# Cover Page and Abstract

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During civilian encounters, law enforcement personnel are tasked with maintaining alertness for situational awareness and threat detection. Challenging enough on its own, many officers are also faced with fatigue, further compounding the challenge. Fatigue has been gaining broader awareness in recent years as a major safety risk to law enforcement personnel, and decision fatigue is a contributing factor. Law enforcement by its nature operates in a high stress environment, and often demands that an officer be on guard. This phenomenon can lead to a dulled threat detection and situational awareness, and can be particularly hazardous when interacting with criminals.

Because police database systems do not track individuals who have not had a previous encounter with law enforcement, skilled criminals are often able to fabricate an identity and evade detection. More dangerously, a law enforcement officer may unknowingly engage a violent felon. If an individual is planning an assault during an encounter, an officer is unaware, and is only able to react. Law enforcement personnel are faced with the challenge of identifying threats and distinguishing them from routine, non-threatening civilian interactions.

Here we present a solution that can rapidly identify faces within an officer's field of view, match the identity of the face, and display relevant criminal information in a heads up display that allows the officer to stay focused on an individual. Using the low profile Google Glass that is compatible with active motion, the system is able to operate passively, meaning the officer is not required to do any additional work to use the instrument, yet is still provided with additional information in their field of view.

When a face is identified, three possible outcomes are displayed in the top, right corner of an officer's field of view, and each is color coded for ease of comprehension. A heads up display will present a green message indicating "No record found," a yellow message indicating at most the two most egregious previous interactions with law enforcement for that individual, or a red message, indicating that the individual is wanted or potentially dangerous. In the event that an individual's face registers as "wanted," the user interface will additionally display the message "Tap to alert dispatch." If an officer taps the side of the glass while this message is displayed, the identified individual, along with the officer's current geospatial position, is relayed to dispatch.

This solution provides threat information and eliminates the need for other cognitive heuristics. It may therefore be able to reduce racial bias, while still improving an officer's safety. Further, the system can be powered down when not actively preparing to engage an individual for potential unlawful activity. This solution is able to enhance an officer's situational awareness by annotating their vision, and providing the officer with important data that can help them carry out their duties safely and more effectively. The solution presented here offers a transparent method of enhancing law enforcement personnel with information that can help keep them safe, and identify wanted individuals.

# Project Description

In 2016, more than 57,000 police officers were assaulted while performing their duties, up from about 51,000 the previous year. That puts the rate of assault at a staggering 9.8 per 100 sworn officers, or almost 1 in 10, and 66 were killed. Of the 59 alleged offenders identified in connection with the 66 police officers killed, 45 had prior criminal arrests.

Additionally, many criminals have become skilled at avoiding identification during police encounters, largely by lying. Police databases do not return a positive identification for individuals who have never had an interaction with police, and skilled criminals are able to exploit this by fabricating an identity. As more police are being assaulted and criminals become savvier, there is a clear need to bolster an officer's ability to rapidly detect potential threats.

The average person makes approximately 70 decisions per day, leading to a phenomenon known as Decision Fatigue, which makes the brain more sluggish and less able to make good decisions in a limited time. In high tension encounters, Decision Fatigue can be potentially life threatening. Because of the limits of human physiology, it is unlikely that much more advancement in officer training will be able to meet the demands of a job that interfaces with an increasingly threatening criminal world. A more effective approach might be to automate certain tasks in an effort to reduce cognitive load, and preserving an officer's mental acuity.

Here we propose to develop Advance Warning AR, an Augmented Reality (AR) system capable of rapid facial detection and identification in a manner that is unobtrusive to the officer's field of view. The system we propose will be able to operate while the officer's attention is focused elsewhere, such as the body language of an individual. The system will be able to detect wanted individuals and violent offenders, and alert the officer in a Heads Up Display (HUD) discreetly without alerting that individual.

## *Specifications*

Our system is designed around Google Glass, an AR headset that has a built-in camera, a low profile that is compatible with active professions like police work, and a robust software development kit. Glass uses a 640×360 Himax HX7309 LCoS display, has a 5-megapixel camera capable of 720p recording, an Intel Atom processor, 32 GB of storage memory, and 2 GB of RAM onboard, and includes Dual-band 802.11n/ac wifi. Glass runs on an Android operating system, and a well-documented API exists for development.

Using this hardware, we propose to run OpenCV, an open source facial recognition package that scores 99.38% on the University of Massachusetts' Labeled Faces in the Wild benchmark. In order to process images in real time using onboard hardware, every other frame will be dropped, and the resolution will be reduce to ¼ size.

For initial testing, we will use the NIST Special Database 18, "NIST Mugshot Identification Database," for image recognition. For performance metrics, mugshots of participants in a test will be added to the database, and the system will be rated on its ability to properly detect participant faces in terms of speed and accuracy. In the final deliverable, we propose to partner with NCIC to compare actively wanted and potentially dangerous criminals. An offline copy of the database can be stored and synced in a police cruiser, allowing an officer to use the system even if they're offline.

## Display

When a face is detected, a faint, gray rectangle is drawn around the face in the HUD, and the words "Scanning face…" appears above it. All HUD graphics are faint so that they are not obtrusive. The detected face is then compared to the database for possible matches. In the event that an individual matches a violent offender entry in the database, the image will be flagged as "potentially dangerous." If a positive match is detected, the box will remain translucent, but will turn yellow and indicate that the individual is wanted. The text above will change to "Wanted for " and be followed by the appropriate text from the database. In the event that the "potentially dangerous" flag is thrown, the box will turn red, and the text above it will indicate that the individual is potentially dangerous on screen.

## Additional Features

When online, the Advance Warning AR system can automatically alert police dispatch of an encounter with a wanted criminal, and indicate if the individual is potentially dangerous. All data will be sent to a log file and include time of day and geolocation for ease of reporting. By leveraging technology, the system we propose here helps keep an officer safer while maintaining police transparency.

## Future Advancements

The Advance Warning AR system gives a police officer access to tremendous amounts of data for more informed decisions that she could never remember on her own, and streamlines it into an intuitive display. Yet, because of the nature of incorporating novel technology into a potentially tense situation, we recommend an iterative approach that builds and perfects one element at a time, and through interviews with police, we have identified facial recognition as the most salient feature. However, future implementations of the system can also be used to detect additional features, including driver's licenses and license plates. Alternatively, future implementations might include other features, such as the ability to automatically broadcast an interaction through the camera once a potential threat has been identified.

In addition, the hardware package can be retrofitted with thermal or other imaging, and by pseudo-coloring the HUD, can allow an officer to see when vision is obscured, as by smoke, debris, or insufficient lighting. Finally, because a large number of offenders were under the influence of a controlled substance at the time of assault, future implementations might include speech recognition capable of detecting disfluency and other signs of possible inebriation, providing the officer with even more threat analysis. Currently, the best systems are approximately 77% accurate at detecting intoxication through speech patterns, but are expected to improve rapidly as speech recognition technology improves.

## Feasibility

The Advance Warning AR system we propose here is comprised of commercially available off-the-shelf hardware. Components of the system are available today, including the appropriate software and API's. Our team has a demonstrated ability generate easy to use interfaces from large, government-run databases, and is very capable of assembling these existing components into a product with high utility and ease of use, and with a minimal learning curve.

# Resume Information for Key Team Members

## *Jonathon Keeney – Founder, Program Manager*

**Summary of Qualifications**

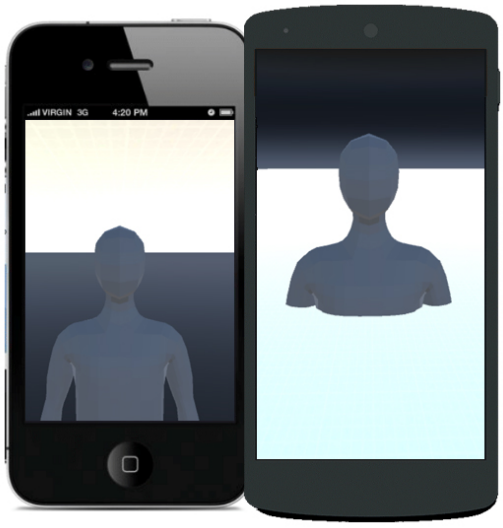
Jonathon Keeney has a Ph.D. in neuroscience and has run a small business, Quandary Studio, for three years. Quandary Studio is a content provider, and has developed content for grants, outreach activities, educational campaigns, documentaries, publications, instructional videos and marketing campaigns, including a spine surgery in virtual reality displayed at the North American Spine Surgery annual meeting in 2016.

More recently, Jonathon launched a startup as cofounder and CSO, called Delta Training, that uses virtual reality technology to train law enforcement. Specifically, Delta Training combines biometrics with virtual reality to evaluate a user's state of mind. The technology immerses a user in a highly stressful environment, while training them to maintain presence of mind. Delta Training fully leverages the immersive potential virtual reality by exposing a user to a threatening environment, training the user to identify and understand their own automatic reactions, and reinforcing leadership habits under these high pressure situations that are intended to mitigate escalation and facilitate a safer outcome for all participants.

Through these experiences, Jonathon has developed skills in developing content for virtual reality, particularly in the field of law enforcement. Jonathon has interfaced with the law enforcement community multiple times, and he has become sensitive to the specific needs and challenges faced by this community.

## *Past Performance*

**VR Spine Surgery:** We developed a virtual reality simulation of a spine surgery for the HTC Vive. Presented at the North American Spine Surgery annual meeting in Boston in 2016, the simulation walked surgeons through a novel form of minimally invasive spine surgery as an orientation. The simulation used a combination of both interactivity and pre-rendered animation. The simulation fully immersed surgeons in an operating environment, and walked experienced and novices through every step of the procedure while adhering to time constraints.



**Body Scan Meditation VR:** A mobile VR app was developed as part of a software package used as a pain management solution. The app acts as a guide for body scan meditation, and provides a user with a visual guide for body scan meditation. The guide not only provides visual cues for body scan meditation, it also sets the appropriate pace, and acts as a focal point to train attention.

## *Brian Lacey – CEO, Executive Oversight*

**Summary of Qualifications**

Brian Lacey is Mobomo LLC's Chief Executive Officer. Brian is responsible for ensuring the successful execution and delivery of all projects across the organization. He also leads the Mobomo User Experience and Design team, responsible for designing and building attractive web, mobile, and cloud applications that are easy to use. Brian has managed and successfully launched cloud-based web and mobile projects including: www.USA.gov and www.GobiernoUSA.gov, the responsive design for www.NASA.gov, the Navy App (iOS/Android) for the U.S. Navy, and The White House Android and iOS apps. In addition to being responsible for the design experience across all applications developed at Mobomo, Brian brings deep expertise in cloud infrastructure, mobile applications, UI/UX, and front-end web development. He holds a degree from Claremont McKenna College. delivery.

**Educational Background**

*B.A., Economics and Psychology, Claremont McKenna College, Claremont, CA 2002.*

**Relevant Experience**

**Mobomo, LLC, Washington, DC**

*Chief Executive Officer, 2011 – Present*

Responsible for overseeing the successful execution and delivery of all projects across the company

- Managed and successfully launched web and mobile projects including:
  - www.USA.gov and www.GobiernoUSA.gov
  - Responsive design for www.nasa.gov
  - OpenSeas for the Navanti Group
  - The Navy App (Web, iOS, Android, Windows Phone)
  - The White House Android and iOS app

- Responsible for the design experience across all applications developed at Mobomo
- Manages a team of graphics designers and front-end developers to create engaging and user-friendly mobile applications and websites
- Managed the design and deployment of apps including Votifi (featured at SWSX this year), Wilmax, InfoAlchemy, Export.gov and USA.gov
- Expert in front-end technologies including jQuery, HTML5, CSS3, responsive design

## *Adam Barthelson – DevOps Software Engineer*

**Summary of Qualifications**

Mr. Barthelson is a full-stack software engineer with a technical background in Python, Ruby, and Javascript web frameworks. As Mobomo's Docker subject-matter expert, he focuses on technical architecture and DevOps engineering. He also heavily advocates test driven development and continuous delivery.

**Relevant Experience**

**Mobomo LLC, Washington, D.C.**

*Senior Software Engineer/Technical Director, 2014 – Present*

***Primary Projects***

**NASA**

- Developed and helped redesign the www.nasa.gov front-end using Ember.js.
- Developed a tool to run load tests and collect performance data using Locust.io and Node.js.

**ITA/Trade.gov**

- Developed a Rails and Angular 1 application to integrate with the Trade.gov API.

**US Department of Defense**

- Developed a Rails and Angular 1 application.

**Center for Cancer Genomics**

- Developed a dashboard to interact with research data using Angular 1 and D3.js.

**Multistate**

- Contributed to a state level legislation tracking tool using Rails.

**Intermedia's Aero Innovation Lab**

- Designed and developed a monitoring and control system prototype for commercial drones with tools including Raspberry Pi, Node.js, Angular 1, Socket.IO, Docker, and AWS.

**Gallup**

- Architected and contributed to the Exchange platform using Angular 1, ASP.NET, Node.js, Grunt, Socket.IO, and AWS.

## *Eddie Ringle – Android Software Engineer*

**Summary of Qualifications**

Mr. Eddie Ringle is a self-taught mobile developer with Mobomo. He has worked as a lead developer on many applications with clients such as White House, US Navy, and the Department of Housing and Urban Development.

**Relevant Experience**

**Mobomo, LLC • Washington, DC**

*Android Developer, 2012 - Present*

**The Official White House App**

- Designed and developed a mobile application to work on both phone and tablet form factors.
- Worked with the White House technical team to refactor their APIs and content for multi-device consumption
- Created dynamic views for the display of text, video, and photo content via feeds
- Built in customizable push notifications to alert user of live broadcast from the White House and enable playback of live events and broadcasts.
- Collaborated and optimized the code base with the White House for the release of the code as part of the White House's open source initiative

**The Official U.S. Navy App**

- Worked with the Navy's Public Office of Communications to design and develop a new mobile app designed to inform active sailors, their families, and the media about real time events and customizable content that impacts their daily lives.
- The application included customizable push notifications and alerts, offline storage of favorited content, interactive live maps & visualizations, video streams, image galleries, and content from over 100 data sources from around the fleet.

**Tactical Edge - Asset Logistics Mobile App**

- Prototyped a logistics system for DOD shipments/inventory/orders, including interactive mapping of those items

- Implemented barcode scanning to easily add items and query specific information
- Utilized the open MQTT protocol in a later stage to add real-time push-like updates to the data and the UI.

## *Scott Thomas – User Experience (UX) / Designer (Graphic Designer)*

**Summary of Qualifications**

Mr. Scott Thomas is our User Experience and User Interface Designer at Mobomo. He offers 4+ years of design experience, launching over 40+ digital projects across various sectors. In his role he develops user strategy and design to create friendly tools that balance business goals and user needs. Scott's keen eye for design and his strong technical background is an essential asset to Mobomo.

**Certifications**

Nielsen Norman Group UX Certificate, Oct 2017 – License 1020017

**Educational Background**

- B. S., Graphic Design, The Art Institution of Pittsburgh, PA, 2011
- Information Technology, Juniata College, PA, 2008

**Relevant Experience**

**Mobomo • Vienna, VA**

*User Interface / User Experience Engineer, 2015 – Present*

Create web products for both commercial and government space. My responsibilities include developing user experience deliverables, conducting research, and designing responsive digital solutions.

- Lead designer for the *NOAA Fisheries redesign* by centralizing 12 regional web properties into a single unified site. Conducted card sorting tests, tree jack test, and click tests. Wireframed and designed responsive solutions that met users needs, business incentives, and requirements. Completing an soft launch with in 12 months.
- Lead the user experience in Gallup Inc upcoming online coaching market place. Designed out the initial user flows and requirements for coaches to book, schedule, and manage coaching system all online. Designed the initial framework for *and* assisted in online and in person user testing and interviews.
- Lead designer for the *NASA Science Mission Directorate* redesign in transitioning from an informative destination to a science news outlet. Conducted card-sorting test to improve the existing navigation. Designed the aesthetics and frame work for both NASA Science and NASA Ciencia.

## Summary Slide

# Advance Warning AR
# Quandary Studio and Mobomo LLC

### Project Summary

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### Participant Summary

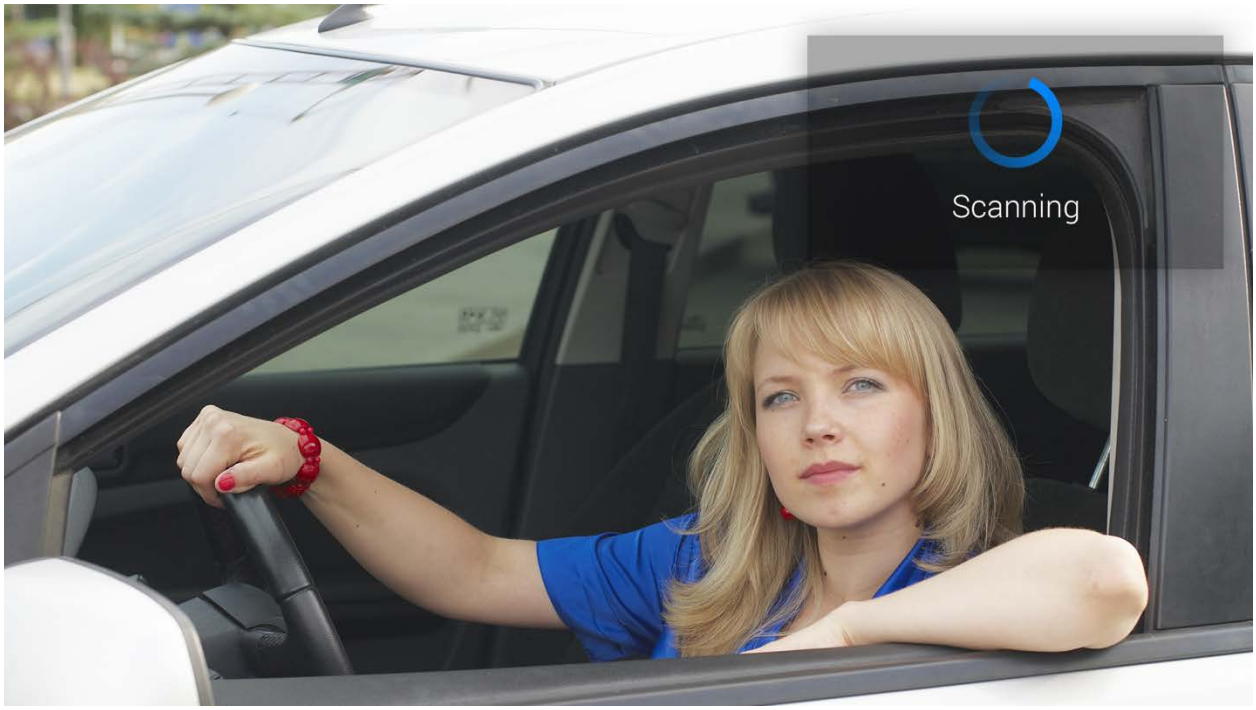
- Quandary Studio is a content provider, and has developed content for grants, outreach activities, educational campaigns, documentaries, publications, instructional videos and marketing campaigns, including a spine surgery in virtual reality displayed at the North American Spine Surgery annual meeting in 2016.
- Mobomo LLC is an award winning software development company that specializes in app development and consumer engagement, serving clients such as The World Bank, USGS, NASA and the National Cancer Institute.

### Technical Outcome

- The Advance Warning AR, an Augmented Reality (AR) system capable of rapid facial detection and identification in a manner that is unobtrusive to the officer's field of view. The system we propose will be able to operate while the officer's attention is focused elsewhere, such as the body language of an individual. The system will be able to detect wanted individuals and violent offenders, and alert the officer in a Heads Up Display (HUD) discreetly without alerting that individual.

# Concept Sketches

## *Situation Example 1: No Record Found*




## *Situation Example 2: Records Found / Potential Threats*



## *Examples of Alternative Screen / Alert Configurations*


MAY BE
DANGEROUS
John Doe
• First degree murder
• Another felony
TAP FOR MORE


John Doe
Wanted for: First degree homicide...
POTENTIALLY
DANGEROUS