Video and Imagery Dataset to Drive Public Safety Capabilities

Andrew Weinert

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LINCOLN LABORATORY
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Bottom Line Up Front

- **Video and imagery are increasingly becoming important to public safety operations but require training data to develop analytics and capabilities**
- **Commercial and open source computer vision capabilities are not robust to and can perform poorly with incident and disaster imagery**
- **An imagery and video dataset of operational and representative public safety scenarios was funded by Public Safety Innovator Accelerator Program (PSIAP) under the Public Safety Analytics portfolio**
- **Presentation scoped for a beginner level of technicality**
  - **Peer reviewed academic publications available for more technical details**
  - **Software available on GitHub in MIT LL organization with "psiap" label: https://github.com/mit-ll**

Computer Vision Is Rapidly Advancing…

"These fake images tell a scary story of how far AI has come – Vox"

Machine Generated Images (These People Don't Exist)

2014

2015

2016

2017

2018

PSIAP Milestones

PSCR Analytics Roadmap Started

PSIAP Funding Announced

PSIAP and Dataset Started

PSIAP Starts Producing Results

https://www.vox.com/future-perfect/2019/5/31/18645993/ai-deepfakes-gan-explained-machine-learning
https://arxiv.org/abs/1406.2661 *https://arxiv.org/abs/1511.06434*
https://arxiv.org/abs/1606.07536 *https://arxiv.org/abs/1710.10196*
https://arxiv.org/abs/1812.04948

… But Is It Advancing for Public Safety?
Most AI Models Not Trained For Public Safety Imagery

"Highway Surrounded by Flooding"
Civil Air Patrol – Hurricane Florence

Cutting Edge Benchmark
AI Labels with Highest Confidence

1. Runway
2. Heliport
3. Landing Deck
4. Airfield
5. Industrial Area
6. Windmill
7. Dam
8. Hangar / Outdoor
9. Construction Site
10. Rice Paddy
11. Moat / Water

… But Is It Advancing for Public Safety?
Many Accurate Labels, Few Useful to Public Safety

"FEMA Urban Search and Rescue on the Road"
Hurricane Maria Response

Commercial "Tech Giant" Service
AI Labels with Highest Confidence

1. Off-roading
2. Vehicle
3. Regularity Rally
4. Car
5. Off-road Vehicle
6. Automotive Tire
7. Jeep
8. Trail
9. Recreation
10. Tire
11. Geological Phenomenon

Objective: Develop Easily-Accessible Imagery Datasets Representative of Public Safety Operations

> **"One of the most fundamental barriers to seamless data integration is simply a lack of awareness or access to datasets that are accurate, current, and relevant to improving response."**
>
> ***– NIST Technical Note 1917: Public Safety Analytics R&D Roadmap, April 2016[1]***

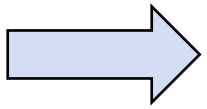
- **Widely used datasets (YouTube-8M[1], YFCC100M[2], COCO[3]) often lack scenarios and features of interest relevant to public safety**
  - **COCO has 1000's of toilet and teddy bear images but none of public safety hazards**
  - **Lack of datasets and benchmarks hinders technical advancement and innovation**

- **PSIAP dataset is a risk reduction to accelerate technology innovation for network providers, application providers, and public safety agencies**
  - **Tailor applications for the public safety community**
  - **Identify where open source and commercial computer vision capabilities are not robust**

PSIAP – Public Safety Innovation Accelerator Program

[1] http://dx.doi.org/10.6028/NIST.TN.1917

Outline



- Introduction
- End-User Driven Design
- Dataset Overview
- Body Worn and Vehicle Use Case
- Low Altitude Aircraft and Drones Use Case
- Reference Architectures for Testing
- Conclusion

End-User Human-Centered Design
Operations Research Methods with Frequent User Engagement

- An iterative design process focused on meeting the needs, and considering the abilities and goals of the person using a product or system
  - Needs: Understanding the person in her/his context
  - Abilities: What is a person able to do safely, comfortably, effectively?
  - Goals: What is the person trying to do? What actions do they think they need to take?

- User failures with products and systems often result from a fundamental mismatch between the designer's mental model and the user's mental model for how the product or system works

- Identified and continually evaluated needs, abilities, and goals
  - Literature review & analysis of FBI Law Enforcement Officers Killed and Assaulted (LEOKA)
  - Engagement with academic, industry, government, and public safety agencies
  - Outreach to and observed New Jersey public safety agencies

Trends in Summaries of Law Enforcement Officers Feloniously Killed (2002-2016)[1]

Foot Investigation / Pursuit

- 150+ narrative summaries
- Officers often operate in unfamiliar areas, limiting SA
- Significant risk in rounding corners or hoping fences

Prior Criminal Record

- 300+ narrative summaries
- Officers may not be aware of prior criminal record
- Injuries often occur in known dangerous scenarios

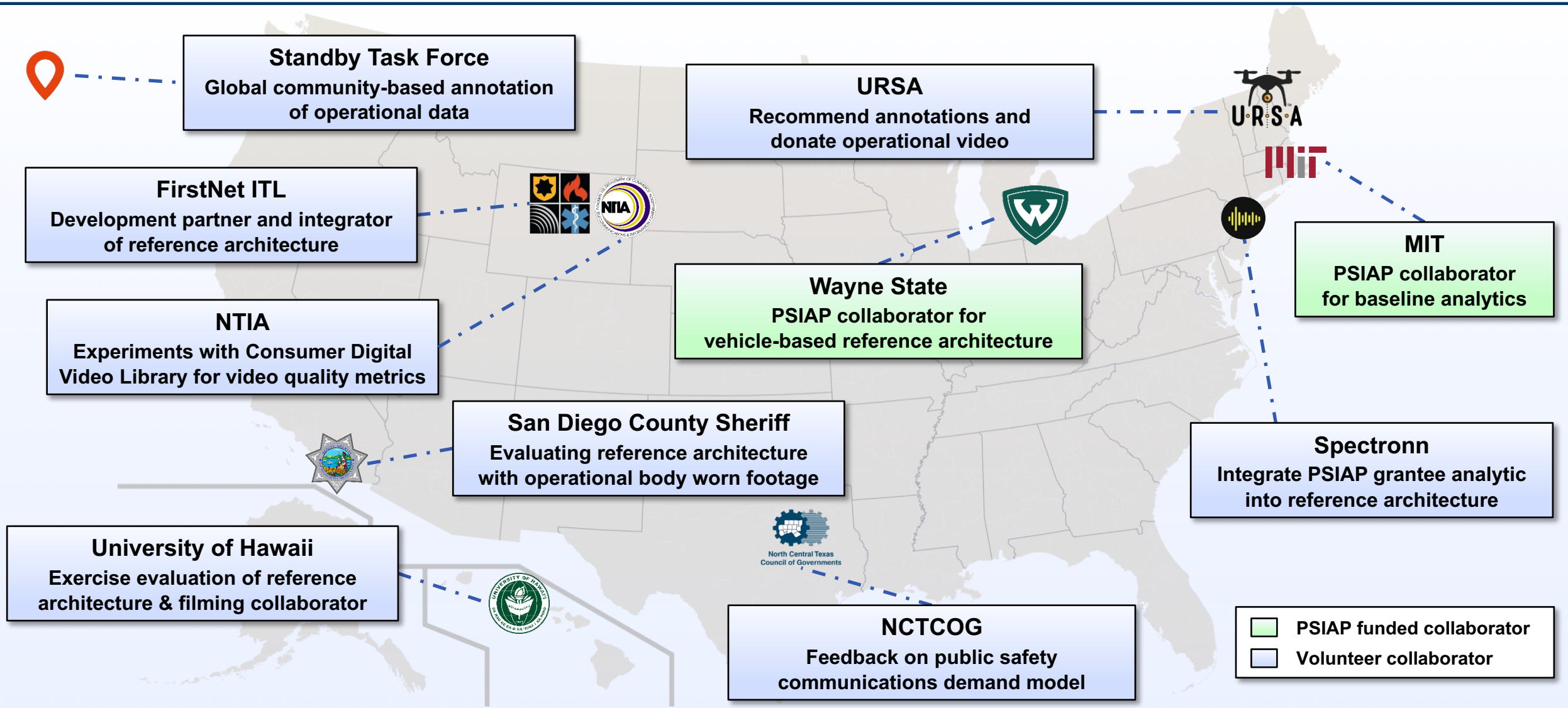
Body Armor

- 400+ narrative summaries
- Often equipped with appropriate PPE when killed
- Victims often shot at close ranges (≤ 10 ft.)

< 40 summary narratives explicitly mention "camera" or "video"

SA – Situation Awareness
PPE – Personal Protective Equipment
[1] Law Enforcement Officers Killed and Assaulted, FBI UCR, https://ucr.fbi.gov/leoka/2016/ebook-and-pdf-of-narratives/

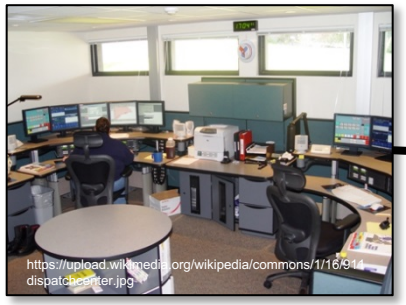
External Engagements Supporting PSIAP Dataset Development



MIT: Massachusetts Institute of Technology
ITL: Innovation and Test Lab
NTIA: National Telecommunications and Information Administration
NCTCOG: North Central Texas Council of Governments
URSA: Unmanned Robotics Systems Analysis

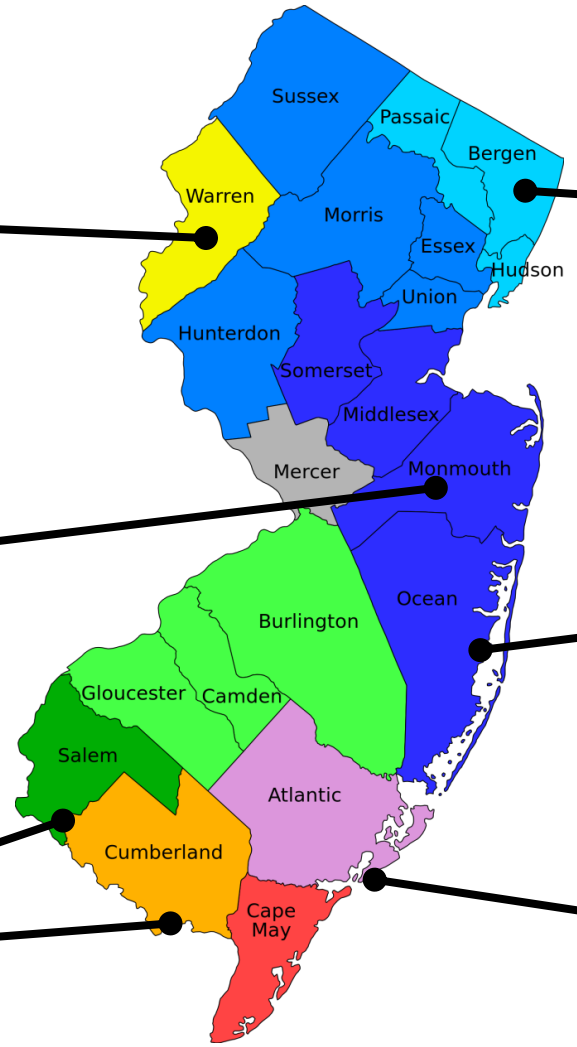
New Jersey Public Safety Engagement
Discussed Routine Incidents to Large Diasters

Warren County PSAP



Fire Academy

Southern NJ Long Term Care



New Jersey State Police

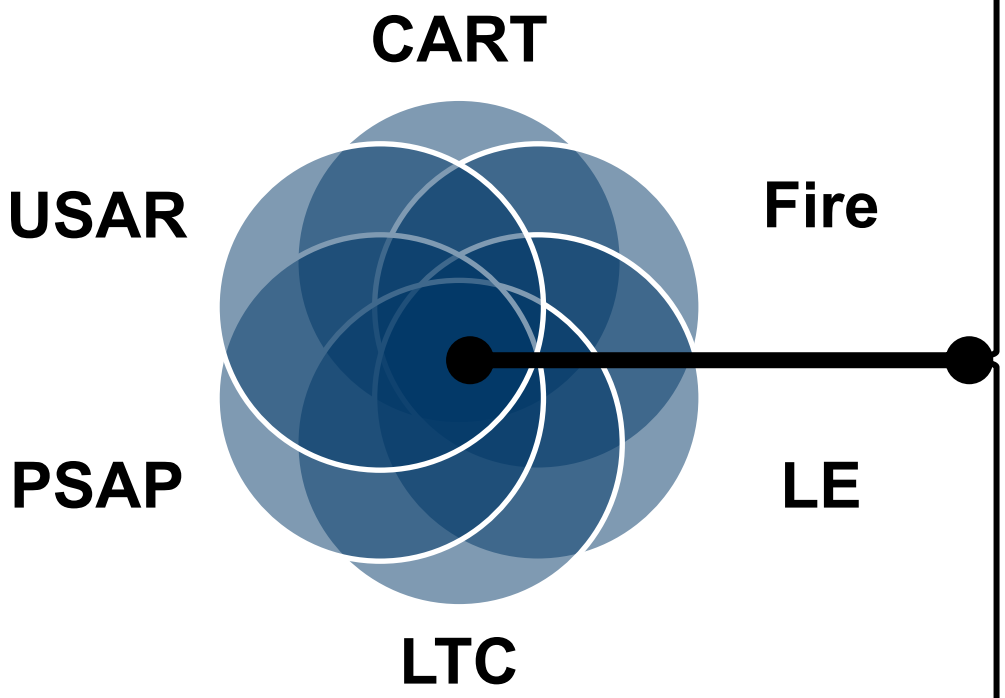
County Animal Response Team

New Jersey Task Force-1 (USAR)

Atlantic City Police Department

CART – County Animal Response Team
PSAP – Public Safety Answer Point
USAR – Urban Search and Rescue

Common Desired Capabilities:
What Should the PSIAP Dataset Help Develop?

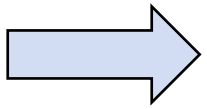


- **Improve incident or threat description**
  - Improve resource allocation (personnel and gear)
  - Reduce response time with more efficient response
  - Prepare back-up resources better
- **Improve two way situational awareness**
  - "Second pair of eyes" for 1-officer assignments
  - Cue "central" (PSAP, etc.) of responder's status
  - Respect privacy and limit spying perception
- **Minimize implementing new workload or policies**
  - Reduce amount of data needed by transmit computed edge analytics, not raw video
  - Consider limited budgets and strict governance

CART – County Animal Response Team
LE – Law Enforcement
LTC – Long Term Care

PSAP – Public Safety Answer Point
USAR – Urban Search and Rescue

Outline



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PSIAP Dataset Scenarios Priorities
Informed by Public Safety Community

Body & Vehicle Use Case

1. **Foot Pursuit**
   - Pursuit can occur in a variety of low and high risk law enforcement scenarios
   - Body-cam footage often an important forensic resource after incident

2. **Approaching an incident**
   - Common occurrence consisting of initial seconds of a traffic stop, approaching a crowd, etc.
   - Rapid escalation to a dangerous scenario possible within seconds

Airborne Use Case

3. **Wide Area Search**
   - Indicated as time and personnel intensive response
   - Encompasses a diverse range of environments and conditions

Scenarios selected based on applicability across jurisdictions to maximize utility: urban / rural, state / local, high / low income

Rational for not focusing on CCTV

- **Many responders operate in areas without indoor or outdoor CCTV capabilities**
  - **Not all surveillance cameras are public safety owned with real-time access for public safety**
  - **Interoperability challenges across surveillance vendors**
  - **Criminal behavior influenced by CCTV presence**

- **CCTV systems are a recognized force multiplier with well defined use cases**
  - **"adding extra eyes in public areas throughout the city[1]"**
  - **Predictive policing already an active research area and commercial capability**

"We're seeing a lot of people beginning to sell [drugs] from houses. It's a little bit difficult to make an arrest. Whereas when you're watching a drug deal on the street, you can just make the arrest right there [sic]"

– Camden County Police Department Officer,
on how drug activity change in response to police use of CCTVs[2]

[1] Closed Circuit Television Annual Report of the Metropolitan Police Department – 2007, August 2012, https://mpdc.dc.gov/node/209052
[2] VICE on HBO Season 2: Surveillance City and The Forgotten War (Episode 12), Feb 2015, https://youtu.be/fVDvJCeCe54

Imagery and Video Sources

500,000+ operational images and 50+ hours of video

Civil Air Patrol

Defense Visual Information Service

Massachusetts Task Force One

MIT Lincoln Laboratory

Unmanned Robotic Systems Analysis

United States Geological Survey

University of Hawaii

YouTube Creative Commons

Annotation Approach

- **The PSIAP dataset includes both *thing* and *stuff* categories[1]**
  - ***Thing:* something that can be easily and discretely labeled (i.e. book, person, yacht)**
  - ***Stuff:* less discrete and many have no clear boundaries (i.e. damage, flooding, danger)**
  - **Many datasets consist of just only *things***

- **Annotations are hierarchically structured with scene descriptions and polygon borders**
  - **Scene description: "Does this image contain a vehicle?"**
  - **Polygon border: "Trace a polygon around the border of the vehicle"**

- **Amazon Mechanical Turk (Mturk) used to crowdsource annotations with humans**
- **Machine generated annotations from pretrained classifiers computed using Lincoln Laboratory Supercomputing Cluster (LLSC)**
  - **Adopted best practice proposed by YouTube8M of "remov[ing] computational barriers by pre-processing the dataset and providing state-of-art features[2]"**

[1] Heitz, Geremy, and Daphne Koller. "Learning spatial context: Using stuff to find things." European conference on computer vision. Springer, Berlin, Heidelberg, 2008.
[2] Abu-El-Haija, N. Kothari, J. Lee, P. Natsev, G. Toderici, B. Varadarajan, and S. Vijayanarasimhan, "YouTube-8m: A Large-Scale Video Classification Benchmark," arXiv:1609.08675 [cs], Sep. 2016

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Body Worn and Vehicle Cameras: Significant Unrealized Analytical Potential

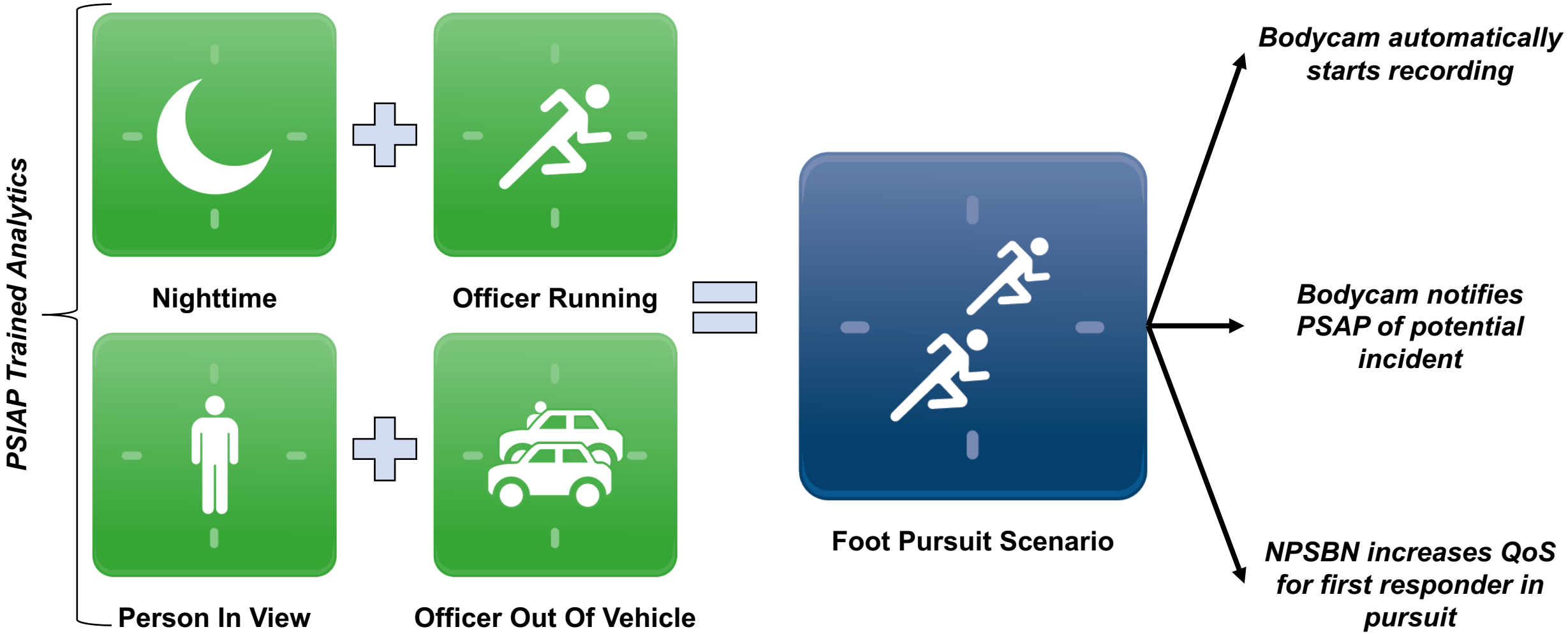
- PSAP reliant upon LE to actively check-in, respond to status queries, or activate BWC
- PSIAP dataset should enable the development of video analytics at the device / network edge that reduce cognitive overload on first responders
  - BWCs are continually being invested in but have varying buy in / acceptance from the public safety community and public at large
  - Vehicle capabilities are increasing with one-vehicle patrols common

The officer […] exited his patrol vehicle, and cut through backyards on foot. When he came upon a wooden fence, the veteran officer climbed it, at which time he apparently encountered the subject, who shot him with the rifle...

"The dash-mounted camera showed […] the officer approached the suspect's vehicle and engaged in a conversation with the driver. As the officer looked down at his ticket book, the man produced a handgun. The white flash of an apparent gunshot appeared…"

BWC – Body Worn Camera
LE – Law Enforcement
PSAP – Public Safety Answer Point

PSIAP Dataset Can Train the Intelligence of the "Body Worn Camera of the Future"



PSAP – Public Safety Answer Point
NPSBN – Nationwide Public Safety Broadband Network
QoS – Quality of Service

Strategic and Fiscal Needs for Body Worn Analytics

- **Storage and maintenance costs are significant and relatively new burden on budgets[1]**
  - **Archiving just body camera footage could be $500K+ per year[2]**
  - **Forensic and investigative policies have varying data retention policies…potentially years**

- **Agencies may not have infrastructure or policy to monitor influx of new data streams**
  - **Many video streams go relatively unmonitored already (i.e. traffic cameras)**
  - **Analytics to cue human operators are increasingly becoming needed**
  - **Streaming all deployed cameras may be fiscally infeasible due to cellular data costs**

- **Redacting video for Freedom of Information Act requests is resource intensive**
  - **Indexing video frames that unlikely need redaction is a potential gamechanger and can support better allocation of human resources**
  - **i.e. If an officer is in their vehicle and alone, redaction likely isn't needed**

[1] Rick Callahan. "Some police departments shelve body cameras, cite data costs." September 2016. https://apnews.com/f19d7270535f4202b92de1872278330f
[2] Kate Ryan. "Cost of archiving police body cam footage for year: Over $500K." April 2017 https://wtop.com/montgomery-county/2017/04/archiving-police-body-cam-footage-for-year-500000/

Daily Law Enforcement Features of Interest

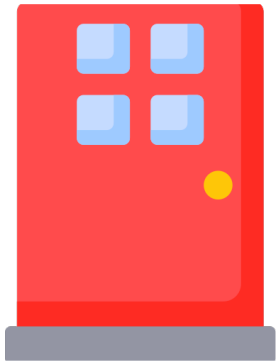
"When I'm chasing someone, there isn't any special training…just catch them"

– *NJ State Police Officer*

Daily Routine Law Enforcement

Completing Reports

Driving



Knocking on Doors and House Checks

Speaking to People

Features of Interest Comparable Between Operational and Representative Video

Denver Police
Operational Video

MIT Lincoln Laboratory
Representative Video

Sensitive and private video is NOT required to capture the technical features of interests associated with many daily law enforcement activities

Body Worn and Vehicle Annotations: Supporting Computer Vision Scene Description Analytics

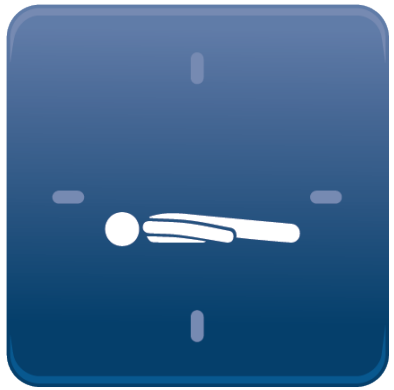
Nighttime

Officer Running

Backpack in View

Multiple People

Officer Out of Vehicle



Officer Prone

Vehicle In View

Person in View

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Annotating Civil Air Patrol (CAP) Imagery For Response and Research

- **Public safety outreach indicated a need for an airborne-based dataset**
  - **Desire and intent to deploy drones in response to small and large incidents**
  - **Analytics based on airborne image can improve situational awareness for first responders**
  - **Drone operations are particularly stressed at the tactical edge where public safety operates**
  - **Difficult to quickly and efficiently share airborne imagery collected during an incident, indicating a need to develop analytics to support processing, exploitation, and dissemination**

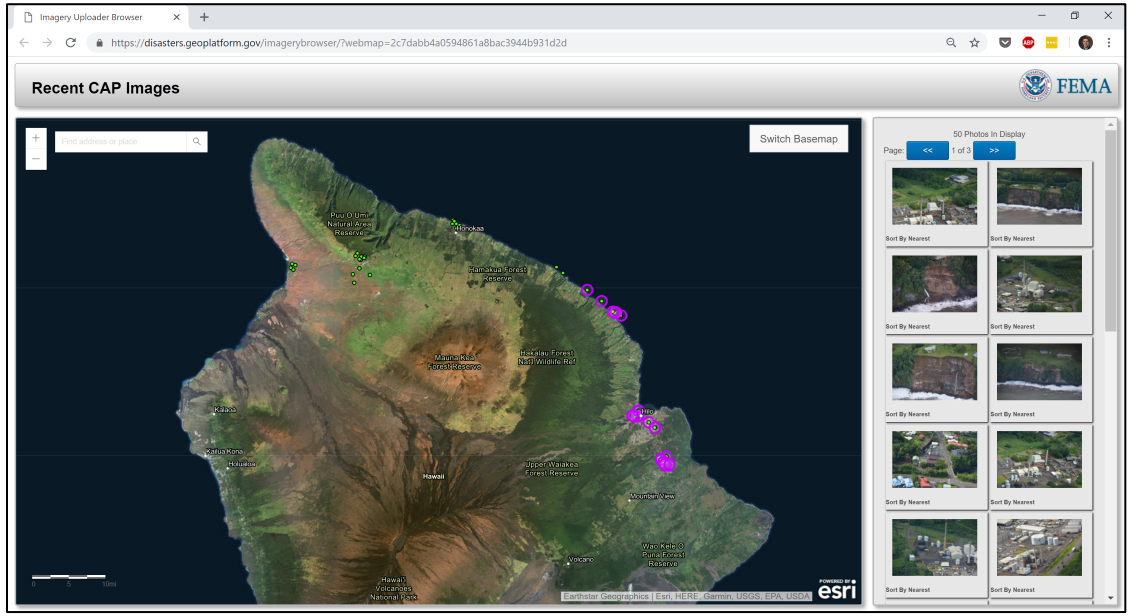
- **Development of representative dataset for public safety is a large combinatorial challenge[1], leveraging existing resources is crucial**
  - **CAP responds to wide range of incidents, which PSIAP can freely and easily leverage**
  - **CAP response enables PSIAP program to focus development efforts on other datasets**

- **Potential technology transition partners across government, academic, industry and response organizations**

[1] A. Weinert and C. Budny, "Outreach to Define a Public Safety Communications Model For Broadband Cellular Video," 2018 IEEE International Conference on Technologies for Homeland Security (HST), Woburn, MA, 2018

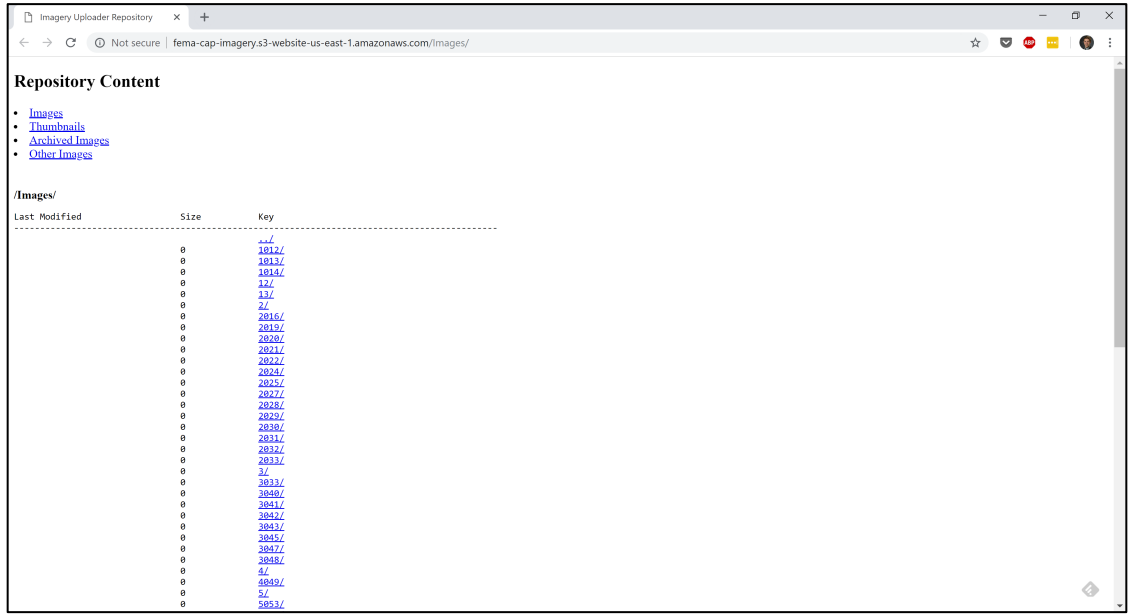
CAP Imagery Access: Web Browser and Interfaces

Web Browser



https://disasters.geoplatform.gov/imagerybrowser/?webmap=2c7dabb4a0594861a8bac3944b931d2d

AWS, ESRI, OFC WMS, WFS



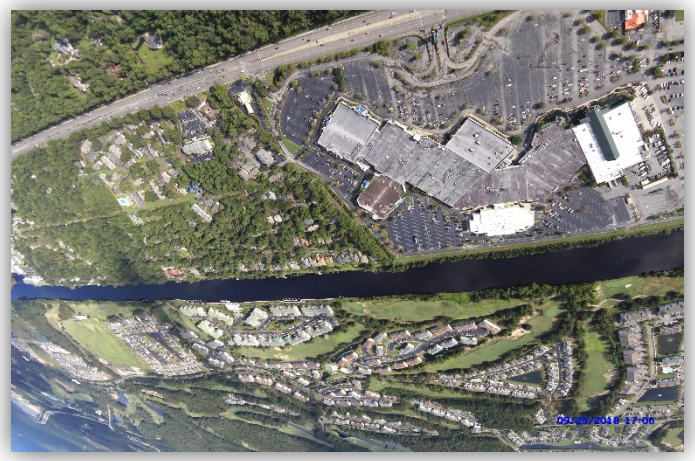
http://fema-cap-imagery.s3-website-us-east-1.amazonaws.com/Images/
https://imageryuploader.geoplatform.gov/arcgis/rest/services/ImageEvents/MapServer
https://imageryuploader.geoplatform.gov/arcgis/services/ImageEvents/MapServer/WMSServer?service=WMS&request=GetCapabilities

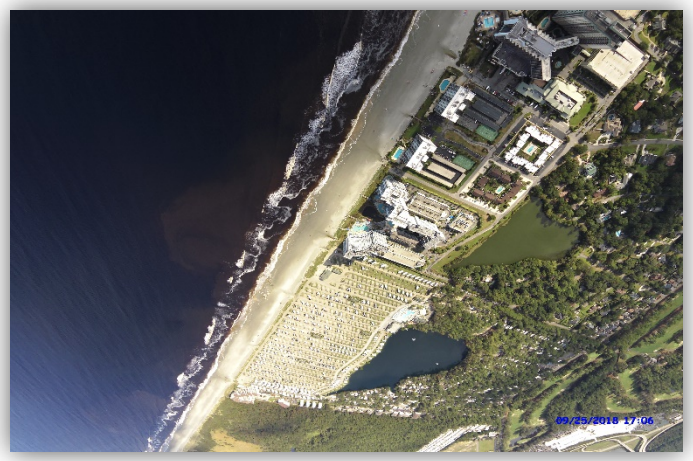
Imagery is easily and freely available but lacks annotation and features required to support response and research

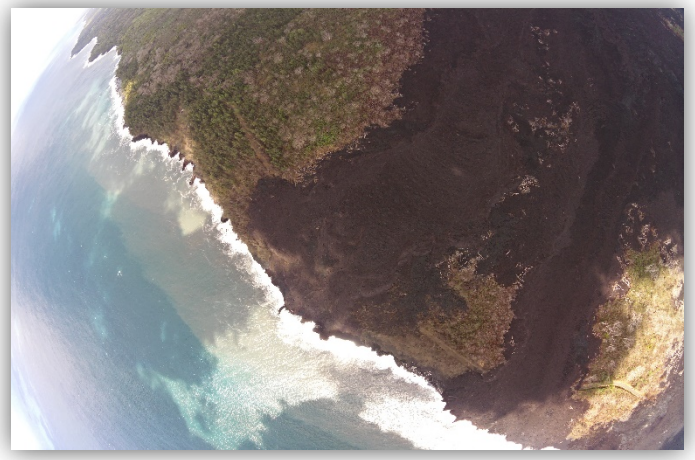
Website retrieved on 2018-12-05

Real World Data is Challenging and Messy

Different Angles, Zoom, Distortions, Biases…







https://fema-cap-imagery.s3.amazonaws.com/Images/9096/615118/VIRB0470_b5dc723f-e102-4215-a6d7-6f8b83ba6172.jpg
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https://fema-cap-imagery.s3.amazonaws.com/Images/9096/615077/DSC_4173_ddb900bd-9878-4ba0-96e3-99fe77cb5afa.jpg
Website retrieved on 2018-12-05

Ideal Dataset: Significant Diversity of Features

Raw Data Exists, We Just Need to Annotate It

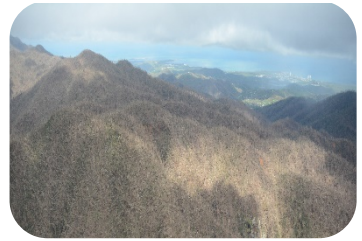
Coastal

Critical Infrastructure

Debris

Flooding

Landslide



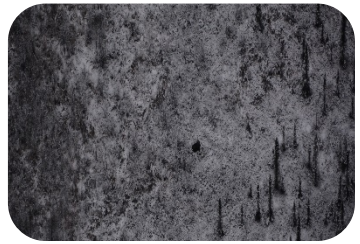
Mountainous

Offshore

Rural

Snow

Urban



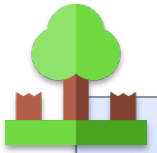
Vegetation

Volcanic

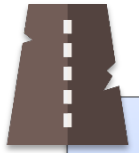
Tens of thousands of images with a wide range of relevant public safety features across different environments that will continue to grow independent of the PSIAP effort

32 Features of Interest Across 5 Classes
Polygon Annotations

Damage (6)
- damage
- fire
- landslide
- road washout
- rubble
- smoke



Environment (7)
- dirt
- grass
- lava
- sand
- shrubs
- snow
- trees



Infrastructure (9)
- bridge
- building
- dam
- pipe
- powerlines
- railway
- road
- tower communications
- tower water

Vehicle (5)
- aircraft
- bicycle
- boat
- car
- Truck

Water (5)
- flooding
- lake
- ocean
- puddle
- river

Features of interest selected based on engagement with two USAR teams, prioritization of labels for a popular object detector[1], and aligning with ASPRS classification codes

ASPRS – American Society of Photogrammetry and Remote Sensing

[1] Redmon, Joseph, and Ali Farhadi. "Yolov3: An incremental improvement." arXiv preprint arXiv:1804.02767 (2018).

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Reference Architectures

- **Developed data set should address specific video workflow components**
  - **Potential use of data set and targeted analytics need to be stated upfront**
  - **Technology transition of assumed future R&D should be a key consideration**

- **Reference architectures prototyped to streamline and enable easy use of PSIAP dataset by academia and industry**

- **Development significantly supported by engagement with external organizations**
  - **Demonstrate that others can use the PSIAP dataset**
  - **Open sourcing software is more than releasing code of the internet...**

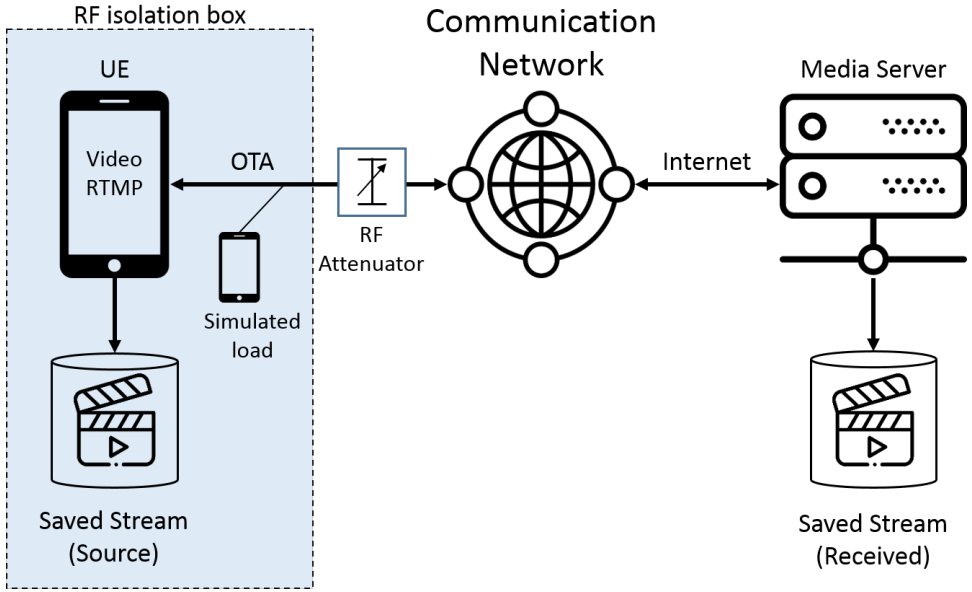
Major Public Safety Video Workflow Components[1]

[1] J. Garofolo, et al., "First Workshop on Video Analytics in Public Safety," NISTIR 8164, Jan. 2017. https://www.nist.gov/sites/default/files/documents/2017/01/19/ir_8164.pdf

Reference Architecture for Testing at FirstNet
PSIAP Dataset over the AT&T Network

- First 3rd party to prototype video experiments at the FirstNet Innovation and Test Lab
  - Open source software leveraged; new software will be open sourced
  - Revocable license signed prior to testing
  - Test parameters included attenuation, radio spectrum, ARP, QCI, and SIM
- Network stressing limited to simultaneous active UE connections rather than bandwidth constraints
- Technical details will be found in future IEEE Networking Letters submission

PSIAP Testing Architecture

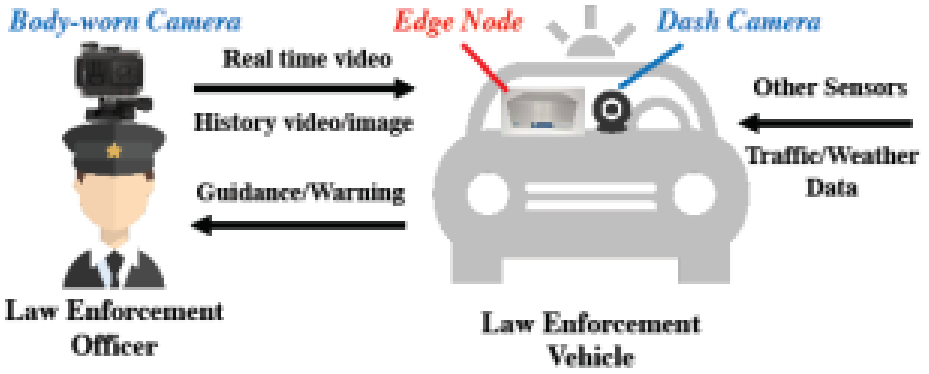


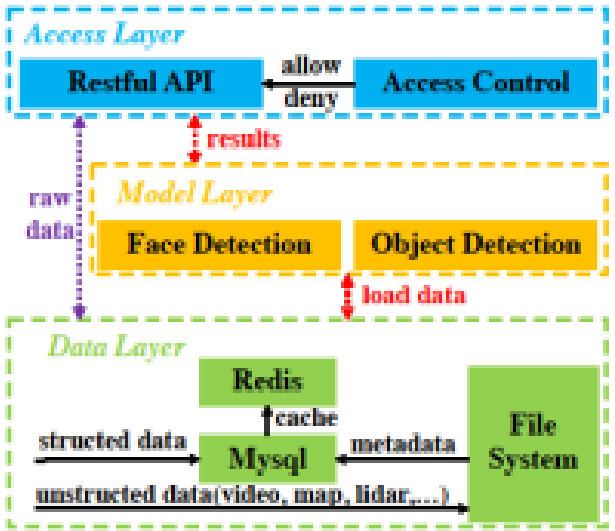
ARP: ALLOCATION AND RENTION PRIOIRTY
QCI: QoS CLASS IDENTIFIER
SIM: SUBSCRIBER IDENTIFY MODULE

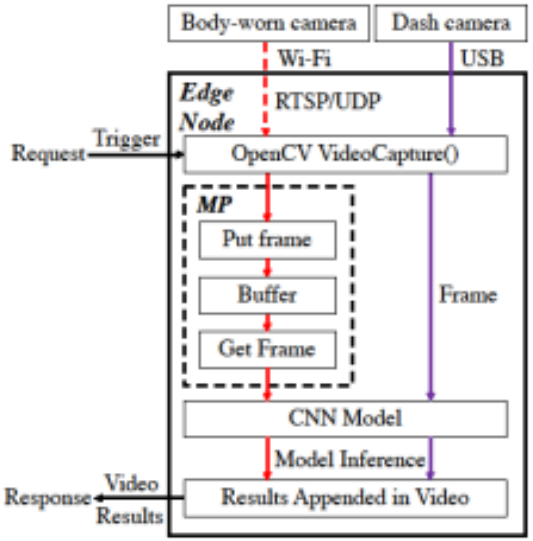
UE: USER EQUIPMENT
RF: RADIO FREQUENCY
RTMP: REAL-TIME MESSAGING PROTOCOL

Reference Architecture for In-Vehicle Testing
AutoVAPS: an IoT-enabled public safety service on vehicles

- Dr. Weisong Shi and Wayne State are developing a prototype that integrates representative public safety sensors and vehicles
- Initial performance of AutoVAPS highlighted latency challenges of the public safety environment
- Led to collaboration with another PSIAP grantee, Spectronn







L. Liu, et al. "AutoVAPS: an IoT-enabled public safety service on vehicles." Proceedings of the Fourth Workshop on International Science of Smart City Operations and Platforms Engineering, Montreal, CA, 2019. doi: 10.1145/3313237.3313303

Available Software Today
https://github.com/mit-ll

- https://github.com/mit-ll/PSIAP-DL-YouTube-CC
  https://vqeg.github.io/software-tools/helper%20tools/psiap-dl-youtube-cc/
  - Python script to download all Creative Commons licensed videos from a YouTube channel
  - Adopted by the Video Quality Experts Group (VQEQ): Tools and Subjective Laps Setup Group

- https://github.com/mit-ll/PSIAP-Video-Classifier-Deployment
  - A containerized deployment of a Tensorflow-serving server and client container for classifying frames of video
  - Leveraged by PSIAP grantee, Spectronn, to prototype an edge situation awareness analytic

- https://github.com/mit-ll/PSIAP-CAP-Annotation
  - Web application for semantic annotation of Civil Air Patrol images
  - Iterated design with feedback from Standby Task Force

FirstNet reference architecture and more software will be released later this summer

Outline

- Introduction
- End-User Driven Design
- Dataset Overview
- Body Worn and Vehicle Use Case
- Low Altitude Aircraft and Drones Use Case
- Recommendations to the Community
- Conclusion

Available Peer Reviewed Publications

- J. Liu, D. Strohschein, S. Samsi, and A. Weinert, “Large Scale Organization and Inference of An Imagery Dataset for Public Safety,” *submission to IEEE High Performance Extreme Computing Conference (HPEC)*, Waltham, MA, 2019
- J. Liu, A. Weinert, and S. Amin. "Semantic Analysis of Traffic Camera Data: Topic Signal Extraction and Anomalous Event Detection." *arXiv preprint arXiv:1905.07332*(2019).
- L. Liu, et al. "AutoVAPS: an IoT-enabled public safety service on vehicles." *Proceedings of the Fourth Workshop on International Science of Smart City Operations and Platforms Engineering*, Montreal, CA, 2019. doi: 10.1145/3313237.3313303
- J. Liu, A. Weinert and S. Amin, "Semantic Topic Analysis of Traffic Camera Images," *2018 21st International Conference on Intelligent Transportation Systems (ITSC)*, Maui, HI, 2018, pp. 568-574. doi: 10.1109/ITSC.2018.8569449
- A. Weinert and C. Budny, "Outreach to Define a Public Safety Communications Model For Broadband Cellular Video," *2018 IEEE International Symposium on Technologies for Homeland Security (HST)*, Woburn, MA, 2018, pp. 1-4. doi: 10.1109/THS.2018.8574193

Upcoming Publications

- **Submission to IEEE Networking Letters (LNET) on experimenting with the PSIAP dataset at the FirstNet Testing and Innovation Lab**
- **Submission to MDPI Remote Sensing on the technical details on the hierarchical annotation approach and Civil Air Patrol (CAP) use case**
- **Analysis of USAR GPS tracks to characterize environment in which public safety broadband will need to support**
- **Recommendation on crowd source qualifications to support incident and disaster response annotations**

Bottom Line

- Video and imagery are increasingly becoming important to public safety operations but require training data to develop analytics and capabilities
- Commercial and open source computer vision capabilities are not robust to and can perform poorly with incident and disaster imagery
- An imagery and video dataset of operational and representative public safety scenarios was funded by Public Safety Innovator Accelerator Program (PSIAP) under the Public Safety Analytics portfolio
- Presentation scoped for a beginner level of technicality
  - Peer reviewed academic publications available for more technical details
  - Software available on GitHub in MIT LL organization with “psiap” label: https://github.com/mit-ll

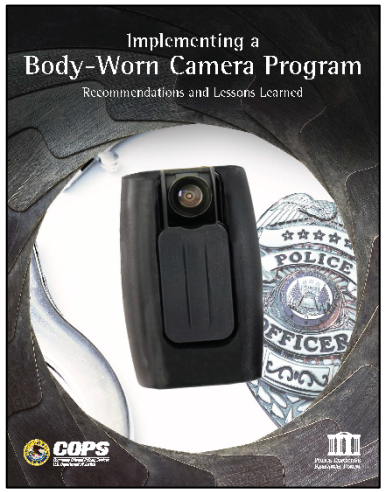
Thank You!

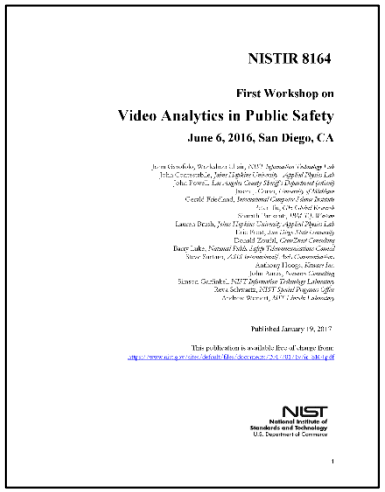
Questions?

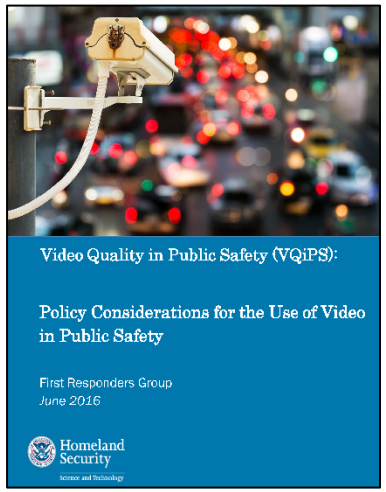
Feedback?

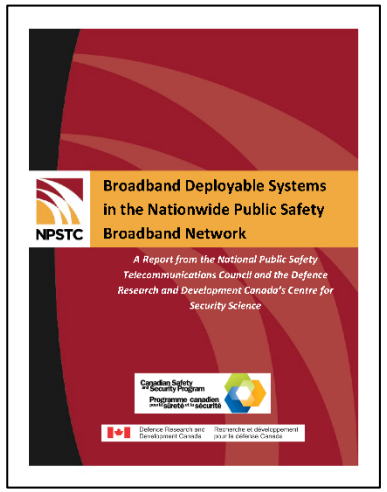
Andrew Weinert
Associate Technical Staff
Humanitarian Assistance and Disaster Relief
Email: andrew.weinert@ll.mit.edu

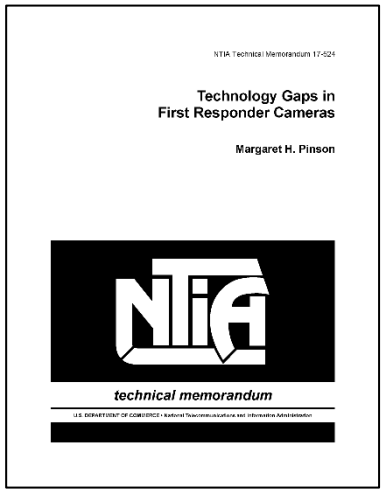
National, State, Local Literature

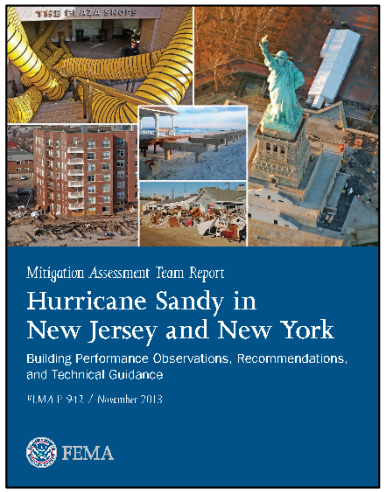


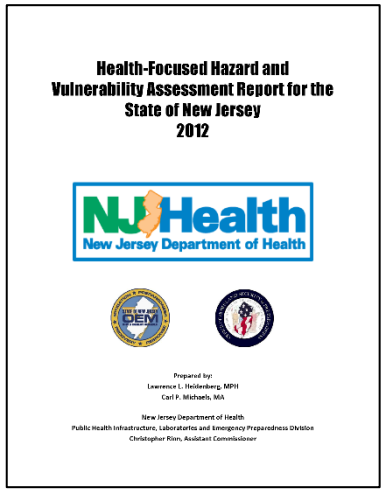


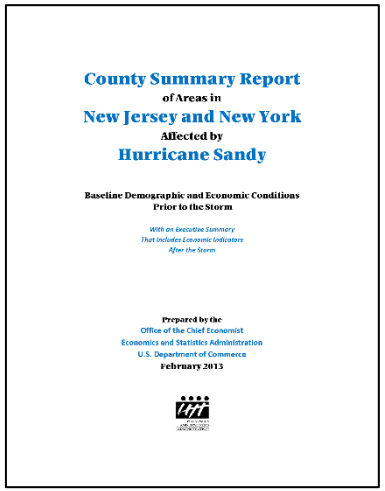


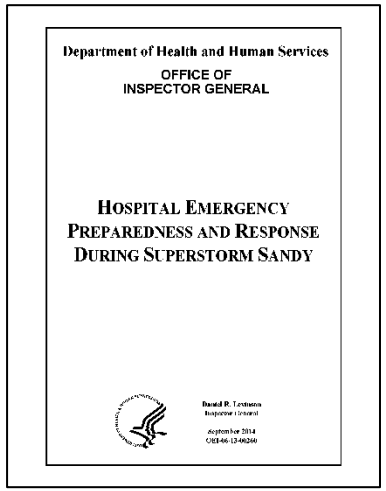












The New York Times

VICE

npr

FBI Uniform Crime Report
Law Enforcement Officers Killed & Assaulted

- **FBI aggregated data from 12K+ law enforcement agencies employing 586K+ officers**
  - **Agencies servicing 268M+ person (83% of nation's population)**
  - **Statistics available for the last ten years since 2007**
  - **Narrative summaries available for each officer's felonious death since 2002**

- **Analyzed to identify and characterize dangerous scenarios faced by law enforcement**
  - **Consideration that technology development should help address dangerous scenarios**
  - **57,180 officer assaults in 2016 (8.8 per 100 sworn officers)**
  - **118 officers died in 2016 (66 – felonious incidents, 52 – accidental)**

UCR – UNIFORM CRIME REPORT

[1] Law Enforcement Officers Killed and Assaulted, FBI UCR, https://ucr.fbi.gov/leoka/2016

Commercial Computer Vision Product Accurate Labels

CIVIL AIR PATROL IMAGE
PUERTO RICO

COMMERCIAL COMPUTER VISION

Aerial Photography	Bridge	Controlled-Access Highway	Geology
Geological Phenomenon	Infrastructure	Photography	Road

Bridge-Tunnel	Dam	Geological Phenomenon	Hill Station
Infrastructure	Resource	Water	Water Resources

False Positive (Mislabel)

True Positive (Accurate)

Commercial Computer Vision Product Mislabels

CIVIL AIR PATROL IMAGE

COMMERCIAL COMPUTER VISION

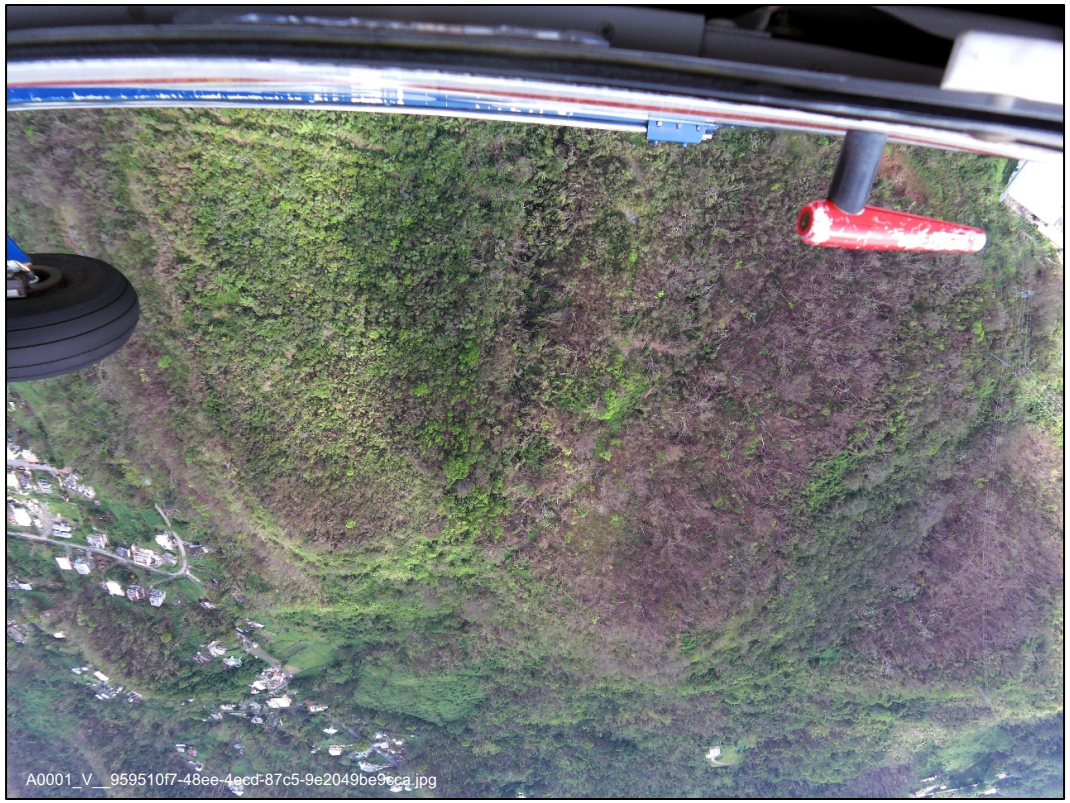
Automotive Design	Auto Part	Car	Design
Electric Motor	Metal	Motor Vehicle	Vehicle

Aerial Photography	Bird's-eye view	Bridge-Tunnel	Overhead Power Line
Sky	Tower	Transmitter Station	Tree

False Positive (Mislabel) True Positive (Accurate)

Aerial Photo of Forest Labeled as “Car”
Commercial Computer Vision Product Mislabels

CIVIL AIR PATROL IMAGE
PUERTO RICO



CROPPED
(Removed Aircraft Wheel and Fuselage)

COMMERCIAL COMPUTER VISION

Automotive Exterior	Car	Grass	Luxury Vehicle
Motor Vehicle	Sedan	Tree	Vehicle

Aerial Photography	Biome	Forest	Geology
Geological Phenomenon	Grass	Map	Vegetation

False Positive (Mislabel) True Positive (Accurate)

#PSCR2019

Come back for the

Next Session

2:40 PM