ARKE

The Situational Intelligence Platform for Rapid Emergency First Response

FAA SMART AIRPORT STUDENT COMPETITION

ROWAN UNIVERSITY TEAM

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EXECUTIVE SUMMARY

***ARKE**: The Situational Intelligence Platform for Rapid Emergency First Response*

PROBLEM STATEMENT Emergency Management in the United States is a $180 billion dollar market that includes over 60,000 departments (fire, EMS, and law enforcement), 3,000,000 First Responders, and affects over 330 million Americans' quality of life annually (Department of Homeland Security, 2017). 700,000 calls are placed to 911 every day; 8 calls per second. On average, it can take 9 minutes or more for help to arrive (National Emergency Number Association). Reducing the national average emergency response time by just one minute, could save 10,000 lives each year (FCC, 2018, 20). Inspired by this mission, Rowan University students have developed a next-generation mobile situational awareness platform to put First Responders on-scene digitally, before they arrive. Over the past year, the team has conducted extensive market research, developed, and commercialized a cloud-based mobile platform called ARKE, an **A**ctionable **R**eal-Time **K**nowledge **E**ngine. From Greek Mythology, "Arke" was a winged goddess and messenger to the titans; an eye in the sky and a protector in battle. Similarly, the ARKE platform protects and empowers First Responders, wherever they are, with enhanced situational awareness to accelerate informed decision making and save lives.

PROBLEM SOLVING APPROACH The Rowan team's research objective was, "to develop a scalable and holistic solution that addresses the unique operational Public Safety challenges at Medium and Large Hub Airports, in a post-pandemic world, by leveraging modern technology". To achieve this objective, the team executed a comprehensive literature review and six month national market research campaign including surveys, customer interviews, industry outreach, product demos, and focus groups with active First Responders. This resulted in a technology that would enhance Public Safety at Airports across every stage of the emergency management life-cycle by connecting the existing technology infrastructure directly to First Responders.

IMPACT While ARKE was designed for First Responders, the effects of emergency management operations can be felt by anyone and safety remains the top priority for airport operators and the FAA. Based on an analysis of internal and independent research, this report identifies 1,500 Medium to Large Hub airports and 60,000 Public Safety Departments that would see tangible and significant financial benefits and operational enhancements through the implementation of ARKE across their organization. Anticipated impacts include: (1) Reduced emergency response times by 15%~30% or more; (2) 5%~10% reduction of Airport Liability, Environmental Liability, Commercial Property, and Workers Compensation insurance premiums for Airport operators; (3) 50% reduction to administrative time for departments through enhanced operational visibility for chiefs and airport administrators; (4) 5%~10% decreased total cost of ownership of Public Safety operations due to mitigated damages to terminal, aircraft, support equipment; and (5) Reduced pollution and environmental impact from fire induced air-pollution, hazardous material spills. For the past year, the entire aviation industry has experienced an unprecedented decline in air-travel due to the pandemic. For people to return to airports, they need to feel safe. With the proliferation of digital technology, airports can no-longer afford to ignore the pace of innovation. The research effort included in this report focuses directly on each of these outcomes, and how ARKE can help US Airports protect travelers, employees, and First Responders with a holistic solution that maximizes their existing investments in technology, and saves them money.

PROBLEM STATEMENT & BACKGROUND

PUBLIC SAFETY | OVERVIEW

The US Emergency Management and Public Safety market has a combined annual spending of $180 billion dollars, and affects every single American's quality of life (Department of Homeland Security, 2017). Every 24 hours, 700,000 people dial 911 and wait 9 minutes on average for help to arrive; in many cases, seconds can make the difference between life and death (National Emergency Number Association). Increasing 911 call volumes, increasing response complexity, and aging technology infrastructure built on legacy systems are putting responders and the public at risk, making this a severely underserved market that is ripe for innovation. Statistically speaking, every adult in the United States will dial 911 at least once per year. For patients in cardiac arrest, their chances of surviving decrease by 10% each-minute without CPR (American Heart Association, n.d.). Single-family homes 30 years ago typically took 17 minutes or more to burn down, however, the average home today burns down in under 5 minutes due in part to changes in construction methods (Ready, 2021). Active shooter incidents last 10~15 minutes on average, making it critical for responders to arrive as fast as possible (Department of Homeland Security, 2008). Unfortunately, the number of 911 emergencies is increasing at an alarming rate. Fire department call volumes alone increased over 340% between 1980 and 2018 (National Fire Protection Association, 2019).

Despite their best efforts, the limited tools firefighters, law enforcement, and emergency medical personnel have to collect, consume, and share information often prevent them from arriving in time. Fighting to beat the clock, responders often unknowingly rush towards dangerous situations with incomplete, or inaccurate information about the incident; putting both the caller, and the responder at risk. According to the US Bureau of Labor Statistics, 838 emergency responders lost their lives due to fatal occupational injuries from 2011 to 2015 (United States Bureau of Labor Statistics, 2019). Reducing response times by just one minute could save 10,000 lives each year in the U.S. alone (FCC, 2018, 20).

PUBLIC SAFETY | AVIATION

In 2019, United States airports saw over 1 billion passengers, 2.9 million passengers every day, and 181 billion pounds of cargo, making the U.S. the most active airspace in the world (Federal Aviation Administration, 2020). As a global leader in aviation and innovation, ensuring safety and efficiency continues to be the top priority for the Federal Aviation Administration and their partners (Federal Aviation Administration, 2019). Situational Awareness tools like ARKE have been shown to reduce response times, enhance communication, and accelerate the decision making process for emergency management and First Responders (Kedia et al., 2020) (Loten, 2019). Increasing volumes of passenger traffic come with the risk of increasingly complex emergency response challenges ranging from natural disasters to terrorist attacks. As Covid-19 restrictions are being lifted across the United States, air travel is beginning to rise back to pre-covid levels. The Transportation Security Agency recorded 1.82 million passengers on June 1, 2021 which is over a 450% increase from June 1, 2020 (Transportation Security Administration, 2021). United Airlines CEO Scott Kirby predicts that profits made in 2023 will exceed that of 2019, which was the busiest air travel year in history (Chokshi, 2021). This rapid

resurgence in passengers makes the need to innovate emergency management technology as urgent as ever.

OVERALL APPROACH

The Rowan team's objective was to develop a scalable and holistic solution that addresses the unique operational Public Safety challenges at Medium and Large Hub Airports, in a post-pandemic world, by leveraging modern technology. The intended outcomes for the commercialization of this technology at Airports include decreasing emergency response times, increasing the situational awareness of all parties involved in emergency situations. Along with these factors, the ARKE platform is being designed in a way that would increase the operational efficiency, visibility, and accountability of First Responders and emergency management personnel. Improving these key elements will result in decreased liability for airports, while increasing the public support passengers feel towards First Responders. These improvements to first response and emergency management will create a safer airport environment, while improving the efficiency and effectiveness of fire, EMS, law enforcement, and disaster preparedness. To achieve this objective, the team executed a comprehensive literature review and six month national market research campaign including surveys, customer interviews, industry outreach, product demos, and focus groups with active First Responders. This resulted in a technology that would enhance Public Safety at Airports across every stage of the emergency management life-cycle by connecting the existing technology infrastructure directly to First Responders.

The Rowan University FAA Challenge Competition Team includes an active First Responder and is composed of graduate and undergraduate engineering, computer science, and business students. The Rowan team has partnered with Arke Aeronautics, a Rowan student founded and managed Public Safety & Defense software technology company backed by Rowan University, the University City Science Center of Philadelphia, and the Smart Airport and Aviation Partnership, a regional economic development partnership. To further their mission, the team has partnered with multiple industry advisors including Sage Technologies, a Service-Disabled Veteran-Owned Small Business (SDVOB) and a leader in the development of advanced electronics solutions for the US Army, Navy, Airforce, Coastguard, and public safety community for over 30 years. The team has also assembled an industry advisory board including active Fire chiefs, retired NJ State Police, and current or past employees of Boeing, Lockheed Martin, NASA, and other various government agencies.

UNIVERSAL PUBLIC SAFETY CHALLENGES IDENTIFIED

The 911 system in the United States is a complex and interdependent system of people, processes, and technology systems. To respond to a medical emergency, put out a fire, or investigate a potential threat, the right responders must arrive fast, informed, and well prepared. Despite the critical nature of emergency services, Public Safety departments and emergency communications centers, also referred to as Public Safety Answering Points (PSAPS), across the country have limited access to accurate and complete response information. This is due in large part to 911 caller information traveling between as many as ten people and software systems passing from the 911 caller, to the operator, to the dispatcher, to the corresponding department, to the actual first responder saying "hello" on scene. In the industry, this denotes

the “true-response-time” or “hello-to-hello-time” and is a key metric that can be used to evaluate the response as a whole, as opposed to fragmented component analysis at just the dispatcher, or just the department. The Fire and Emergency Medical Service Department in Washington D.C. (FEMS) requires the first fire engine to arrive on scene in under 5 minutes and 20 seconds and the first EMT must arrive in under 5 minutes (Fire and EMS Department, 2021). While these universal Public Safety challenges are felt by all responders across the country, Airport First Responders often feel these even more so given the increased density of people, hazards, and other risk factors that are associated with large high-traffic public spaces. For US airports, US 14 CFR § 139.319 - Aircraft rescue and firefighting: Operational requirements, states;

> “Within 3 minutes from the time of the alarm, at least one required aircraft rescue and firefighting vehicle must reach the midpoint of the farthest runway serving air carrier aircraft from its assigned post or reach any other specified point of comparable distance on the movement area that is available to air carriers, and begin application of extinguishing agent” (Code of Federal Regulations, 2011).

Maintaining regulatory compliance is critical for departments, but reporting is often recorded manually, and is prone to inaccuracies. The lack of modern mobile-first solutions has forced responders to rely on manual forms of communication like pagers, 2-way radio, laminated cards, information binders, white boards, and in many cases vehicle mounted computers or tablets connected to the Computer Aided Dispatch system (CAD). This operating model hasn’t changed materially in over 50 years, and is the primary driver of “Five Universal Public Safety Challenges” identified through our research:

1) Manual data entry and exchange limits responders ability to have a “common operating picture” of what is happening, where people are, and what resources are available
2) Decision fatigue Command decision makers are faced with as many as 10 different sources of information while driving to the scene, making it difficult to assimilate only the most pertinent information at that time and communicate their plan of action to the team.
3) Legacy Systems Many departments are currently using technology that is outdated or even unsupported, which can give them incorrect information, take them to the wrong address, and puts the public at risk.
4) Not Responder Focused Many of the outdated legacy systems fail to present information and features in a way that are easy to use or understand while performing their duties
5) No Common Operating Picture When responding to larger incidents, departments often work together, but their technology systems don’t talk to each other. This limits their ability to coordinate their response, share information, or communicate in general.

PUBLIC SAFETY PERFORMANCE METRICS DEFINED

A holistic evaluation of emergency management effectiveness involves multiple metrics ranging from response times to report generation. The U.S. Environmental Protection Agency issued a report on Performance Indicators which describes this model in detail. Table 1 contains 9 critical performance metrics for emergency response (Environmental Protection Agency, 2008).

Table 1. Emergency Management & Public Safety Effectiveness Categories

Human health protected	*No responders or civilians injured*
Environment protected	*Reduce pollution and other damage*
Coordinated effectively	*Federal/ state/ local emergency coordinated appropriately*
Cost-effective response	*Cost reasonable for emergency at hand*
General public satisfied	*Data collection, analysis, and reporting*
Responded in timely fashion	*Responders arrived on scene quickly*
Communicated with public	*Consistent and Frequent messaging, questions answered*
Minimize economic impact to community	*Minimize closures to allow quick reacclimation to emergency site*
State and local Government satisfied	*Data collection, analysis, and reporting*

With these criteria in mind, the team explored how ARKE could assist in developing more effective emergency response operations while considering the size as well as the geographical location of the airport. Survey and questionnaire results were used to yield solutions and comparisons on the impact of technology like ARKE for small and large airports alike to establish what campuses need the platform the most. Understanding the baseline measurements and comparing them to the same measurements post-implementation of the platform in the future will validate the benefit analysis for current users and future customers.

CURRENT TECHNOLOGY STANDARD

Understanding the tools and systems in practice today is critical to addressing current technology challenges and standards. Table 2 shows some examples of how the ARKE platform would integrate with legacy systems to mitigate those challenges. While this is a non-specific review, a comprehensive competitive analysis can be found in Appendix F.

Table 2: Assessment of Current Technology Segmented & Legacy Systems

CURRENT TECH	STATUS & LIMITATIONS	OPPORTUNITY FOR INNOVATION
Centralized Emergency Operations Center	Numerous systems, software, and communication methods lead to decision fatigue and reduced communication	Compatible with & enhanced performance of existing legacy CAD and MDT legacy systems *(send & receive)*
Computer-Aided Dispatch System	Access limited to PSAP Emergency Operations Center (EOC)	Integrates with existing CAD systems to enhance mobile information access
Geospatial Information Systems *(ArcGIS / ESRI)*	Access limited to PSAP and EOC	Eliminates need to maintain multiple Geospatial or Pre-Plan datasets
Emergency text alerting system	One-way alerting/limited to text	Two-way alerting, multimedia & live display
Intercom Announcements & Public Information Displays	One-way, nondescript, and omnidirectional (heard by all)	Two-way, highly specific, & targeted user or group-specific

Radio Communication	Legacy systems and miss-matched encryption levels prevent inter-group comms.	Hardware agnostic → cross-compatible between groups
Vehicle Mounted Mobile Data [access] Terminals (MDT's)	Expensive to maintain, install, and configure w/ limited interoperability between departments	Cost-effective mobile solution & fully interoperable to enable secure data sharing during joint response / mutual-aid

PROJECT DESCRIPTION

CONCEPT OVERVIEW

The chosen theme for this research was "Data-analytics" with the primary objective of innovating the way First Responders collect, consume, and share information to enhance Public Safety. ARKE is a cloud-based, hardware-agnostic, mobile software platform that connects First Responders to life-saving information on their cell phones and tablets before they arrive on scene. ARKE uses a proprietary data-fusion algorithm to ingest, organize, and serve the most relevant and critical response information to mobile users based on the type of emergency and their responder profile. It then collects and records that data so it can be recalled later for after action reporting, regulatory compliance, and training.

FEATURES & FUNCTIONALITY

ARKE has functional modules that can be used in combination or stand-alone to address the specific needs of any Public Safety department. These modules communicate with each other and external data sources to collect relevant Public Safety data before, during, and after the emergency occurs. Where today First Responders would have to manually collect this information, the ARKE platform engages the community autonomously on their behalf. Where today First Responders rely on manually sharing that data during the emergency, the ARKE platform prioritizes and shares the most relevant response information with responders automatically. Where today First Responders would have to manually track their response for After-action reports and training purposes, the ARKE platform automatically collects that information for them. The six primary functional modules are described in more detail below:

1. Prevention & Mitigation (Remote Inspections, Incident Pre-Planning, & Data-Collection)
2. Mobile Alerting & Response (Mobile Responder Phone / Tablet Application)
3. After Action Reporting, Analytics, & Compliance (NFIRS, NEMIS, ICS, NIMS etc.)
4. Staffing, Certification, & Training Records Management (Responder Accountability)
5. Inventory Management & Asset Tracking
6. Community Engagement (Automated Public Safety Data Collection & Communication)

PLATFORM ARCHITECTURE

ARKE is a secured platform; meaning users must be invited to join a department. The platform currently has 3 user levels: ADMIN, MANAGER, or MEMBER. ADMINs are Arke Aeronautics employees with unrestricted access to departments within their organizational domain. MANAGERs can configure their departments, while MEMBERS can only modify their own

personal information. To set up a new department, the MANAGER identified will be invited to the platform by an ARKE ADMIN. Once they've created their account, they will send an email invitation to all department MEMBERS. To be invited, users must be an active responder at that department. Invited users will create their accounts, download ArkeMobile, and enable notifications. New departments will also need to grant ARKE access to their CAD and GIS databases. This process should take 5 business days from contract start to go-live. Once live, users will have access to the six primary subsystems shown in Figure 1; ArkeCloud, ArkePortal, ArkeMobile, ArkeSafe, ArkeLive, and ArkeAPI. Each of these are described in detail below.

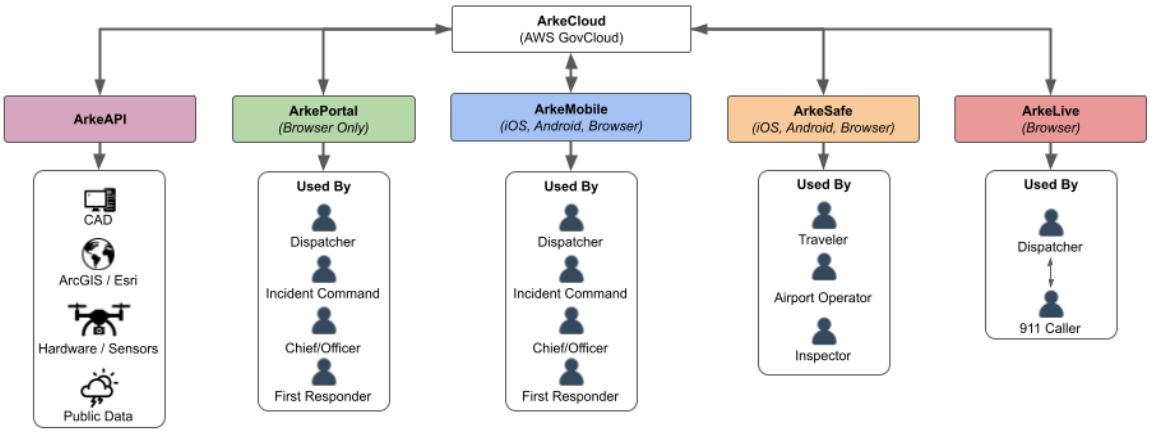

Figure 1. ARKE Platform Solutions & Offerings

ArkeCloud ARKE is a cloud-based platform, meaning that all of the hosting and server management is handled by an independent 3rd party provider such as Amazon Web Services (AWS). AWS offers a "Government Cloud" option for Federal entities. AWS GovCloud is PCI-DSS, HIPAA/HITECH, FedRAMP, GDPR, FIPS 140-2, and NIST 800-171 compliant, and enables rapid deployment of highly secure compute resources as the user-base grows.

ArkePortal Managers are able to edit their department's information, while Members are able to access and modify their personal accounts within the software. ArkePortal is used to configure department accounts, manage department data, generate reports, review reports, create custom dashboards and view automatically generated performance metrics.

Figure 2: ArkeMobile User Interface

ArkeMobile The primary end-user target of the ARKE platform. It provides mobile First Responders with enhanced situational awareness during an emergency. Mission critical information, pinpointing the location of a reported emergency, viewing or managing assets (ex. Hydrants, ARFF vehicles, HAZMAT storage), and details regarding mutual aid are all available within the ArkeMobile interface. Information acquired through various sources will be organized and provided to parties such as dispatchers, incident commanders, chief/officers, and First Responders. *(See Figure 2)*

ArkeSafe Passengers, airport employees, or local community members could assist in keeping the airport safe by proactively sharing information, which could potentially lead to an emergency being resolved before it even happens. Personal aircraft owners could share information about their specific aircraft, which could be used to assist First Responders during the event of a crash.

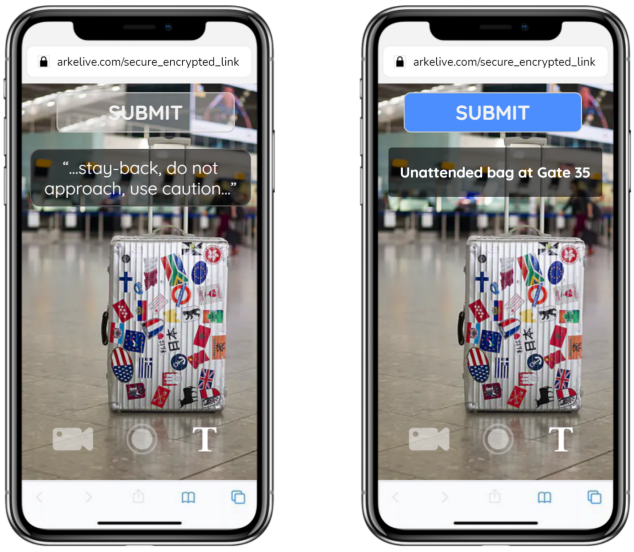

Figure 3: Conceptual ArkeLive User Interface

ArkeLive After an emergency is reported, the caller will be prompted to consent to allow ARKE to access their current location and smartphone camera. By accessing the camera, a live video feed of the emergency scene can be directly broadcasted to the ArkeMobile platform. The 911 caller would not be required to download an app; they would simply receive a non-intrusive text message asking to allow or deny access while still on the phone with the 911 operator. Along with live video, passengers could provide audio, text, or images that would also be made available to First Responders through ArkeMobile. Any passengers using ArkeLive would be coached by the 911 operator to ensure the passenger remained out of harm's way. Figure 3, displays a conceptual UI screen of an unattended piece of luggage being reported through ArkeLive on a mobile browser.

ArkeAPI Connects the existing technology ecosystem by enabling confidential structured two-way communication between existing and future technology systems. This enables the Airport operations center, Emergency Communication centers, Public Safety Answering Points, or First Responders to see a complete digital representation, a “Digital-Twin," on one map.

1. **Autonomous UAS and terrestrial robotics systems** *example: Skydio Autel Drones*
2. **Perimeter security systems** *example: Asylon Perimeter Security*
3. **Counter UAS** *example: AeroDefense*
4. **Manned aircraft tracking systems** *example: Sunhillo FlightAware*
5. **FOD detection, Wildlife Tracking & Mitigation** *example: Cellular Tracking Technologies*
6. **Building Controls:** Digital signage, CCTV cameras, alarms, door access
7. **Gunshot detection** *example: ShotSpotter*
8. **IoT sensors:** airport vehicle tracking systems,wearable electronic devices,
9. **Meteorological data:** On Airport, or Public data *example: National Weather Service*

USE CASE - "FAA TECH CENTER FIRE" (SEE APPENDIX H)

With six functional modules and six sub-systems, it's difficult to imagine the true value of the ARKE platform conceptually. Due to space constraints, we've included a compelling use-case based on a building fire that occurred at the FAA Tech Center in 2012 and included a narrative explaining how ARKE could have helped First Responders that day (APPENDIX H).

ENGINEERING APPROACH

As an interdisciplinary team, developing an engineering approach that would allow each team member to utilize their specific skill set was critical. Team members were assigned unique roles on one of two project sub-teams; Software Development, Research & Outreach. The figure below displays each team member, along with their respective roles.

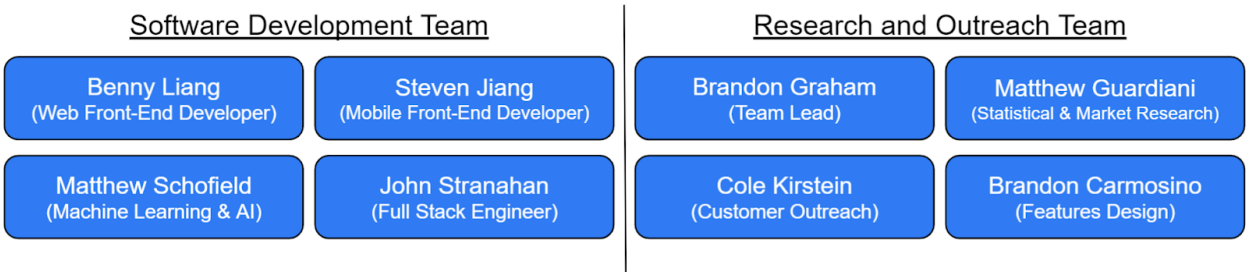

Figure 4: Team Member Responsibilities

The utilization of two sub-teams allowed for an engineering design process that was fast and effective. The process consisted of five stages, which helped to reduce the amount of wasted effort. The first stage of the engineering process was to conduct an in-depth literature and market review. This provided the necessary background information needed to ensure any proposed ideas were innovative and could successfully fill a need. Next, virtual meetings were conducted with airport personnel and First Responders from across the United States. These meetings were used to gain insight into the day-to-day operations of industry professionals, while also gaining valuable feedback regarding which features would be most beneficial. Following the outreach efforts was stage three of the design process. This consisted of creating a features list, along with developing conceptual user interface (UI) screens. All design decisions made during stage three were based on the information gathered during the first two stages of the design process. The features list and conceptual UI screens were then provided to the software development team. An Agile software development framework was used to help quickly develop and iterate a working prototype for Beta-Testing. The project management tool

“Trello” was used to coordinate research and development efforts, post new builds weekly, remaining agile to the feedback being gathered across the team from customers. The final stage of the engineering design process consisted of reviewing the current prototype and iterating previous stages when necessary.

CONCEPT LIFECYCLE

Guiding Principles

Public Safety technology providers have a tremendous responsibility to the First Responders who depend on it, the 911 caller, and the general public. Recognizing this responsibility, the development of the ARKE platform is driven by a multi-part thesis comprised of the following guiding principles:

1. Do no harm Never get in the way of the responder doing their job.
2. Holistic approach “ARKE can help you manage your department from one platform.”
3. Cybersecurity (zero-trust) Maintain confidentiality, access control, user roles, data integrity, and redundancy to remain operational in austere environments or worst case scenarios
4. Hardware agnostic Connect existing technology investments on any platform, or any device. (iOS, Android, Browser on desktop, laptop, tablet, or mobile)
5. Interoperable Integrations with leading industry partners like Geospatial Information Systems like ESRI, RapidSOS, Flight-Aware, Google Weather, etc.
6. Automation Automate data collection, sharing, and reporting whenever possible
7. Connect the Existing/Future Technology Ecosystem Designed for integration with all commercially available industrial Autonomous UAS and terrestrial robotics systems, counter UAS, perimeter security systems, wildlife tracking, gunshot detection, door access, facial recognition, IoT sensors, alarms, wearable electronic devices, Citizen etc.
8. Future-Proof Leverage modern cloud-based, edge-compute, Artificial Intelligence, and Machine Learning to bring future value to existing users and enable aggressive innovation
9. Mutual-Aid Ready For building and sharing a common operating picture with local partners
10. Simple & Powerful Having a simple interface with powerful insights makes ARKE easy to install, train, and maintain for any department. “Simplicity is the ultimate sophistication” - Leonardo DaVinci

Design Assumptions *(See Appendix K | Design Assumptions Detail)*

ARKE relies on airport first responder personnel already having or are capable of acquiring access to an internet accessible mobile device such as a cell phone or tablet. In an effort to promote safe and secure adoption of mobile devices in the workplace, the DHS has recently created the Mobile Device Security (MDS) project, which allows federal employees to bring their own devices to work (Department of Homeland Security, 2021). This initiative ensures employees have access to the necessary mobile devices needed to perform work related activities, while also meeting security and privacy needs. Through outreach efforts with industry professionals it was determined that the assumption of mobile devices being readily available was reasonable and would be regarded as true going forward.

Commercialization Strategy

PHASE 1 | Market Research: The first phase of work focused on defining the current standard of care within the Public Safety and Emergency Management industry. A market study was conducted to identify current challenges, existing solutions, technology capabilities of the tri-service, across the US. Reports generated by federal agencies such as the Federal Aviation Administration (FAA), Transportation Security Agency (TSA), and Federal Communication Commision (FCC) were used to identify regulatory compliance standards, and general operating practices. Publicly available Medical journals, United States Fire Administration Reports, Airport Emergency Plans, and explosives incident reports (EIR) were used to identify the most prevalent emergencies at airports and their severity in order to prioritize the initial target market for ARKE and the corresponding features that would serve that market best. A competitive landscape analysis and SWOT analysis was conducted, identifying nearly 40 related commercially available technologies to inform the team's go-to-market strategy including pricing, positioning, marketing, distribution, training, and product support.

PHASE 1A | Customer Discovery: A national outreach campaign was also conducted to gain direct feedback from airport administrators, department chiefs, and active First Responders from across the county. This campaign consisted of a mix of hybrid and virtual meetings that provided a direct "voice of the customer" to ensure ARKE would sufficiently meet the needs of industry professionals. During the research period, the Rowan team identified and partnered with 4 Fire departments that agreed to Beta-Test ARKE and are currently evaluating the technology today.

PHASE 2 | Beta-Testing (LIVE): While this is a research based competition, this team has developed a working prototype which is described in detail in the Project Description section. The team fully intends on commercializing this technology for use at Airports, and due to the "can-not-fail" nature of Public Safety technology, live beta-testing is being conducted at the departments listed below. Each of these organizations have supported the Rowan team on a weekly basis during the competition and have expressed that ARKE has the potential to benefit their department. Letters of support can be found in the Appendix. It is important to note that securing the support and beta-testing with Atlantic City International Airport and Cape May Airport's primary fire department are both critical indicators for technology viability in the aviation market as both airports are known for conducting industry leading research as FAA classified "Research Test-Beds". ACY and WWD are the ideal locations to test due to the complexity of nearby operations at the national hub for aviation research, the William J. Hughes Technical Center.

SJTA Aircraft Rescue and Fire Fighting Department - Atlantic City International (ACY)
- ➢ Contact: Chief Nelson Wiest

Erma Volunteer Fire Company - Cape May Airport (WWD) Primary FD
- ➢ Contact: Chief Dave Lepor

Glassboro Fire Department - Rowan University, Gloucester County, NJ
- ➢ Contact: Chief Steve Smith

Bushkill Township Volunteer Fire Company - Bushkill Township, PA
- ➢ Contact: Alex Thompson (President)

PHASE 3 | Commercial Launch: ARKE was originally developed by Arke Aeronautics LLC, founded by the Rowan Team Project Lead as a commercial solution for State and local Public Safety organizations (i.e. Law Enforcement, EMS, Fire Rescue). If selected as the recipient of the competition grand prize, the Rowan team intends on continuing it's efforts along with its industry partners by leveraging the grant into a future private financing with local economic development programs, investors, and future SBIR applications. Arke is currently in early-stage discussions with multiple area investors, funds, and economic development programs who have expressed their interest in participating in our next round of financing. Our award-winning team of Rowan engineering, computer science, and cybersecurity students have developed a minimum viable product currently in "live-beta" with multiple Public Safety departments. This trial is being conducted to test feature performance, while debugging any discovered issues. Figure 5 displays a timeline for both the completed and upcoming implementation phases.

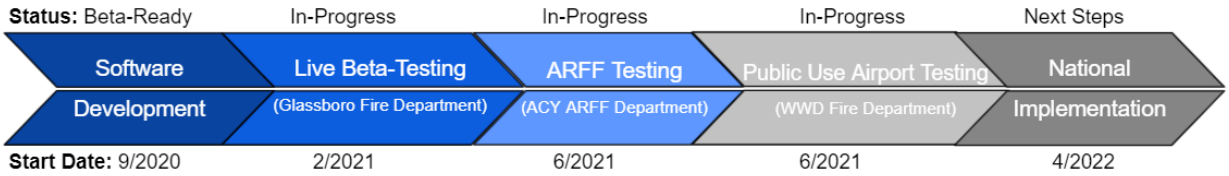

Figure 5: Testing and Implementation Plan

A beta-ready product was successfully completed in January of 2021. This allowed for the implementation process to proceed to the live-testing phases. As seen in Figure 5, live beta-testing with the Glassboro Fire Department began in February. Along with testing ARKEin a municipal setting, additional environments were sought out to test the viability of the platform in a variety of situations. Testing within an Aircraft Rescue and Firefighting (ARFF) department will be essential to gauge the effectiveness of ARKE within an indexed airport setting. Atlantic City International Airport (ACY) is an index E airport, which means it is required to have 3 ARFF vehicles, making it an ideal candidate for the ARKE platform. Through outreach efforts, ACY's ARFF department agreed to test the software, which is anticipated to begin in June. Testing within a general aviation airport fire department was also identified as an ideal testing environment. Again, outreach efforts proved successful as the Cape May Airport's (WWD) primary fire department agreed to beta-test the ARKE technology, which is expected to begin in June. These three unique test settings will provide valuable information in a variety of situations that will prepare the ARKE platform for a national implementation campaign. It is reasonably expected that by April of 2022 the ARKE software platform will be completed and ready for deployment. After deployment, periodic maintenance and updates will ensure the platform stays up to date and continues to operate as intended.

RISK ASSESSMENT

A risk assessment was conducted to effectively characterize the inherent risks associated with the proposed technology implementation for Smart Airports. The top five risks categories identified were derived from a combination of literature review, and customer interviews. In this assessment, each risk was assigned a factor of "likelihood" and "severity" ranging from low to high, selected and evaluated based on ISO standard 14971.

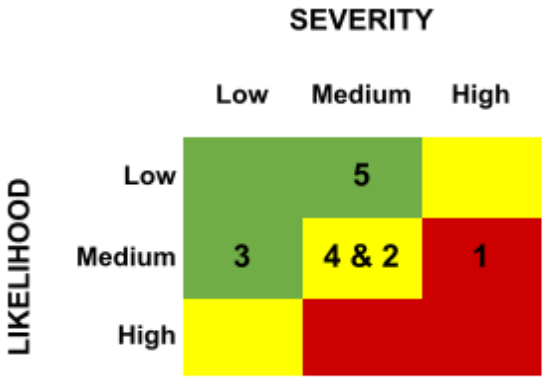

Figure 6. ISO 14971 Risk Assessment Matrix

Table 3. Risks and Risk Mitigation Strategies

No.	Threats Identified	Severity	Likelihood	Mitigation Strategy *(Arke Advantage)*
1	Cybersecurity attack	H	M	AWS GovCloud Security *(Zero-Trust Architecture)*
2	Poor Personal Device Internet Connection *(AT&T First Net, Verizon, Local WiFi)*	M	M	Internet Connection Type Agnostic *(WiFi, 4G, 5G)*
3	Incorrect Navigation Routing / Response Information	M	L	Source multiple routes and A.I. driven optimization
4	Distraction from real-life tasks/other apps	M	M	Straightforward User Interface
5	Emergency Management Communication Systems Disruption *(CAD, Radio, Phone)*	M	L	Isolated / Redundant Cloud-Based Service

Table 3 describes the top 5 risks identified through research and customer interviews. Each of these risks are inherent to emergency management technology solutions and can be overcome through the implementation of best practices, design innovation, detection of failure modes, and redundancy. Specific mitigation strategies are highlighted on the right for each risk and a comprehensive mitigation strategy with special emphasis on our robust cybersecurity posture is included in Appendix G.

IMPACT ANALYSIS

One of the unique challenges Airports face is the variety of emergencies such as terminal fires, hazardous material spills, and counter terrorism. ARKE enabled Smart Airports are anticipated to see a reduction of their liability through improved Public Safety operational transparency, accountability, and overall effectiveness across the tri-service (Law enforcement, EMS, and Fire). This will ultimately lead to an overall improvement in airport safety, which would not only enhance the experience of all passengers, but also encourage them to fly again.

PASSENGER EXPERIENCE

ARKE enabled Smart Airports will see a greatly enhanced holistic passenger experience, from arrival to departure, both directly and indirectly. Specific impacts depend on the incident, but range from fewer delayed departures, to a simplified 911 reporting experience, to reduced response times for 911 callers.

Land-Side

An internal review of publicly available Public Safety incident reports at medium and large hub airports across the country was conducted to understand the most prevalent Public Safety incidents affecting passengers. This study found that the most common Public Safety incidents at Airports are general calls for service to the Police 20% of which included low-risk traffic violations (Metropolitan Washington Airports Authority, 2020). In terms of actual life-threatening emergencies, Medical emergencies are most common. With an aging population, differently abled individuals, or those traveling with heart conditions are at risk for cardiac arrest. The ARKE platform would ensure that Emergency Medical Services arrived at their location faster and with the proper equipment. While Fire calls for service in termal are significantly fewer in number, actual working fires or smoke in the building can have lasting effects on the customer perception far beyond risk of physical harm, or facility damages. Despite all medium and large hub airports having aircraft rescue and fire fighting capabilities, typically calls for service in terminals are covered by local municipalities, not the ARFF department. With ARKE, these local departments can get an enhanced level of detail inside the terminal about the emergency, and coordinate their response to minimise risk to passengers and the facility.

Air-Side

In the event of an aircraft crash, ARFF departments are well trained and prepared to swiftly extinguish flames and evacuate passengers to safety. With the proliferation of Advanced Air Mobility, Urban Air Mobility, and Vertical Take-Off and Landing capable vehicles, ARFF departments will be dealing with both petroleum and lithium powered vehicles. Having emergency shut-off procedures and access points shared with first responders based on the type of air-craft they are responding to will ensure that passengers involved have the best quality service and highest possible chances of survival.

General

Effective communication between emergency management and First Responders will be beneficial during extreme weather conditions, natural disasters, or utility failure to ensure passengers remain calm and orderly, therefore preventing the situation from escalating. In the case of a medical emergency, First Responders will arrive quickly with the information necessary to ensure the distressed passenger is treated as effectively as possible. Lastly, the impact of disruptive passengers will be dealt with more efficiently, reducing the chances of delayed or cancelled flights.

One of the things customers fear most about airports is the danger associated with them; whether that be the plane itself, a terrorist attack, or fire. These dangers can push people away from wanting to fly. ARKE's technology allows passengers to have their own input in the emergency response ecosystem through ArkeLive and feel much more empowered when something does go wrong. This will not only encourage more people to travel but also has the potential to save the lives of other passengers. This will create an airport environment that feels safe and hospitable for passengers.

Airport Operator Impact

The primary customer of ARKE's platform is the airport or airport Public Safety and Operations administrators. The overall value proposition for these customers is based on risks reduction by

increasing communication and situational awareness in each airport environment. This increase in communication and situational awareness allows a more improved and efficiently commanded emergency response. This in turn reduces the risk and liabilities of the airport, which then reduces insurance premiums. This increase in command and communication ability can also help to allocate equipment and resources more accurately. The more that is known about the emergency, the more specialized the equipment for each response can get. This reduction of equipment could save money in budgeting, and also save lives. The ARKE platform integrates with all of the other legacy systems in place if chosen by the customer, which makes everything a lot easier for the operator to put to use. Training for the application will not need to be extensive and will soon make overall training easier and more efficient.

Emergency Response Impact

The largest impact of the ARKE platform is the impact on rapid emergency response. The time required for an emergency response will decrease and save lives in the process. Decreasing the average response time by just 1 minute could save up to 10,000 lives in the U.S. alone every year and ARKE is striving to make that possible. Assuming the average response time to airports' Rapid Response Area (RRA) for the first firefighting vehicle is 2.5 minutes, from the NFPA 403 (National Fire Protection Association). ARKE enabled departments are anticipated to reduce this time by an estimated 30% on average. When regarding a response of this speed and dealing with potentially volatile chemicals and materials on the runway, seconds can be the difference between life and death for one or multiple aircraft filled with passengers and staff.

The ARKE Platform also enhances the communication and command between departments, which in turn increases the accountability of each department dispatched. The platform allows these units to comply more closely with regulatory guidelines and allows easier and more efficient training, maintenance, and after-action reporting. With these inspections, responders can analyze and learn more from their own and others' mistakes and ensure they do not happen again.

COMMERCIAL POTENTIAL

MARKET SIZING & SEGMENTATION

To effectively assess the commercialization potential of the Smart Airport market for the situational intelligence platforms like ARKE, a top-down market sizing and segmentation analysis was conducted. This helped identify the airports that would benefit most from the Arke technology. The team evaluated 19,633 airports in the US based on two factors; (1) impact potential, and (2) revenue opportunity (FAA, 2020). While every airport would stand to benefit, public primary commercial hubs were selected for the following reasons:

1. ***Greater Risk*** As airports become larger and more active, there is a proportional increase in emergency event frequency and severity
2. ***Larger Staff*** Increased emergency activity requires more responders to be staffed, trained, and coordinated during response operations
3. ***Maximum Contract Value*** Emergency Management budgets scale to our advantage

4. ***Greater Impact*** Increasingly complex operating environments result in greater efficiency gains, enhanced insights, analytics, and added value to the customer

EXISTING MARKET SOLUTIONS

To understand the current state of existing market solutions, research was conducted to identify and analyze any software platforms that are intended for use during first response and emergency management situations. This research helped identify the shortcomings of current technologies, while also ensuring that the ARKE software platform was not recreating an already existing concept. Nearly 40 existing technologies were analyzed in-depth and then classified in one of three ways. Segmented partial solutions and outdated technologies were classified as replaceable by ARKE. Any solutions that have limited functionality, or simply have not kept up with the pace of modern technology were placed in this category. Next, integration with any technology that is not provided within the ARKE software platform is necessary to ensure smooth operation within departments. It is necessary to integrate with technologies such as computer aided dispatch, geographic information systems, weather services, and any existing hardware (CCTV, wearable sensors, fire alarms, outdoor warning sirens, carbon monoxide detectors, etc.) since these are essential for day to day operations. Lastly, any multi-purpose fire, EMS, and law enforcement technology solutions were categorized as competitors. Although none of the existing solutions that were deemed as competitors are necessarily comparable to ARKE, departments that are currently using competitor solutions may need additional convincing when tasked with subscribing to ARKE or keeping their existing platform. Table 4, located below, displays each of these categories along with examples of existing market solutions. See Appendix F for a complete Competitive Landscape Analysis.

Table 4: Existing Solutions Analysis

01	**Consolidates (Replaces)**	Partial / Outdated Solutions	first due, ACTIVE 911, lamresponding, blueforce COMMAND, Tablet Command, PS TRAX, omnilert, ALERTUS
02	**Partners (Integrates with)**	Computer Aided Dispatch, Weather Services, Geographic Information Systems, Hardware	ProPhoenix, aladtec, wi-fiber, everbridge, CENTRALSQUARE, AccuWeather, RapidSOS, esri
03	**Competitors (Competes with)**	Modern Multi-Purpose Platforms	MOTOROLA SOLUTIONS, Intterra, EPR FIREWORKS, DRAKONTAS

GO-TO-MARKET STRATEGY

The ARKE Platform will be sold as Software as a Service with a one-time up-front fee and per user per month recurring subscription. Based on initial customer conversations, and Airport Emergency Management budget Research (*Appendix A*) the team has priced the ARKE platform at $12 per month per user. This price will include any maintenance and upgrades to the platform. Customers may have custom integration needs which will be accommodated on an individual basis and will be billed separately at an additional cost based on an hourly market rate for development time.

COST BENEFIT ANALYSIS

The team estimates that ARKE enabled Smart Airports could save a net 15%~30% on combined Insurance Premiums and Public Safety expenses on average including the annual subscription price of the software. Since it will replace many of the other options out there, the price alone will be cheaper than what most airports are already paying for technological platforms. On top of that it will save the airport insurance premiums by reducing risk and in turn liability. Budgeting will also be more precise, as responders will not need to prepare as much equipment for each emergency response at hand. Along with direct financial benefits, ARKE will allow departments to take full advantage of the technology that they have already invested in.

Expected Benefits

1) Reduced emergency response times by 15%~30% or more(through enhanced situational awareness, decision support, communication, coordination, and overall operational effectiveness);
2) 5%~10% reduction of Airport Liability, Environmental Liability, Commercial Property, and Workers Compensation insurance premiums for Airport operators (automated after action reporting & response analytics) (International Air Transport Association, 2021), (International Union of Aerospace Insurers, 2012), (Wiff, 2016), (General Liability, 2021.), (Global Aerospace, 2021);
3) 50% reduction to administrative time for departments through enhanced operational visibility for chiefs and airport administrators(assets, staffing, training, after action reporting, records management, automated analytics, automated regulatory compliance audit, etc.);
4) 5%~10% decreased total cost of ownership of Public Safety operations due to mitigated damages to terminal, aircraft, support equipment; and
5) Reduced pollution and environmental impact from fire induced air-pollution, hazardous material spills).

RESEARCH | TESTING

To develop a platform for first-responders and airport operators it is necessary to gain a deeper understanding of their experienced viewpoints. The team has not all directly been a part of an emergency response, so oftentimes ideas that sound viable to the average person have glaring holes in the eyes of real emergency responders. With this in mind it is essential to gather a voice of the customer to not only understand their needs, but also gain the support of real potential users. This support could eventually be used to gather beta-testing partners and real-world results to truly analyze the potential of the ARKE platform. A national research campaign has been conducted over the past few months and is planned to continue until the end of the platform's lifespan. This campaign included findings from third-party first responder opinions on general technological platforms and applications, direct outreach with an in-house generated survey and questionnaire via email, and direct “face-to-face” interviews (conducted via Google Meet).

Third Party Research

Third party resources were analyzed in regards to technological platforms that are present today. This gave a clear understanding of what First Responders and other users would benefit most from in a platform such as ARKE. The input of over 7,000 First Responder's was found and analyzed regarding first response technology, which allowed a great baseline for prioritization and definition of features (Dawkins et al., 2020). This research addressed many of the questions regarding maximizing effectiveness and whether the platform was something that responders would actually be interested in using. The general consensus from the third-party research was that almost all first-responders would benefit from a platform like ARKE's, however, only if it was executed properly. This research was used as a starting point, providing the necessary background needed to inform future direct outreach efforts.

Direct Outreach

In an effort to gain a "voice of the customer" from potential ARKE users, a national outreach campaign was conducted. Over the course of this campaign, over 100 chiefs, managers, and directors were directly contacted, which can be seen in *Appendix I*. This outreach campaign began with cold-calling, which led to many unanswered emails. Fortunately, this effort did result in a number of responses, which helped to form a fast growing network of industry professionals. As part of the initial outreach efforts, a questionnaire and survey - *referenced in Appendices B, C, and D* - were sent out to each person that was spoken with, along with their departments. The results obtained from these surveys were useful, however, it was determined that speaking with these individuals directly would be more effective, which led to "face-to-face" interviews being conducted.

"Face-to-Face" Interviews

"Face-to-face" interviews provided the most effective form of research throughout the national research campaign. These interviews were conducted via Google Meet, which allowed the team to have meaningful conversations with First Responders and airport operators from across the United States. Conversations were held with professionals from Alaska, Arizona, Michigan, New Jersey, Pennsylvania, and Texas. These conversations typically consisted of presenting the ARKE platform and asking for constructive feedback. This feedback gave new perspectives, which allowed features to be prioritized or added depending on whether they were deemed as potentially useful or not. The key takeaways from these interviews were that creating a single sign-on platform that reduces time and waste within an airport or department would be extremely beneficial. From these interviews, the team gathered a number of direct quotes that validify the value behind the ARKE platform as seen by real responders and managers. To view a small selection of these quotes, please reference *Appendix E*. Ultimately, the most beneficial aspect of conducting "face-to-face" interviews was the potential to secure beta-testing partners. The ARKE platform was viewed positively during the outreach campaign, which led to securing testing agreements with four airport/municipal fire departments.

Testing | Beta-Testing

Through the conversations conducted throughout this project's lifeline, the team has been able to accrue a number of different beta-testing partners. Currently the team is beta-testing with Glassboro's Fire Department in Southern New Jersey, as well as Bushkill's Fire Department in

Pennsylvania. The team has also begun the process of beta-testing with Atlantic City International Airport which is an FAA classified research airport co-located at the FAA Tech Center. Cape May Airport's Fire Department (Erma Volunteer Fire Company), which is also an FAA classified research airport, have also agreed to begin beta-testing very soon. The team is confident that these beta-tests will not only give great real-world feedback in real or simulated use cases for analysis, but potentially open up new opportunities at other departments as well. The platform is far enough developed to see what it would truly look like in use cases and will continue to be tested and developed further.

CONCLUSIONS | KEY FINDINGS

Across the nation, opinions and experiences differ drastically among First Responders, however, there is one common idea that is nearly unanimously agreed upon. This idea is that by improving the communication capabilities of a department and its partners, safer and more effective responses would occur. This improvement would not only benefit First Responders, but also reduce the total cost of ownership and operation of an airport's emergency management and first response departments. Also, by providing one common operating picture through the ARKE user interface, First Responders would be able to better utilize the technology that is already available to them. Chiefs and airport executives would also benefit from increased operational visibility before, during, and after emergency situations through the implementation of a common operating picture. Lastly, by enhancing operational visibility and training capabilities, emergencies will be handled faster and more effectively, reducing the operation liability and cost of damages incurred within the airport.

TECHNICAL DEMONSTRATION

ArkeMobile is live-demo ready. The team intends to walk through the live-app during our video presentation. All necessary technology is in place to screen record this for our presentation video. We also have a number of new UI/UX screens that haven't been released to production yet that can be shown via powerpoint slides to further demonstrate future features and functionality of the platform. This second component of the technology demonstration will also be added into the video presentation. If a non-pre-recorded demonstration is required, we can join any commercially available video conferencing platform and screen share from our device.

PROJECT TIMELINE

As part of the initial plan proposed by the team, a tentative project timeline was created that followed the time constraints provided in FAA challenge guidelines.

Timeline	Activity	Status	Description
Days 0 -60	Customer/ Stakeholder Research	***Complete***	Identify customer and FAA Smart Airport needs to create and implement Arke Technology to satisfy those needs through in-depth research, surveys, questionnaires, focus groups, etc. to create a voice of the customer
Days 15 - 50	Define problem and develop features	***Complete***	Define overall problem and study what causes them. Use this information to then develop prioritized features to solve these problems
Days 30 - 60	Create and Test Features	***Complete***	Create the features researched in prior weeks and Beta-test with likely partners identified • Glassboro Fire Dept. • Gloucester, Cape May, AC • AC International
Days 40 - 90	Beta-Testing	***In-progress***	Create technology and parameters for beta-testing for interested stakeholders with limited release and access in a restricted real-world environment
Days 60 -90	Gather findings + Adapt	***In-progress***	From beta-testing process report and analyze findings to adapt the platform, to be ready for real-world operational use
Days 90 -120	Launch final operational product	***In-preparation***	Finalize the platform and release it for operational use in smart airports across the country
Days 120+	Continue to improve and maintain	***Awaiting Prior Steps***	Continue to gather data from final product and make changes and maintain as used

Figure 7. Project Timeline

Originally, this timeline was subject to change, but the team followed it very closely in actual working operation. At the current juncture the team has met nearly all of these marks. Literature review and customer research was conducted and completed in the first 60 days of the project lifespan, but still continues as needed. During this time, this research and review was directly used in order to define and prioritize feature sets for the application. As these features were defined they were also created and adopted into the final technical solution to be used for testing and refining. Through this process enough features were created to potentially beta-test with the partners referenced in the *Beta-Testing* section of this document. Through the team's outreach efforts through the first 60-70 days, 4 beta-testing partners are already on-board. These partners will allow beta-testing, which will yield results for analysis, reporting, and changes as necessary. The ultimate goal is to use this to lead to commercialization of the platform after approximately 2-3 months of beta-testing and analysis of said beta-tests.

PARTNERS AND SPONSORS

This report, technology, and research effort would not be possible without our academic partners, investors, beta-testers, and advisory team.

Academic Partners

- ➔ Rowan University

Investors

- ➔ Rowan University Foundation
- ➔ University City Science Center

Industry Partners

- ➔ Arke Aeronautics
- ➔ Sage Technologies

Beta-Testers

- ➔ SJ Transportation Authority Fire Department *at Atlantic City International Airport*
- ➔ Erma Volunteer Fire Company *at Cape May Airport*
- ➔ Glassboro Fire Department, Glassboro NJ
- ➔ Bushkill Township Volunteer Fire Department, Bushkill Township PA

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APPENDIX A | COMMERCIAL OPPORTUNITY MARKET SIZE

FAA Commercial Airport Dataset		% Distrobution
large_airport	166	10.84%
medium_airport	548	35.77%
small_airport	818	53.39%
Grand Total	**1532**	**100.00%**

Annual Fees for a Large Sized Airport (PHL)		
	Year 1	Subsequent Years
Setup Fees	$250,000	$0
Subscription Fees	$33,696	$33,696
Total Annual Fees	$283,696	$33,696

Annual Fees for a Medium Sized Airport (OGG)		
	Year 1	Subsequent Years
Setup Fees	$90,000	$0
Subscription Fees	$7,920	$7,920
Total Annual Fees	$97,920	$7,920

Annual Fees for a Small Sized Airport (ECP)		
	Year 1	Subsequent Years
Setup Fees	$36,000	$0
Subscription Fees	$4,176	$4,176
Total Annual Fees	$40,176	$4,176

Annual Recurring Revenue *(Average Per Airport)*	Arke Opportunity @ Scale *(30% Market Share)*	Total Available Market Opportunity *(100% Market Share)*
$ 317,392	$ 15,806,122	$ 52,687,072
$ 105,840	$ 17,400,096	$ 58,000,320
$ 44,352	$ 10,883,981	$ 36,279,936
$ 95,932	**$ 44,090,198**	**$ 146,967,328**

# Organizations /Airport *(Based on Example Shown)*	# First Responders /Airport *(Includes All Organizations)*	CY19 Enplanements *(From FAA Dataset)*
10	**234**	**16,006,389**

# Organizations /Airport *(Based on Example Shown)*	# First Responders /Airport *(Includes All Organizations)*	CY19 Enplanements *(From FAA Dataset)*
5	**55**	**3,791,807**

# Organizations /Airport *(Based on Example Shown)*	# First Responders /Airport *(Includes All Organizations)*	CY19 Enplanements *(From FAA Dataset)*
3	**29**	**621,406**

APPENDIX E | INTERVIEW DIRECT QUOTES

***In an effort to protect the integrity of the interviewees, the following quotations have been kept anonymous ,unless otherwise stated, until further agreement between Arke and the airport themselves.*

- ➔ “The more information, the better the response, the more accurate response, the safer the First Responders.”
- ➔ “I’ve been on the field for 40 years and from the day I walked on the field ‘till now the hardest challenge to deal with is communication.”
- ➔ “I like how it takes away the chaos of the situation.”
- ➔ “This is clearly something that is advantageous to us and we would love to do everything we can to help.”
- ➔ “Without a doubt it would be a big plus.”

 **For more quotes and anonymous list of interviewees, please see the spreadsheet linked.

APPENDIX F | COMPETITIVE LANDSCAPE ANALYSIS

Partners (Integrates with)	Consolidates (Replaces)			Competitors (Competes with)
ProPhoenix	Rover	First due	Alertus	Motorola Solutions
everbridge	PS Trax	Active 911	Zoll	Intterra
AccuWeather	omnilert	Iamresponding	ImageTrend	EPR Fireworks
aladtec	Tablet Command	Whoisresponding	Adashi	Drakontas
CentralSquare	Agility Recovery	D4HTechnologies	Streamline Automation	Blueforce Development
RapidSOS	MobileEyes	Vector Solutions	ESO	CivTak (ATAK)
wi-fiber	RapidDeploy	Zetron		
esri				
Telestaff				
Mark43				
ZeroEyes				

APPENDIX G | CYBERSECURITY

During an extensive review of the potential risks associated with the ARKE software platform, five primary risks were identified. These consist of cybersecurity, poor personal device internet connection, incorrect navigation routing/response information, disruption of real life tasks, and communication systems disruptions. The following sections explain each of these risks in detail, along with the mitigation efforts ARKE employs to reduce their likelihood.

Cybersecurity (1)

Cybersecurity attacks are a pressing issue that might concern users of the ArkeLive technology as mission-critical information is sent from the device of the user. If this information were to be compromised, the visitor could lose their privacy and be prone to cyber-attacks. Stringent policies and strategies are put in place to protect, prevent, detect, and respond to internal and external cyber threats.

Components of Threat/Risk

Data leakage

An important event to consider the possibility of is data leakage between departments. These could potentially compromise a large number of passengers or workers within seconds. Evidence of this can be seen with roughly 9.4 million passengers of Cathay Pacific having sensitive information such as passports and other identification data stolen in a single incident. Data Leakage can occur if the system is not patched for vulnerabilities, or there is a logical attack that allows unauthorized resources to be accessed. The data must be isolated and protected from unauthorized access via access control.

"Man in the Middle" Attacks

The most probable type of cyber attack to occur during the implementation into Smart Airports would be a "Man in the Middle" cyber attack. This occurs when hackers place themselves into a two-party transaction and steal and alter the data. This is relevant to ARKE's technology because to communicate effectively between emergency personnel at the airport and passengers, ArkeAPI must be utilized. These "Man in the Middle " attacks often occur at locations with an unsecured public Wi-fi network; which is common in airports. The risk of attack can be minimized by making sure any public networks the users connect to while in the airport are secured and have updated protections as well as other measures. With man-in-the-middle attacks, the data can be stolen and viewed and possibly altered if they have the credentials - if they don't have the credentials the requests will fail. Man-in-the-middle attacks are much more lethal when data is not encrypted. Another attack that results from Man in the middle attacks is replay attacks, so replaying an action from the past. This action may cause issues if done at the incorrect time and may cause an effect on real-world processes. This is solved with the use of HTTPS because there is protection at the network layer level.

Mitigation Measures

Cyber Security Tenets

ARKE technology mitigates the risk involved with cyberattacks by satisfying the core information security tenants. ARKE data is transferred with confidentiality, integrity, availability, authentication, and nonrepudiation in mind. In order to protect data mechanisms that prevent

attacks such as access controls, encryption, and firewalls are used. To detect cyber attacks audit logs and intrusion detection systems are utilized. And In the event of a cyberattack, there exist backups and the ability to run computer forensics on the event.

Zero-Trust Architecture

Another element that is included with the ARKE Technology is a zero-trust architecture (ZTA). This ZTA is a set of guiding principles for system design and operations with the goal of preventing data breaches. This improves the security posture of the ARKE technology architecture. The platform is designed with the principle of least privilege in mind. The importance of this is evident within many federal agencies with sensitive information being asked to move towards zero-trust principles for many years with some being FISMA, Risk Management Framework (RMF), Federal Identity, Credential, Access Management (FICAM) and Trusted Internet Connections (TIC). These agencies align closely with the requirements met by ARKE's utilization of AWS GovCloud. A main focus of ZTA is to lessen uncertainties by implementing authorization processes while still maintaining efficiency of the application. This implementation of ZTA principles and utilization of AWS GovCloud will be ARKE's way of ensuring any information shared by/between users is secure and does not comprise either party's personal information. All data within our platform must be correct, isolated from unauthorized use, and obfuscated if an attack occurs.

AWS GovCloud Integration

To mitigate this very important risk of cyber attacks ARKE Technology will integrate ArkeCloud (AWS GovCloud) along with its security benefits. The extra classification of AWS GovCloud compared to just using the regular AWS is needed because the ARKE technology will be used to transmit privately secured information such as floor plans or designs within the airport to emergency responders for assistance. Also, another important feature of AWS GovCloud is it protects against Personally Identifiable Information (PII) which is any personal information about the passenger such as social security number, date of birth or financial records. These documents will be kept private to the correct people but also can be used to identify people on the scene by responders.

Another element of AWS GovCloud that fits closely to the structure of ArkeLive and ArkeSafe is the identity management of AWS. This gives the Airport management the ability to restrict the sensitive information based on the individual, time of day or location. It is also possible to select which API calls the users can make. This is a useful tool for Airport management as they can restrict certain phone numbers on a contact list given to the passenger through a secure link, based on up-to-date events. It is also helpful to be able to set up clearance levels to limit access/transfer of classified documents to appropriate parties.

The other benefit of AWS GovCloud (US) Regions is that multiple security and compliance requirements are met. Some of these include FedRAMP, FISMA, SRG, U.S. ITAR, CJIS and NIST. These compliances help us to ensure that ARKE is taking all the necessary steps to minimize the risk of a data breach during transfer of sensitive data.

Cryptography

Every client-side and server-side device communicates using the Transport Layer Security (TLS) protocol. With this technology, the packets and data sent to and from the platform is confidential with end-to-end AES-256 encryption enforced. The data can only be decrypted by the holder of the valid shared secret key, which is negotiated via perfect forward secrecy with the Ephemeral Diffie-Hellman key exchange. TLS also provides integrity, where the client-side can verify the digital certificate that is attached to the shared key belongs to our platform. The digital certificate is issued by a trusted Certificate Authority to verify authenticity of the client and server. All data that is stored on the platform is encrypted to reduce the impact of any internal or external attackers from accessing the plaintext data that is collected. To access data from a resource, the credentials must match the access controls provided by their user role. A token, which identifies the requester is signed by a HMAC-SHA512 algorithm and a secret key, is required to receive the data if the requester is authorized and authenticated. All user passwords are hashed with a salt before they are stored and the hash function is adaptive, making the result resistant to brute force attacks.

Poor Personal Device Internet Connection (2)

A second potential risk with our technology is what happens if the user has slow or fading internet connection from a personal data connection service such as Verizon, AT&T, or a WiFi connection. This could potentially delay the user in response and make it hard for emergency responders to get the information they need in a timely manner. The alerts sent to the device could be missed and must be handled appropriately. In order to mitigate this risk, it would make sense to be compatible with several data infrastructure including all data carriers and any secure WiFi internet connection within the airport. Stale data can occur where the information may not reflect the real world state of the response. This can be mitigated by acknowledging that the data is not relevant or useful.

Incorrect Navigation Routing/ Response Information (3)

Another risk that would apply to ARKE technology's solution would be the possibility of incorrect navigation or providing incorrect information. When incorrect navigation happens in the ArkeMobile app the emergency responder could become distraught and waste valuable minutes rerouting his response coordination. This is mitigated by ensuring failures are handled to ensure client-side/user side input and response is fast and accurate. Any abnormal state or condition returned to the application must be handled without interrupting normal operation. This makes it of importance to make sure the functionality of using a navigation in-app can be easily canceled or reloaded if necessary. Also, there should be options to link to multiple different popular, well-known navigation apps such as Waze, Google Maps or Apple Maps just in case one has a problem with a specific destination input.

Disruption of Real Life Tasks (4)

An additional risk to consider while utilizing ARKE technology data analytics is the disruption of the ability to use other applications that might also be needed at the time. Also, using ArkeMobile could distract users from real-life live events/tasks. This could be for example when a first responder is driving a vehicle to the scene in response to an emergency. Worst case scenario is they are alone in pursuit and have to drive and use the ARKE platform for

updates simultaneously. In this case, it is important to make sure the user interface on the platform is simplistic and efficient. It is also important to also allow for quick cancellation of navigation directions if an alternation in location occurs during the pursuit. The design of the application is critical in order to ensure that all users can interact with the app efficiently.

Emergency Management Communications Systems Disruption (5)

A last potential risk with this technology is the possibility of weather conditions causing a disruption in emergency communications. In this situation it would be vital to have effective and functioning communication between citizens in danger and emergency responders to ensure their safety. That is why the ARKE technology will provide isolated redundant cloud-based service. The cloud based service ensures that as long as the user is able to access the internet they are able to input their data simultaneously along with other users.

APPENDIX H | USE CASE - FAA TECH CENTER FIRE, 2012

Location (Egg Harbor Township, NJ): The William J. Hughes Technical Center is the national scientific test base for the FAA. The Center is home to the New Jersey 177th Air National Guard, US Coast Guard, Federal Air Marshals, Transportation Security Lab and encompases 5,000 acres of property, over 300 buildings, approximately 3.5 million square feet of office space, and approximately 4,000 employees (FAA, 2020). The SJTA Fire Department at Atlantic City International Airport has recently installed ARKE at it's department. The Tech Center Operations Manager James Connett recently completed an emergency profile via **ArkeSafe** including building floor plans, average building occupancy, hazardous materials, building access, and fire protection systems information which is now available to the SJTA Fire Department in **ArkeMobile**.

Emergency Scenario:
(12:30PM) *A fire has broken out on the roof of building 300. Three explosions, two large ones followed by a smaller blast have been reported to 911 by tech center employees.*

(12:35PM) *Building alarms have sounded and all 1,600 employees from building 300 and 316 are being evacuated. Thick white smoke can be seen billowing from the roof, but the exact origin is unclear. Employees are worried the building may have been victim to a terrorist attack.*

- ➔ Employees are able to share their live video of the smoke billowing from the building from a safe distance directly with the 911 operator via **ArkeLive**

(12:37PM) *SJTA Fire Department has been dispatched to the scene. Flight operations at ACY have been halted temporarily.*

- ➔ SJTA Fire Chief Nelson Wiest and his on-duty firefighters each receive an alert on their personal cell phones via **ArkeMobile** shortly before their station tones
- ➔ Clicking the notification takes them to an **ArkeLive** video stream from a Tech Center parking lot CCTV camera showing smoke billowing from the roof of the building.

(12:42PM) *SJTA FD first due engine arrives on scene and confirms this is a working fire. The off-duty recall has already been activated by the Chief via **ArkeMobile**. Mutual-aid departments at Pomona, Bayview, Farmington and Galloway Township, and NJ State police have been dispatched.*

- ➔ *SJ*TA FD deploys a UAS connected via **ArkeAPI** with a thermal imaging camera to identify the source of the smoke. The UAS and remote-pilot locations are made visible on ArkeMobile with the live video feed streaming from the UAS to **ArkeMobile**
- ➔ Chief Wiest and his incident commanders can see mutual-aid departments and additional resources on-route, in addition to building access, floor plans, utility shut-offs, FDC/sprinkler connections, flammable and hazardous materials in or around the building via his tablet running **ArkeMobile**

(12:45PM) *Additional SJTA FD resources are on scene and firefighters are entering the building. EMS is standing by on scene to receive casualties.*

- ➔ *Mut*ual-Aid department volunteers receive notifications on their personal devices with directions, building floor plans, live video from on-scene, and their response ETA

- ➔ Chief Wiest can see the GPS position of each firefighter and truck on the map via **ArkeMobile**
- ➔ Evacuated Tech Center Employees receive a text notification via **ArkeSafe** from James Connett informing them of the *situation advising them to return home.*

(1:00PM) *Pomona, Bayview, Farmington, and Galloway Township have arrived on scene and are deploying ladders, and water fighting to knock down the fire. Police roadblocks are in place to close access to the Tech Center and the Atlantic City International Airport at Terminal Road.*

(1:23PM) *A portion of the roof has collapsed on top of firefighters inside the building who have sustained non life threatening injuries, but are incapacitated.*

- ➔ Their wrist-worn smart sensors have detected a possible fall and notified the incident commander automatically with an alert through **ArkeMobile**
- ➔ Nearby firefighters are directed to their location and able to perform a safe extrication from the building

(1:45PM) *The fire has been contained and firefighters are working to extinguish the remaining hot spots on the roof and in affected areas of the building. Dark black clouds are approaching from the south.*

- ➔ UAS operations over the scene continue to provide an eye in the sky to ensure water is being deployed effectively and to identify residual hot-spots on the roof.
- ➔ Incident command is automatically alerted of high-potential for lightning in the area via **ArkeMobile** and ladder operators are instructed to return to ground.

(2:30PM) *Firefighters have extinguished the roof blaze and are continuing to check for hot spots and embers that may have spread further into the building.*

- ➔ Rapid Damage Assessments are completed inside the building conducted by firefighters via ArkeMobile and made available to Atlantic County Fire Marshal Harold “Whitey” Swartz, and Egg Harbor Township and State Police fire investigators
- ➔ Automated After-Action Reports are generated by ArkePortal for later review by incident command including every time-stamped action, video source, and personnel movement during the operation.
- ➔ 911 callers and tech center employees receive text notifications that the building is not safe for re-entry until further notice. (**ArkeSafe**)
- ➔ 911 callers and tech center employees also receive text notifications asking for positive feedback on the quality of response service, and any other information pertaining to the incident. This data collection is automated via **ArkeSafe** and is stored in the **ArkeCloud** for later review in **ArkePortal**.
- ➔ The individual response record is made available to James Connett to submit to the insurance company for claims processing.

The scenario above is based on eye-witness accounts of the actual events of the June 22nd, 2012 Tech Center building 300 and 316 fire which caused 2.1 million dollars of damage, displaced 230 tech center employees, disrupted national air traffic control, and left three firefighters in the hospital with non life-threatening injuries. No FAA employees were injured during the incident (Press of Atlantic City, 2020).

APPENDIX K | DESIGN ASSUMPTIONS DETAIL

1. Airport Security / Emergency Management stakeholders are open to implementing new technology
2. Airport Operators recognize the positive financial impacts of increased emergency management performance and enhanced safety for their customers
    - Insurance companies recognize the risk reduction impacts of increased emergency management effectiveness when evaluating pricing & coverage
3. Airport Budgets can support the cost to acquire, integrate, and sustain a subscription to the ARKE platform
4. First Responders have the means to supply either their own personal device, or a department issued device and carry that with them during their duty shift
5. Sufficient internet connection / infrastructure to maintain a stable connection anywhere within response area
6. Emergency Operations Center (EOC) willing to authorize access to share certain data with the ARKE platform (video feeds, dispatch notifications, pre-plan information etc.)
7. Emergency Management leadership is open to sharing (limited) response information securely with local departments during mutual aid operations

APPENDIX L | ABBREVIATIONS & DEFINITIONS

Acronym	Meaning
ACY	Atlantic City International Airport
ADS	Applied Digital Solution
AEP	Airport Emergency Plan
API	Application Programming Interface
ARFF	Aircraft Rescue and Firefighting
AWS	Amazon Web Services
CAD	Computer Aided Dispatch
CCTV	Closed Circuit Television
CJIS	Criminal Justice Information Services
DHS	Department of Homeland Security
EIR	Explosives Incident Report
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
EOC	Emergency Operations Center
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEDRAMP	Federal Risk and Authorization Management Program
FEMS	Fire and Emergency Medical Services
FICAM	Federal Identity, Credential, and Access Management
FIPS	Federal Information Processing Standards
FISMA	Federal Information Security Management Act
FOD	Foreign Object Detection
GDPR	General Data Protection Regulation
HAZMAT	Hazardous Materials
ICS	Incident Command System
iOS	iPhone Operating System
IoT	Internet of Things
ITAR	International Traffic in Arms Regulations
NEMSIS	National Emergency Medical Services Information System
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NIMS	National Incident Management System

HIPAA	Health Insurance Portability and Accountability Act
NIST	National Institute of Standards and Technology
HITECH	Health Information Technology for Economic and Clinical Health Act
PCI-DSS	Payment Card Industry Data Security Standard
PII	Personally Identifiable Information
PSAP	Public Safety Answering Point
RMF	Risk Management Framework
RRA	Rapid Response Area
SBIR	Small Business Innovation Research
SDVOB	Service-Disabled Veteran-Owned Business
SWOT	Strength Weakness Opportunity and Threat
TIC	Trusted Internet Connection
TLS	Transport Layer Security
TSA	Transportation Security Agency
UAS	Unmanned Aerial System
UI	User Interface
UX	User Experience
WWD	Cape May Airport
ZTA	Zero-Trust Architecture