relief need to stay in place. City, state, and country-wide organizations still need to be around and ready to go whenever there's a potential hurricane threat.

Ethics

Our system necessitates the collection of user data for the purposes of identification and location during emergencies. This data will be stored temporarily to enhance the efficiency of future service requests. To safeguard privacy and prevent unauthorized access, user data will undergo encryption. This information will be utilized exclusively for the duration required to dispatch necessary resources. Access to the data will be set up in tiers: dispatchers will have visibility of both location and contact information; responders will have access only to location data; and government officials will possess full access.

Users must consent to a privacy policy in order to utilize the application, thereby minimizing the potential for disputes. At the beginning of each call, dispatchers will ascertain whether users prefer to share their information or to remain anonymous. In instances where users select anonymity, only essential data will be disclosed. All stored user data will be protected through the implementation of firewalls and encryption protocols. Access will be password-protected and limited to managerial personnel, who are required to inform users of any requests for data retrieval.

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