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The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center surveyed the security landscape (mobile robot security guards, video analytics security) to determine the current state of the art, and identify a system suited to DOE's security situation. The researchers provided information to the project panel supporting lease or purchase of an appropriately sized security system targeted for one yard. The panel opted to pilot test the camera-based system from Omniflow. The researchers procured the Omniflow system, along with construction and installation services from Metro Electric, while organizing the integration to the Marysville equipment yard. The Omniflow security system was deployed to capture security footage and provide live surveillance. The researchers developed a pilot test plan to evaluate key features, including ease of installation and deployment, system optimization by the vendor, power storage and management, video surveillance operation in various conditions (bright sun, night, fog, rain), video transmission, video analytics, autonomous capabilities, remote system monitoring, and maintainability. However, researchers did not have the opportunity to test the system as of the release date of this report.

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Evaluation of Advanced Security Systems for Caltrans Equipment Yards/Maintenance Stations

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Division of Research, Innovation and System Information

Executive Summary

This report details the progress made in a yard security project Phase I, which concluded with the implementation of a camera system (by company Omniflow) at the Marysville Caltrans maintenance yard. This system is made out of seven non-portable surveillance poles equipped with the OmniLED 07 model (which provides 360° lighting and power supply, generation, and storage system) with the addition of fixed camera sensors (detecting movements in the yard perimeter/fencing), rotating Infrared Pan-Tilt-Zoom cameras (tracking intruders during day and night), and radar sensors (detecting movements inside the yard). This task was originally proposed to test and evaluate the above-mentioned security system, but due to several technical and regulatory challenges delaying the implementation of this system, tasks associated with pilot testing, evaluation, and cost-benefit analysis have been reassigned to Phase II project planned to kick off in 2025.

Problem, Need, and Purpose of Research

The California Department of Transportation (DOT) (Caltrans) has many large fenced and secured equipment and maintenance yards, with stored vehicles. Despite security measures, Caltrans still experiences vehicle component theft from their yards. Caltrans yards have experienced significant increase in theft recently. It appears that Caltrans security measures are not adequate to deter today's criminals. Catalytic converter thefts have cost the Division of Equipment (DOE) over $4M cumulatively statewide, and approximately $2M per year. Thefts like the catalytic converter thefts also lead to follow-on costs such as for repairs and replacement vehicle rental or purchase. Caltrans currently uses 24-hour security guards in some yards, which can cost about $400,000 per year per guard and provides risk to the human guard. Caltrans buildings are typically alarmed, but yards generally have insufficient security.

Caltrans needs a modern security system. One possible solution are mobile robot security guards; another possible solution leverages fixed cameras and human monitoring or automatic analytics. Each solution holds the promise of greatly reducing the theft problem and associated costs. The goal of this research is the evaluation and pilot testing of one such modern security system.

Overview of the Work and Methodology

The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center surveyed the security landscape (mobile robot security guards, video analytics security) to determine the current state of the

art, and identify a system suited to DOE's security situation. The researchers provided information to the project panel supporting lease or purchase of an appropriately sized security system targeted for one yard, which was chosen to be the Caltrans' Marysville yard. The panel opted to pilot test the camera-based system from Omniflow. The researchers procured the Omniflow system, along with construction and installation services from Metro Electric, while organizing the integration to the Marysville yard.

The Omniflow security system was deployed to the Marysville equipment yard for extended pilot testing to capture security footage and provide live surveillance in all weather conditions. As of August 2025, AHMCT completed the following tasks:

- Survey the mobile robot security guard landscape,
- Survey the video analytics security landscape,
- Support project panel selection of a security system to be evaluated,
- Develop a pilot test plan,
- Implement the system, e.g., procurement, construction, installation, and system activation at the Marysville yard.

Furthermore, the researchers developed a pilot test plan to evaluate key features, including ease of installation and deployment, initial system optimization by the vendor, power storage and management, video surveillance camera operation in various conditions (bright sun, night, fog, rain), video transmission, video analytics, autonomous capabilities, remote system monitoring, and maintainability. However, researchers did not have the opportunity to test the system as of the release date of this report.

Core features of system monitoring, alarming, and alerting were also the primary focus in this project. The Omniflow security system is expected to support sophisticated analytics for intruder recognition and subsequent alarm generation. A third-party monitoring service is required to communicate with the appropriate agencies, e.g., California Highway Patrol, Caltrans dispatch center, and yard personnel. This detection, alarm generation, and communication process, namely the security/safety event response procedure, was developed in a related coinciding project, research task 4288, which evaluated robot guards for yard security.

Due to unexpected delays caused by technical challenges associated with outdated infrastructure at the pilot testing location and regulatory concerns regarding construction and trenching at Caltrans yards, it was agreed upon with the panel to leave out the following actions dedicated to evaluating the Omniflow system:

- Support pilot testing at Marysville yard,

- Perform specific tests to scientifically assess key issues,
- Perform initial cost-benefit analysis comparing typical theft cost vs. system cost,
- Provide an initial summary of system management issues and options,
- Survey and/or interviews of pilot study personnel to determine their experience with the selected security system.

Major Results and Recommendations

This project concluded with the full implementation of a security camera system at the Marysville yard. While the testing and evaluation of this system was reassigned to a future project, the time spent on dealing with technical and regulatory obstacles allowed the researchers to learn more about Caltrans Equipment Yards and Maintenance Stations and explore aspects of the project which were originally not considered, e.g.,

1. Procurement challenges associated with foreign vendors or even vendors outside of California that require
    - Additional/local vendors to implement the system in coordination with all parties involved,
    - Registration with California Department of Industrial Relations to provide labor,
    - Power of attorney to import cargo into the states,
    - Additional supporting documents for any purchase orders from University of California.
2. The technical hardship of safely implementing electrical modifications and large-scale construction tasks in old or new infrastructure indoor and outdoor within Caltrans properties, including the need for
    - On-site yard surveys to design a practical plan that can be implemented in Caltrans yards, especially ones with older buildings that still have asbestos in their walls and ceilings and do not have access to an updated infrastructure map,
    - Private locator service to scan for old or new underground infrastructure potentially intercepting trenching pathways.
3. The approval process of construction plans to install any wired electrical system often requiring:
    - Delivery of professional drawings of the construction plans, which satisfy various state departments that must be contacted to get approval for working on state/public lands,

- Coordinating with state agencies that need to clear and approve the plans depending on the location and scope of construction,
- Working with the associated Caltrans District office, specifically their engineering department to authorize any task that modifies Caltrans yards,
- Ultimately recording the construction design in the appropriate data repository.

All the above results can be used across Caltrans as a reference for any future projects that require outdoor trenching or repurposing available building space for new electrical and communication technologies.

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Acronyms and Abbreviations

Acronym	Definition
AHMCT	Advanced Highway Maintenance and Construction Technology Research Center
AI	Artificial Intelligence
ASO	Autonomous Security Officer
Caltrans	California Department of Transportation
CHP	California Highway Patrol
COE	College of Engineering
COTS	Commercial Off–The-Shelf
DDP	Delivered Duty Paid
DIR	Department of Industrial Relations
DoD	Department of Defense
DOE	Division of Equipment
DOT	Department of Transportation
DRISI	Division of Research, Innovation and System Information
DSP	Digital Signal Processing
EIS	Electronic Image Stabilization
FAR	Federal Acquisition Regulation
FDA	Food and Drug Administration
FHD	Full High-Definition
GPIO	General-Purpose Input/Output
GPS	Global Positioning System

Acronym	Definition
GSA	General Services Administration
HD	High-Definition
IoT	Internet of Things
IR	Infrared
IT	Information Technology
LED	Light-Emitting Diode
LTE	Long-Term Evolution
META	Maintenance Equipment Training Academy
NADA	National Defense Authorization Act
NASA	National Aeronautics and Space Administration
PO	Purchase Order
POA	Power of Attorney
PoE	Power over Ethernet
PTZ	Pan/Tilt/Zoom
RAID	Redundant Array of Independent Disks
RDAC	Research and Development Advisory Committee
SIP	Session Initiation Protocol
UCD	University of California-Davis
VAT	Value-Added Tax
VMS	Video Management Software
VoIP	Voice over IP

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Chapter 1: Introduction

Problem

The California Department of Transportation (DOT) (Caltrans) has many medium to large equipment and maintenance yards. Vehicles are often stored in these fenced and secured yards. However, Caltrans still experiences vehicle component theft from their yards. In recent years, there has been a significant increase in theft at Caltrans facilities. It appears that Caltrans security measures cannot deter today's criminals. Catalytic converter thefts have cost the Division of Equipment (DOE) over $4M cumulatively statewide, and approximately $2M per year. Catalytic converter theft leads to follow-on costs for repairs or replacement vehicle rental/purchase. Caltrans currently uses 24-hour security guards in some yards, which can cost about $400,000 per year per guard and provides risk to the human guard. Caltrans buildings are typically alarmed, but yards generally have little or no security, including perimeter alarms.

Objectives

Caltrans needed an evaluation of modern security systems, where one possible solution is mobile robot security guards and another solution leverages fixed-spot cameras (often installed on poles with wired connectivity and/or entrances providing higher surveillance quality than portable solutions). The cameras are used with human monitoring or computational analytics to address events in the yard. Each of these solutions holds the promise of greatly reducing the theft problem and associated costs, while having their own advantages and disadvantages. AHMCT supported the Caltrans project panel in choosing the second solution for testing in this project while leaving the first option for another research project.

Scope

The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center surveyed the security landscape (mobile robot security guards, video analytics security) to determine the current state of the art and identify a system suited to DOE's needs. The researchers provided information to the project panel about leasing or purchasing an appropriately sized security system targeted for one yard, which was chosen as the Caltrans Marysville maintenance yard. The panel opted to test a camera-based system from a vendor called Omniflow, based in Portugal. Because system installation required significant construction at the pilot site, Omniflow recommended the

installation services from a local electrical and construction contractor called Metro Electric, based in San Francisco. Concurrently, the researchers developed a pilot test plan identifying key features to be evaluated, including ease of installation and deployment, initial system optimization by the vendor, power generation and consumption, video surveillance camera operation in various conditions (bright sun, night, fog, rain), video transmission, video analytics, advanced autonomous operation, remote system monitoring for system status and safety/security event response, and maintainability. The core features of system monitoring, alarming, and alerting received primary attention. The Omniflow security system is expected to support sophisticated analytics for intruder recognition and subsequent alarm generation. A third-party monitoring service is required to communicate with the appropriate agencies, e.g., California Highway Patrol, Caltrans dispatch center, and yard personnel. This detection, alarm generation, and communication process, namely the security/safety event response procedure, was developed in a related coinciding project, as part of research task 4288, which evaluated robot guards for yard security.

The Omniflow security system was deployed to the Marysville equipment yard, but time constraints did not allow for pilot testing. The research team and Caltrans decided to reassign the pilot study to the phase II follow-up project.

Background and Literature

The current landscape of outdoor surveillance systems was studied as part of an interim report, which is provided in Appendix A.

Research Methodology

This research was initiated by studying potential security systems that can be deployed in Caltrans yards. AHMCT then supported the project panel in deciding on a pilot testing system for a specific Caltrans year. In the following, detailed designs and maps were developed to implement the chosen system. This was followed by procurement of the system hardware and software from Omniflow and installation and construction services from Metro Electric, as the vendor's preferred regional contractor with appropriate licenses to carry out electrical installation and construction. Finally, after a series of yard surveys and safety measures, the system was installed and activated at the Marysville yard for future pilot testing.

Overview of Research Results and Benefits

The key deliverables of this project include:

1. An assessment report that studied and compared a camera surveillance system from Omniflow with a robot surveillance system from Team 1st.
2. The tailored system configuration and technical details of the Omniflow camera system including the initial system configuration and the Marysville yard implementation design.
3. The camera system procurement, import from Portugal, and delivery to Marysville yard.
4. A preparation for safe deployment, including implementation plan drawings for the Caltrans approval process and a private locator service to scan the yard for underground infrastructure.
5. Procurement of installation services from Metro Electric, including electrical modifications at the yard server room, trenching, cabling, erecting poles, and system activation.
6. Installation of an operational surveillance system that is ready for pilot testing and controllable locally from the yard server room located at the Marysville yard main staff building.
7. A documentation of the procurement and deployment process and their challenges in the final report to aid with future installations.

Chapter 2:
Assessment of Modern Security Systems

AHCMT assessed two modern security systems for suitability for subsequent procurement, installation, and pilot testing at a Caltrans yard: a mobile robot security teams system and a camera-based event-triggered monitoring system. The assessment was documented in an interim report, and the updated report is provided as Appendix A. The panel opted to test the camera-based system in the current project. DRISI is supporting an additional research task to study a mobile robot system.

Selected System Implementation Plan

The panel selected the Omniflow OmniLED 07 lamppost for procurement, installation, field testing, and evaluation. The detailed system configuration and technical details proposed by Omniflow were originally documented in an interim report in 2023 and later updated in preparation for deployment. The most recent update of the report is included in Appendix B.

One missing discussion from the above-mentioned reports was the choice of power and data connectivity for the Omniflow system which is discussed in the following.

Wired Power over Ethernet vs. Wireless Battery Powered Network

The choice between a wired (Power over Ethernet (PoE)) or wireless network was a key issue early in the Omniflow design phase of the research. AHMCT researchers and Metro Electric, the construction and electrical contractor for system deployment, surveyed the yard and the main office building in 2023 to gather information to present to the project panel, who decided which connectivity option to take. The two connectivity approaches have distinct advantages and disadvantages, and we had to carefully compare the two to decide on the better approach. There are several factors that went into this decision-making process as discussed in the following.

Quality of Network

Wired PoE networks are cheaper and more reliable compared to long range wireless networks at the same bandwidth level, especially for an outdoor security system, which is present in large Caltrans yards. Additionally, maintaining a wireless network is generally more costly due to the exposure of

electrical devices to the environment. Also, wireless networks are more susceptible to being hacked or disrupted by tools that are easy to acquire by intruders. On the other hand, PoE lines can be potentially cut by intruders outside of the server room if not properly hidden and protected. Overall, as far as the quality and reliability of the network, PoE lines are advantageous as long as the cables are out of reach from outside the yard.

Ease of Deployment

In terms of the ease of deployment, PoE has a major disadvantage as reaching every pole through air cable connections is neither safe nor possible. In the case of the Marysville yard, a wired network would require over 1500 feet of trenching to bury the Ethernet cables at least 2-3 feet deep as demanded by safety standards. Unfortunately, the choice of PoE for this project led to major trenching requirements, which in turn complicated and delayed the deployment due to the uncertain approval process for construction on Caltrans yards.

Power Consumption Limit

Wired systems allow users to equip more cameras and sensors on each pole as it is only restricted by the PoE bandwidth and the capacity of the electric panel used to power the system. For a portable or entirely wireless system though, the system would solely rely on its solar and wind power generation and the battery storage of each surveillance unit while also requiring a Wi-Fi antenna attached to each pole.

With the Omniflow system in particular, the panel demanded higher quality IR-PTZ cameras, fixed thermal cameras looking over the yard perimeter, speakers, and additional radars to detect movements inside the yard. While the OmniLED 07 model provides solar and wind renewable power in addition to batteries, the additional equipment in the proposed system surpassed the power generation and storage capacity of the OmniLED 07 lamppost. Therefore, the research team and the project panel eventually decided to choose PoE over the Wi-Fi network. If this was an indoor system or a yard where power is readily available in every corner alongside the perimeter, the panel might have chosen a Wi-Fi network to avoid the regulatory challenges of trenching and major construction.

Chapter 3:
Procurement of the Camera System and Installation Services

Primary procurement within this research involved the camera system from Omniflow along with contractor services from Metro Electric for the system installation. Several issues complicated these procurements, leading to a prolonged project duration with no full-sized pilot testing. AHCMT worked closely with the panel to support safe deployment in the reduced time available. This chapter overviews the key procurement issues, as some will be illustrative for future work.

Procurement Obstacles and Issues

The cost for the selected system was significantly higher than the cost of the compared mobile robot system at the time of project proposal. The initial estimation had not accounted for the significant costs of an overseas shipment and the necessary installation services by a local contractor (as a second vendor). Due to the large scale of construction and electrical work required for a wired PoE system, the Caltrans project panel chose not to use Caltrans personnel for system deployment because that would risk making the system inoperative or unsafe. Instead, to support the system procurement, AHMCT submitted an amendment for cost addition in May 2023 which was approved. AHMCT directly submitted a Purchase Order (PO) request to initiate procurement.

A typical PO request leads to a PO in approximately one month; the current procurement was very complex and far from typical. The two primary entities involved in this procurement were the College of Engineering (COE) Pre-Purchasing group, and the University of California, Davis (UCD) Purchasing Department. Throughout this process, either COE or the Purchasing Department may have questions for the original requester, and the process can be iterative. The key issues encountered during this procurement are discussed in the following to inform future purchases at Caltrans.

Approval Form for Software and Related Services

Among the items in Omniflow's quote, there was a server with the Omniflow system management software and appropriate licenses. For systems including software, the university can request information for a cyber risk assessment. This

occurred for the Omniflow procurement. The focus of this assessment was data classification, specifically data protection and availability. As the Omniflow system was standalone except for video delivered for research purposes, the system was classified as having minimal risk. The risk assessment had little impact on procurement.

For any future procurement by Caltrans, the same concerns may lead to an involvement of Caltrans IT. In this research task, the project panel chose to purchase a third-party internet service and hire a third-party monitoring service to keep the security footage out of the Caltrans network. For this research, the data security obstacle was resolved, but will need to be revisited for systems outside of research.

Prevailing Wages, DIR and Insurance

The camera vendor was asked to confirm they pay prevailing wages,[1] and that they are appropriately insured (Commercial and General Liability, Professional Liability (if applicable), Business Automobile Liability, and Worker's Compensation: Coverage) to perform this work. If the vendor was directly involved in the system installation in California, they would need to meet the requirements of the Department of Industrial Relations (DIR) and UCD. As a Portugal-based company, meeting the UCD and DIR requirements likely would have been challenging. Because system installation required significant construction at the pilot site and the camera vendor, Omniflow, already planned to have a local contractor, Metro Electric, perform the installation, i.e. the Portuguese vendor would not be directly involved with the installation task and did not need to provide any labor for construction.

Metro Electric was included in quote, but due to the above-described requirements, both vendor and installer would have needed to meet the UCD and DIR requirements. To resolve the conflict, both firms provided separate quotes: one for system purchase (Omniflow) and one for system installation (Metro Electric). Later, more reasons stated in Chapter 4 added to this arrangement being a good decision. The total cost with two quotes did not change at this point. The installer provided evidence that they meet the UCD and DIR requirements. However, the paperwork pushed the start of procurement into July 2023, and led to revised quotes and requisition (COE).

The recommendation for any future purchase is that if the video camera system is deployed as a wired system (hence requiring construction and electrical work), either to procure the system and its installation both from a vendor in California or make sure that the installation contractor has carried out similar tasks in the state of California before.

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[1] DIR Prevailing Wage (https://www.dir.ca.gov/public-works/prevailing-wage.html)

This process also included justification of the installer's wages. AHMCT worked with the installer to provide a list of appropriate labor classifications and wages to the UCD Purchasing Department so that it is clear they are paying prevailing wages and are also not overcharging.

Federally Prohibited Items

In July 2023, Caltrans requested the camera vendor's line-item quote for a Caltrans Information Technology (IT) review. Note that while Caltrans IT did not have to get directly involved in the project's pilot testing, any communication device to be used on Caltrans facilities has to be approved. The analyst noticed that the quoted system included a router (MC801A 5G) from ZTE, a Chinese company. ZTE is listed in the U.S. National Defense Authorization Act (NDAA) (https:/www.congress.gov/bill/117th-congress/house-bill/7900), specifically in Section 889 (https:/www.acquisition.gov/Section-889-Policies) Federal Acquisition Regulation (FAR) Rules Issued by Department of Defense (DoD), General Services Administration (GSA), and National Aeronautics and Space Administration (NASA) as a prohibited company. When advised of the issue, a UCD internal meeting was held with the UCD Research Ethics and Compliance Office to determine the appropriate means to address the issue. The ultimate decision was to ask the camera vendor to replace the offending router with one not on the banned list. The vendor provided an updated quote with a Teltonika access point. UCD and Caltrans IT accepted this change. With this new quote, COE developed a new requisition. This moved the procurement into September 2023.

International Shipping and Customs

Later in 2023, the Purchasing Department requested information about shipping, since the system was being delivered from Portugal, and thus subject to U.S. customs. Specifically, the questions were:

1. Do the freight charges by the vendor include all costs to get it to the final location and not just to customs at the port of entry?
2. Does the vendor's previous 12-week estimate for delivery include the estimated time through customs?
3. What is exactly covered by the vendor's quoted shipping cost?
4. Is the vendor responsible for delivering to a specific address, or are they only responsible for delivering to Port/Customs?

AHMCT discussed with the vendor and the issue was eventually resolved by adding a separate item to the quote: *"freight cost and shipping to Marysville yard - Delivered Duty Paid (DDP)"* to confirm that the vendor is responsible for all the fees associated with shipping and delivery to the yard including the cost of

hiring an import broker (which later was confirmed to be required) and the U.S. customs cargo clearance fee.

Sole Source Documentation

Due to the specialized nature of the camera system as well as its installation, the system purchase and installation were from sole sources. The camera vendor, Omniflow, claimed that Metro Electric was their chosen installer because of the low-voltage solution (Power-over-Ethernet) for this project. This was verified by the manufacturer Voltserver, whose PoE components were selected to minimize trenching, also claiming Metro Electric as their preferred regional installer for the low voltage solution. Additionally, the vendor did not have another installer in the Sacramento area (100-mile radius) so the installer was their only authorized installer for this job. The sole source documentation for the installer added at least a month to the procurement.

Import Broker

Only a month before delivery was scheduled in October 2024, an import broker was discussed between the camera vendor and AHMCT. AHMCT learned that power of attorney (POA) is required for an import broker to clear any goods through U.S. Customs. In the case of this project, UCD can hire American Cargoservice as their customs broker with POA (i.e., the authority to act on behalf of the importer, University of California, Davis). After the acquisition of the broker, AHMCT was asked to investigate if there is any need for additional forms to be submitted for cargo release from U.S. customs. Fortunately, AHMCT could confirm that the camera poles are made of aluminum alloys rather than steel which would have required additional documentation for customs clearance and that the lighting used does not fall under the category of LED products regulated by the U.S. Food and Drug Administration (FDA).

Caltrans will need a similar customs broker with POA for any future procurement of an international system for other yards. As a note, the DDP term does not mean that the vendor is responsible for hiring a broker with POA, only that they are responsible for the broker's fees, i.e., the vendor is not necessarily the importer just because DDP terms are applied.

Risk Assessment, Time/Budget Extensions, and Caltrans Approvals

Late 2023, the Omniflow PO was paused to assess the risk of getting additional funds and project time required to fully implement the system by the installer. This was at the same time when Caltrans advised regarding the need for review and approval of site installation plans by both Caltrans Design

Engineering Services (DES), the CalFire State Fire Marshal, and possibly other entities. AHMCT advised the installer of this requirement and asked them to update their quote to incorporate the necessary Architectural & Engineering (A&E) services to generate site installation plans. The PM later confirmed that the construction task at Marysville yard does not fall within the purview of DES, CalFire, or District 3' Office of Encroachment Permits and Division of Right of Way. However, the Caltrans District's Maintenance and Electrical Engineering branch has oversight for any modifications required at any yard within their district.

The need for A&E professional construction design drawings resulted in a significant cost increase, which led to AHMCT requesting a cost and time amendment. After discussions with the project panel, the PM submitted a contingency request in December 2023. Early 2024, AHMCT was notified that the requested time and cost amendment was approved and finalized. However, the formal requirements, methodology, specific documentation, and permits needed to modify the Caltrans yard remained unclear. The following delays triggered discussions with the panel about the scope of the project and the lack of time to pilot test and evaluate the system. In the following quarter, the panel was provided with options for moving forward. AHMCT was asked to proceed with the camera system PO in spite of uncertainties in the project and accepting the risks of time shortage and the possibility of needing a Phase II project (as a new research task) for pilot testing and evaluation of the system.

The system PO was hence resumed in mid-June 2024, with direct delivery of goods to the Marysville yard expected in the next quarter. Due to these delays, the installer services for A&E and installation had increased in price with increased labor and equipment costs. Fortunately, the remaining budget could support the installation, and the PO for the installer was issued in October 2024.

The Omniflow equipment was delivered to the yard after port release and some logistics in early November 2024. An inspection was carried out the next day by the PM and representatives from AHMCT, the installer, personnel from the Caltrans Marysville yard, and the responsible District 3's Maintenance and Electrical Engineering branch. They soon realized that the delivered system was incompatible with what the installer was planning to provide. It was decided that additional equipment would be purchased by the installer and covered by the camera vendor in addition to modifications to the system in the yard. These modifications were small and did not pose any concern regarding the operation of system.

The first change order for the installer came through as a new PO in late December 2024, accounting for the abovementioned additional equipment and labor plus a private locator service to scan for any underground obstructions on trenching pathways. The approval process from District 3's Maintenance Electrical Engineering branch was concluded in late February

2025 upon finalizing the A&E drawings and one final yard survey on February 28th. By then, the construction materials were ready to be shipped to the yard leading to construction initiating early March 2025.

The construction task was completed by Metro Electric in a timely manner by the end of April 2025. However, there was a faulty thermal camera (assigned to pole 6) which was troubleshot onsite for a few weeks but ultimately could not connect to the network to stream any video. This led to further delays as AXIS support was only available at Portugal (where Omniflow initially purchased the equipment). After two months, it was decided that AHMCT will purchase a new replacement camera from the same model and ship the faulty camera to Omniflow for repair. By the end of July all parts of the system at Marysville yard were operating as expected but Omniflow was not yet done with calibrating the system though the server. A no cost time extension was approved to continue the project until the end of August. This was mainly because system calibration was initiated by Omniflow at the beginning of May and unexpectedly lasted through August. The main challenges with system calibration were as follows:

- Setting up autonomous detection by thermal cameras and radars,
- Connecting each PTZ camera to the thermal cameras and radars on the same pole to rotate and track the intruders
- Setting up the audio horns to alarm the intruder with a prerecorded message
- Setting up automatic notification via email to inform the yard staff regarding the potential incidents

At the end of the project, which concluded with a fully operational system ready for pilot testing, Omniflow made a point regarding the delays emphasizing that using Omniflow's local partners (which were not available for this project) can assist in cutting hurdles such as dealing with imports delays and reducing transportation times as well as providing local physical assistance and even payment terms. Additionally, Omniflow admitted that the experience was a learning curve, and they hope to improve future designs and to offer cost saving solutions for similar projects.

Vendor Indications for Warranty and Maintenance

With the new quote structure, the vendor provided all parts, as well as system settings. The installer provided the installation, including materials needed specifically for installation.

The vendor gave its equipment (e.g., the OmniLED units) a two-year warranty while all materials by camera producer AXIS have a five-year warranty. For the

return and repair, a U.S. based company can provide the repair, without the need to send equipment back to Portugal. The majority of the troubleshooting is expected to be done using the vendor's software platform installed on the control computer in the server room. Further maintenance to provide autonomous annual checkups or to train the Caltrans local team to use the dashboard (software installed on the server) has to be paid for by Caltrans.

The installer provided a one-year warranty on all craftsmanship upon construction and operations plan delivery/acceptance, minus any issues that equipment/materials get from unusual use, e.g. someone is negligent or purposely damages the system, such as cutting something they should not, removing something they should not, etc. The installer does not maintain any system other than basic troubleshooting (mostly physical) as needed, however they can be on Caltrans call-list to be dispatched if emergencies arise or provide a price for a yearly check-in/tune up if necessary. This will mainly cover the construction equipment and material that the installer provided and will usually include a minimal visual check.

Chapter 4:
Deployment and Implementation

The deployment process officially started in early November 2024 when the camera system shipment was completed and inspected at the yard and AHMCT and Caltrans agreed to the terms of the installer quote. A payment plan with clear milestones was created to pay for A&E services, construction materials, and labor.

Problems and Issues that Affected Product Deployment

The first issue with deployment was discovered in the camera components, where the outer ports meant to connect to Voltserver equipment (provided by the installer) missed a component that converts media to copper[2]. Also, the server missed an in-port switch that would facilitate seven connection (from seven poles). The inspection team met with Omniflow the following week and concluded that some additional equipment had to be purchased and assembled into all seven OmniLED units on site at the yard (see Risk Assessment, Time/Budget Extensions, and Caltrans Approvals). This issue was resolved by submitting a new PO and Omniflow covering the cost of additional parts and the labor to modify the system by Metro Electric. This is reflected in the subtraction on the final invoice paid to Omniflow matching the value of the PO submitted to Metro Electric.

Also, A&E engineers surveyed the yard in late December 2024 and suggested hiring a private locator service to scan for underground infrastructure or any obstacles that may intercept trenching pathways. The panel and AHMCT team agreed that the available old yard maps left too much uncertainty regarding what was buried underground. For safety reasons, Caltrans and AHMCT agreed to get the additional private locator service. The result of the scan was that there was in fact a newly installed pipe near one of the pole locations at the depth of around 3 feet. The installer consulted with the company who did the job and confirmed that for that area they can keep the original design but lower the depth of the trenching to about two feet and lay down the PoE

[2] Media to copper conversion is the process of using a media converter to connect copper-based networks to fiber optic networks. Media converters are often used to extend the distance of copper networks, improve network performance, and protect data from interference.

cables above the existing pipes without causing any disturbance to the infrastructure.

Another concern before the start of construction was that the electric panel available at the server room may have insufficient capacity to power the system. This concern was fed by the panel being old and recent power connections made through the server room wall to use the panel's capacity for powering equipment in the main office building. This concern was resolved by confirming the panel's capacity, its current usage, and the system's power requirements.

Chapter 5:
Conclusions and Future Research

Key contributions of this research project include:

- This research qualitatively compared a mobile robot guard system (from Team 1st technologies) to a video analytics perimeter surveillance system (from Omniflow). The advantages and disadvantages of each system in terms of procurement, deployment, and operation were studied to facilitate the panel's decision to choose a system for pilot testing.
- This report documents various technical and regulatory challenges of surveillance technology procurement from overseas and construction and deployment of wired camera systems on Caltrans yards.
- A perimeter surveillance camera system was designed, procured, and deployed. Relevant construction drawings were submitted. The system is ready for pilot testing and further evaluation in a Phase II Yard Security research task.

Future work is planned to be carried out as part of Phase II Yard Security project. This will also include procurement of a high-bandwidth internet service and a third-party monitoring agency to address incidents during pilot testing.

Recommendations

This section summarizes a few notes to consider for any future research project or security system deployments at Caltrans yards. The first consideration is the landscape of security systems in the big picture when choosing the appropriate category of surveillance, e.g.,

- Indoor vs. outdoor surveillance: Outdoor systems must be resilient and reliable in different environments and weather conditions. Lighting is not truly a concern indoors. An outdoor system can benefit more from lighting posts and thermal cameras.
- Mobile vs. stationary: Stationary systems consist of fixed-location elements with cameras or sensors installed on poles and/or high edges of the walls/gates. Mobile solutions consist of robots (on legs or wheels) and portable lampposts (that can be moved around by humans). Stationary and portable lampposts have flexible height and wider viewing angles from above allowing surveillance in a wider range. Portable lampposts

like robots are often wireless battery-powered systems, while stationary systems are often wired and do not rely on batteries, Wi-Fi networks, or strength of LTE signal in the area. Robots on patrol routes can cover blind spots that require too many stationary elements to cover. Looking between buildings, parked cars, and other obstacles in Caltrans yards in all directions can be hard to achieve by stationary elements. However, stationary systems can provide ideal perimeter protection using movement detection sensors/radars accompanied with PTZ cameras installed on poles in the outer edges of the yard.

- Wired vs. battery powered: A security element can be powered by cables or rechargeable batteries or a combination of both. Indoor stationary systems are often wired as it is easier to place them near existing outlets. Outdoor systems often require significant construction, trenching, and electric modifications to make them wired. Mobile robots and portable posts generally rely on batteries and solar panels losing patrol time to charge. Battery-powered systems are limited in terms of quantity and quality of on-board sensors.
- Wired vs. wireless connectivity: Wired connectivity is often in the form of copper PoE or fiber cables connecting all elements of the system to a server or control unit. Wired systems can facilitate more sensors, higher resolution, and overall better video and sound quality when complimented with high-bandwidth fiber-optic internet service. Mobile solutions cannot be wired, so they either use public 4G LTE in the area, or local wireless networks reaching out to every corner of surveillance zone.
- Automatic vs. piloted patrol: Robots can be either preprogrammed to do patrols at certain times and routes or be remotely controlled by human pilot to complete their task. The operation time of piloted systems depends on the availability of human pilots. Automatic patrols can be disrupted by new obstacles on patrol routes resulting in blind spots in the surveillance zone.
- Autonomous vs. semi-autonomous vs. human guard monitoring: Monitoring is the act of detecting and addressing incidents. This is traditionally done by having a human guard going through live footage 24/7 to find and report incidents. On the other hand, modern systems can detect intrusion, generate alarms, notify personnel, and dispatch law enforcement without any human involvement mainly relying on on-board sensors and often resulting in false alarms. A better solution for Caltrans is likely a human-assisted semi-autonomous monitoring system. For instance, an intelligent software can be used to automatically generate alarms and notify an agency, and then a human agent will address the alerted incidents, clear out false alarms, and decide how to proceed.

Policies and regulations must be considered from the beginning of the project to allow sufficient time for administrative procedures for both procurement and deployment. Depending on the selected system, procurement may require:

- inclusion of DDP term in the contract to simplify logistics and its costs,
- importing goods, hiring a customs broker, and documentation from agencies regulating different products for customs,
- checking with IT department to make sure all the electronic and communication devices are authorized for Caltrans facilities,
- additional documentation for purchasing relating to
    - labor wages,
    - insurance,
    - official scope and risk assessment,
    - permission to work on public/state land,
    - registration with California Department of Industrial Relations,
    - sole source justification,
    - software terms of use (if part of the PO),
    - prohibited equipment (federal or state banned items),
    - shipping and logistics.

The deployment of security systems requires

- involving yard (pilot test site) attendants and the associated Caltrans district maintenance and engineering office in panel meetings,
- identifying the vendors that provide equipment and the contractor that is going to deploy the system. Due to existing regulations regarding labor and operation on state lands, a local contractor with previous experience in similar construction tasks across California is preferred to out-of-state or foreign companies who lack proper authorizations,
- yard surveys focused on existing electric panels and outlets, surveillance zone perimeter, blind spots, security hotspots, existing infrastructure, and most importantly practical solutions to provide power and connectivity,
- coming up with practical construction design by acquiring professional maps and private locator service (if needed) to safely implement the system and to avoid redesigns and do-overs,
- clear scope and risk assessment established at the design phase for
    - system installation,

- system activation and operation,
- system warranties and maintenance.

References

[1] S. Delshad Sisi and T. Lasky, "Evaluation of Advanced Security Systems for Caltrans Equipment Yards/Maintenance Stations: Assessment of Modern Security Systems and Support for Selection of System for Evaluation," AHMCT Research Center, UC Davis, Interim report UCD-ARR-22-11-28-01, Nov. 2022.

[2] S. Delshad Sisi and T. Lasky, "Evaluation of Advanced Security Systems for Caltrans Equipment Yards/Maintenance Stations: Technical Details, Design, and Cost for Implementation of Omniflow Surveillance System for the Pilot Test in Marysville Yard," AHMCT Research Center, UC Davis, Interim report UCD-ARR-23-01-12-01, Jan. 2023.

Appendix A:
Overview of Candidate Modern Security Systems

This report provides a technical assessment of two competing security systems, namely Team 1st Mobile Outdoor Robots (who modified SMP Robotics system for security) and Omniflow smart Internet of Things (IoT) lamppost (known as OmniLED) equipped with security cameras. This report compares these two technologies to better understand their features and limitations. This report excludes outdated information in the original interim report including the proposed pricing of each candidate system back in 2023.

SMP Robotics/Team 1st Mobile Robot Security Team

Team 1st offers, installs, and maintains outdoor security robots for surveillance. Team 1st designs a specific plan for each yard, preprogramming a team of robots to routes, and maintains the robots as needed through the subscription period. The robots are intelligent and coordinate their movements and charging/operating times with each other to provide 24/7 autonomous surveillance of the chosen area.

These robots can accompany security guards or work autonomously. Operator attention will be required when an intruder is detected, but robots can handle routine premise patrolling on their own. Team 1st also offers a control center from which one or more operators can:

- Turn individual robots or the entire system on and off,
- Receive potential intrusion notifications, then filter out false alarms or dispatch officers if needed,
- Receive notifications about robots getting stuck or not moving,
- Receive maintenance notifications.

This command center can be located anywhere (connected via internet or any secure connection to the yard) and can be operated by Caltrans employees. It also involves the following features:

- All-in-one interactive display and a computer,
- Direct integration with surveillance, access control and other systems,
- 24/7 security monitoring that verifies and coordinates appropriate response from AI Analytics notifications,

- Integrated event data routing directly to 911 dispatchers and first responders which facilitates a system wide situational awareness for efficient first response in an emergency event,
- Reduced false alarms by 99%,
- Machine learning for proactive responses reduces lockdown times,
- AI automated cross-platform – system-wide emergency notification,
- IP intercom and alarm button.

The Team 1st robot investigated in this project is equipped with a dual-spectral Pan/Tilt/Zoom (PTZ) camera. This arrangement of the PTZ camera allows circular scanning of the surrounding area in the thermal and visible spectrums. Thermal video surveillance provides reliable detection of people and cars at night with little to no artificial lighting. The thermal camera can detect people within a 200 m (650 ft) and cars within an 800 m (2600 ft) radius. The visible spectrum camera forms a high-resolution image. The video image from both the thermal camera and the visible range camera is processed by the on-board computer. It provides PTZ camera control, human detection, and tracking.

Apart from the rotating PTZ camera, to ensure the safe operation of the robot, each robot is also equipped with six high sensitivity and 720p resolution cameras for continuous 360° circular surveillance.

The image from these cameras is analyzed by a separate on-board computer of a panoramic video surveillance system including analytics for detecting people. This solution allows detection of an approaching person at a time when the scanning PTZ camera is not facing in that direction.

The outdoor security robots are robust to harsh weather conditions and rough terrain. Each robot is suited for covering a 200-meter route with operating/charging time of 10/7 hours. With the right planning, a team of robots can provide 24/7 patrolling of preprogrammed routes.

As noted, Team 1st takes care of installation, route planning, maintenance, and command center setup. Additionally, they provide Autonomous Officer Monitoring to manage false alarms, but this feature requires sharing security footage with a third party. To work efficiently, a team of robots need to be connected to each other and the control center to coordinate charging, movement, maintenance, etc. Team 1st can set up a private Long-Term Evolution (LTE) network (to be used in case no Wi-Fi or public LTE networks are available in the yard), taking care of local networking between the robots. Besides the local network, a high-speed internet service or a secure Caltrans network is required for connecting the system to the command center.

See Team 1st website for updated images of Autonomous Security Robots. In the system architecture proposed by Team 1st, the robots are remotely (via LTE or Wi-Fi) connected to Team 1st engineering to monitor system status and maintenance requirements while the footage is sent to both a local command

center (with VMS and archive memory) and also a third-party monitoring agency that responds to any security/safety incidents.

Omniflow Video Analytics Security System

Omniflow is a company specializing in smart lampposts utilizing renewable energy sources. All Omniflow units have IoT connectivity for managing and controlling the integrated applications. These units can be equipped with cameras, microphones, and speakers for security purposes. These camera-equipped lampposts can then be strategically placed to provide surveillance coverage to a desired area. The design offers all functionalities in a fully integrated solution (single component) ready to work out of the box with short installation.

Photos are included below on Figures A.1 and A.2. Omniflow presents two different units. The smaller model, OmniLED 035, is not useful for security purposes as it cannot be integrated with PTZ cameras; hence, we are not considering this model. Instead, Omniflow's larger and more equipped model, OmniLED 07, is being investigated in this project. This pole-mounted light unit (see below) can have up to four internal cameras which can be integrated with an external PTZ camera with near 360° view of the surrounding area (only blocked by the pole itself) sitting on the pole below the main unit. The OmniLED 07 has the capability to create a virtual fence, which will trigger an alert when an intruder crosses it. A speaker can be mounted next to the PTZ camera to communicate with intruders or sound alarms. The PTZ camera can zoom and automatically lock onto moving targets and provide nighttime security.

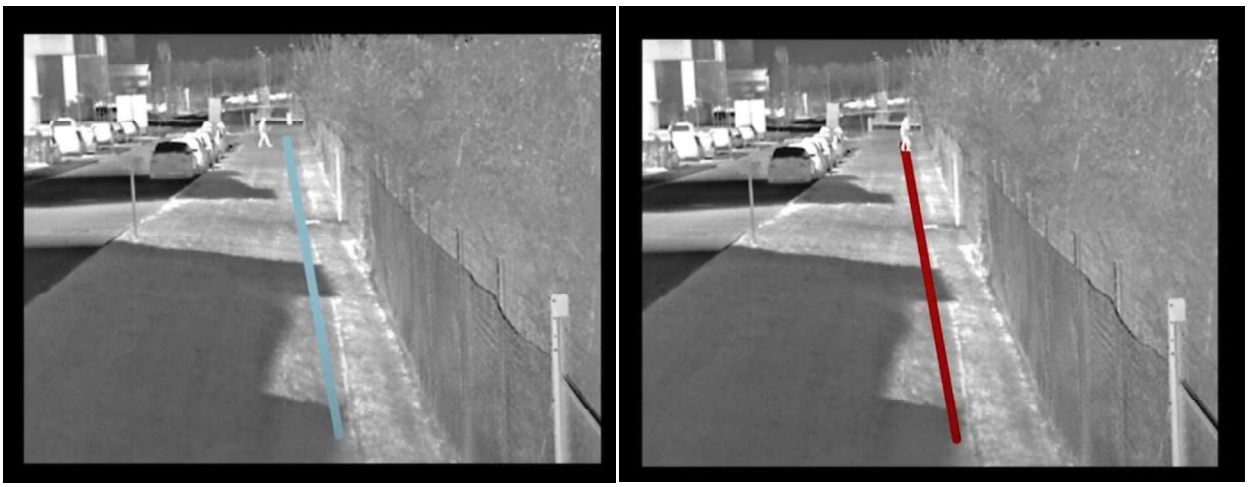

Figure A.1: Virtual fence breach detection with Thermal sensors (credit to Omniflow)

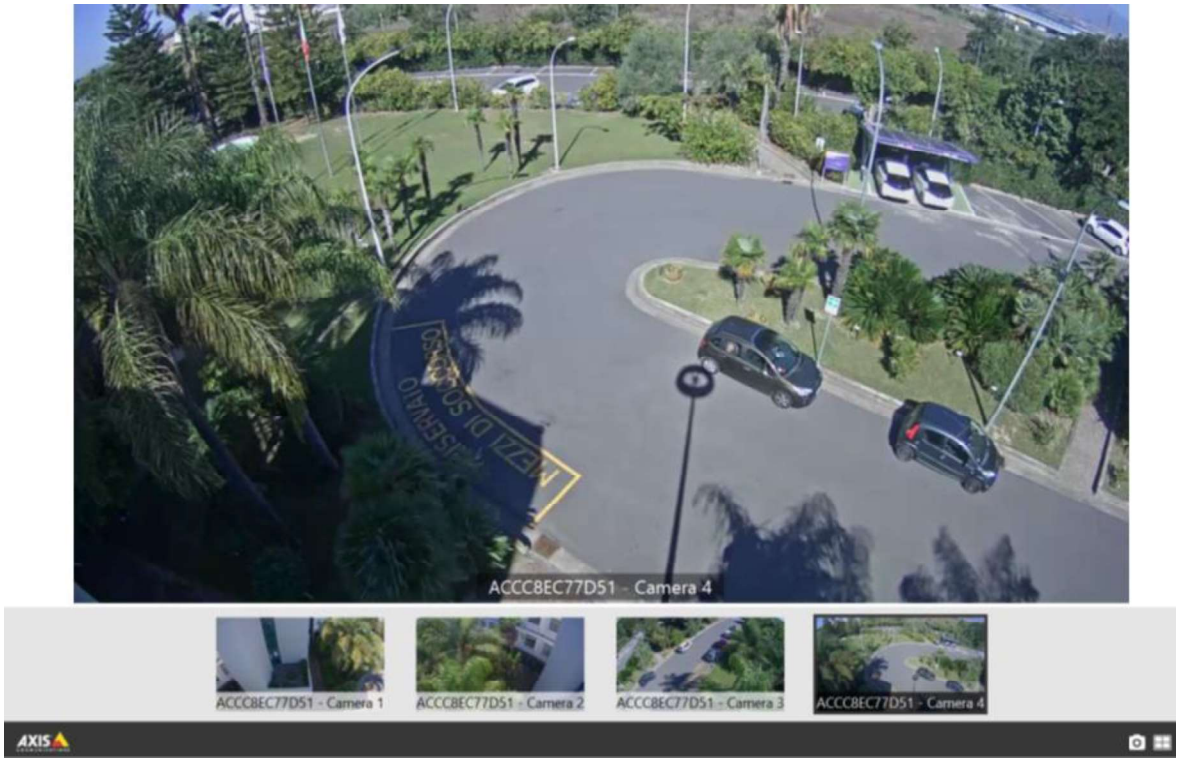

Figure A.2: Sample image from integrated FHD cameras (credit to Omniflow)

A wind turbine and solar panels are standard on the Omniflow 07 unit. The grid connected unit first uses available renewable energy. If the batteries are depleted, it will draw energy from the grid. Omniflow systems achieve energy savings of over 90% compared to regular lighting and above 60% compared to light-emitting diodes (LEDs). Mobile and tablet software supports Omniflow 07 for ease of use and provides real-time information about energy consumption and other conditions of each unit. Omniflow takes care of planning for each yard/location and the overall design, installment, and maintenance. Figure A.3 shows the images of OmniLED 07 model.

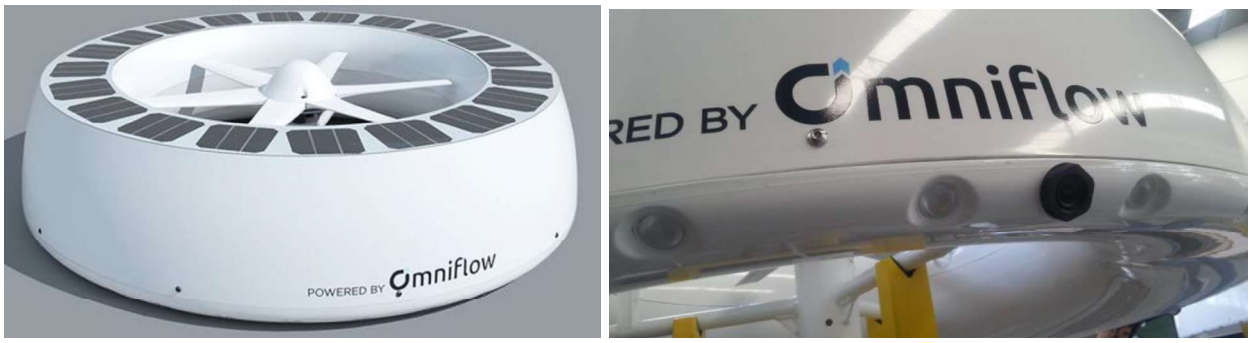

Figure A.3: Omniflow 07 with wind and solar energy capability equipped with LED lights and four unit-mounted cameras (credit to Omniflow)

For this project, OmniLED 07 is more suitable when integrated with the additional PTZ camera, creating virtual fencing for the perimeter when the lampposts are installed on the corners of the yard. OmniLED 07 can also be equipped with up to four high-definition (HD) (1080p) cameras providing a 360° bird's-eye view of the surrounding area and works with the PTZ camera. Figure A.4 shows sample pole configurations and a render of perimeter defense analytics made by Omniflow.

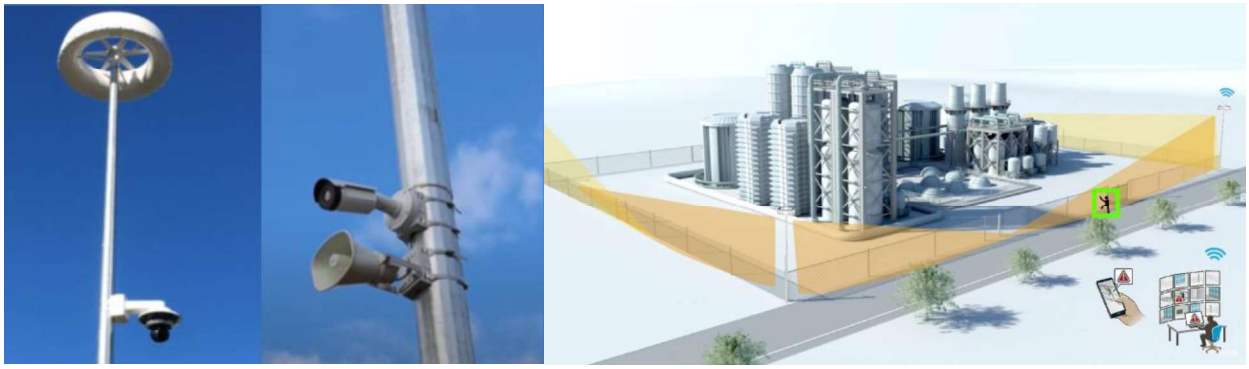

Figure A.4: Omniflow with separate PTZ camera, and PTZ with loudspeaker in addition to a render of perimeter intrusion analytics (credit to Omniflow)

Detailed Feature Comparison of Candidate Security Systems

Team 1st and Omniflow System Similarities

- Smart analytics
  - Both apply 24/7 visual threat detection facilitated by PTZ cameras and other low-light sensitive sensors.
- Autonomy
  - Both autonomously generate alarms and communicate with authorities when they detect abnormal activities.
- Surveillance patterns
  - Both systems have perimeter or area surveillance capability, depending on set paths (Team 1st robots) or the location and direction of cameras (Omniflow lampposts).
- Communication
  - For communicating with the outside world, an internet or any other secure connection to a control center is necessary to monitor each unit for maintenance purposes, and to distinguish

the triggered false alarms from cases where officers have to be dispatched to the yard.

Team 1st and Omniflow System Differences

- Mobility
  - Team 1st robots are moving agents that coordinate with each other and cover predefined paths with 360° panoramic HD view.
  - The Omniflow lamppost is a stationary unit.
- Point of view/perspective
  - Team 1st robots view objects at human-height level, and they must move around objects blocking their view.
  - The Omniflow cameras mount on a pole 30-50 feet above ground providing a bird's-eye view.
- Power management.
  - Team 1st robots need to be taken offline to recharge and together they consume significantly more energy.
  - The Omniflow system is a semi-sustainable security system generating power via solar power and wind and storing the energy in rechargeable batteries.
- Communication
  - Team 1st robots require a wireless or local 5G network to exchange real-time data.
  - The Omniflow security system can also rely on a wired connection.

Table A.1 lists the significant features of the analyzed systems to provide further insight into similarities and differences of the two surveillance technologies.

Table A.1: Technical comparison of candidate security systems (updated as of 2023)

Feature	Team 1st Robotics	Omniflow Lamppost
Model	Argus S5.2 PTZ IR IS	OmniLED 07
Mass	275 lbs without batteries 350 lbs with batteries	80 lbs
Max. Dimensions	2.5 ft wide x 4.5 ft deep x 6 ft high	4 ft diameter & 1 ft high
Point of view height	5.5 ft	30-50 ft (pole or wall)
Ground clearance	0.45 ft	N/A

Feature	Team 1st Robotics	Omniflow Lamppost
PTZ/infrared camera	Integrated	Installed on pole
Max detection distance	250 ft with 6 HD cameras 650 ft with PTZ camera	300 ft with 4 full HD (FHD) cameras
Charger	48 VDC 600 W – 70 lbs	N/A
Operating time	10 hrs	Always on
Charing time	6-8 h	Depends on light & wind
Acoustic noise	64 dB (A)	No significant noise
Traveling speed	2.5 - 4 mph	N/A
Connectivity	4G, Wi-Fi	5G, Wi-Fi, wired

Appendix B:
Technical Details and Construction Design for Implementation of Omniflow Surveillance System at the Pilot Test Site

A total of seven poles were erected around the yard to assure complete perimeter and area coverage, as shown in Figure B.1.

Figure B.1: Omniflow's modified design plan for Caltrans Marysville yard (credit to Omniflow and Metro Electric)

The vendor proposed the pole schematic shown in Figure 2.2. In this schematic, we can see the OmniLED 07 on top of an 8-m galvanized pole, equipped with PoE converter and a 500 Wh battery pack which is charged via wind and solar energy. Beneath the main unit, we have the moving PTZ camera, horn speaker, additional thermal camera for perimeter fencing, and a radar sensor looking inside the yard for any movements. Each component includes PoE switch for power. The lowest component is a bit below 4 m above ground level.

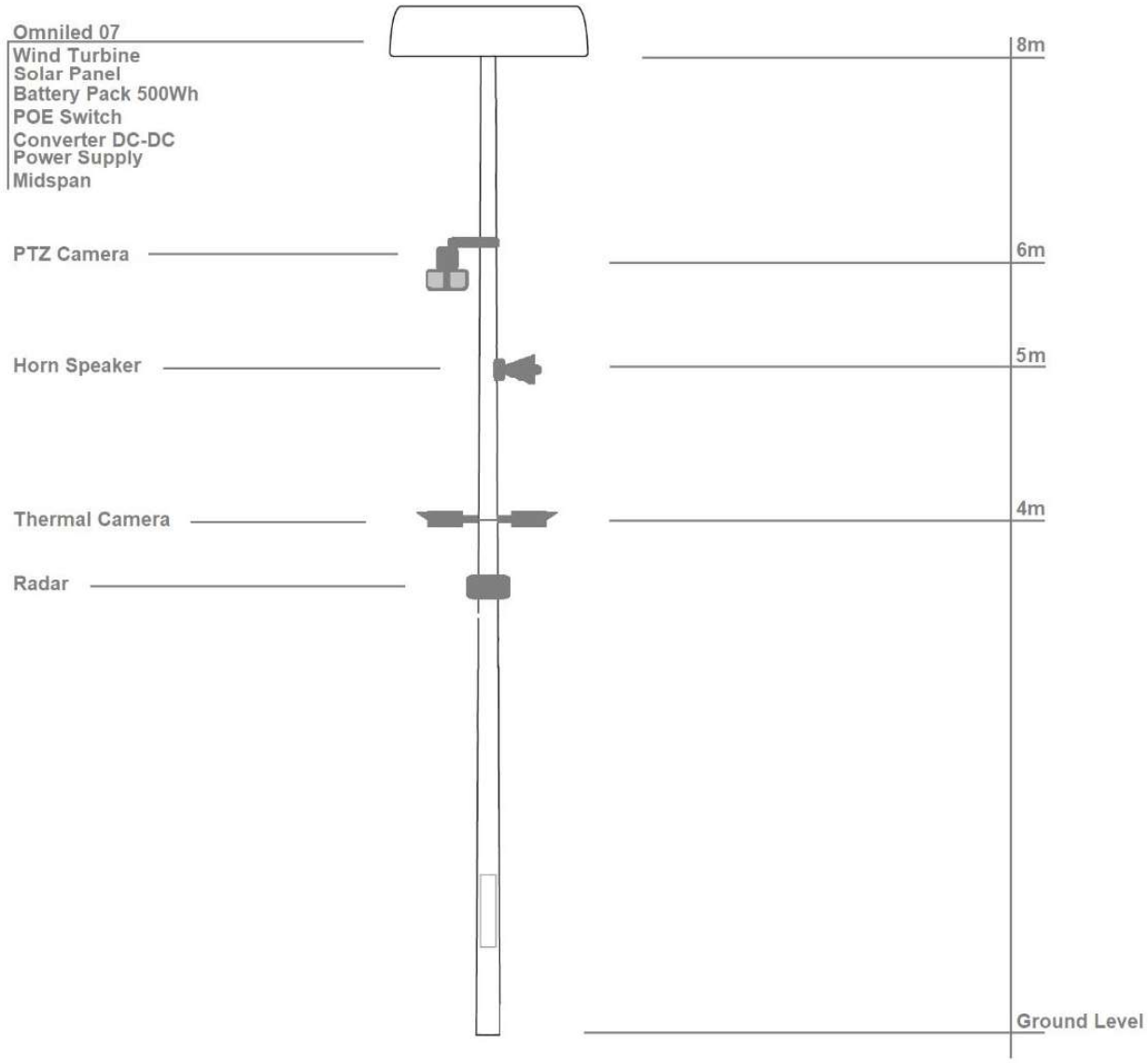

Figure B.2: Omniflow pole schematic for the main units equipped with one PTZ and two thermal cameras designed for Caltrans Marysville yard

Pole Configurations

Pole 1 | Pole 3 | Pole 4 | Pole 6 | Pole 7

These are the five main pole units with the exact same configuration, all having one PTZ and two thermal cameras according to Table B.2.

Table B.2: Main configuration for poles 1, 3, 4, 6, and 7

Model: Nr. Série OL07 24 0250 - OL07 24 0254	Qty.
OMNILED 07 | SMART HYBRID	1
360º Lighting pack (30 LED) Pmax 60W	1
AXIS Q6225-LE PTZ Camera (includes integration)	1
AXIS Q1951-E 13 mm 30 fps (includes integration)	2
SD Card for IP camera	4
AXIS D2110-VE	1
Switch 8 Ports Gb PoE++ 90W	1
DDR 120A/48	1
Omniflow integrated power supply upgrade	1
Audio Horn Speaker for Alerts and Communications	1

Pole 2

Pole 2 comes with two thermal cameras according to Table B.3.

Table B.3: Configuration of pole 2

Model: Nr. Série OL07 24 0250 - OL07 24 0254	Qty.
Nr. Série OL07 24 0255	1
OMNILED 07 | SMART HYBRID	1
360º Lighting pack (30 LED) Pmax 60W	1
AXIS Q1951-E 13 mm 30 fps (includes integration)	2
SD Card for IP camera	2
Switch 8 Ports Gb PoE++ 90W	1
DDR 120A/48	1
Omniflow integrated power supply upgrade	1

Pole 5

Pole 5 comes with one thermal camera according to Table B.4.

Table B.4: Configuration of pole 5

Model: Nr. Série OL07 24 0250 - OL07 24 0254	Qty.
Nr. Série OL07 24 0255	1
OMNILED 07 | SMART HYBRID	1
360º Lighting pack (30 LED) Pmax 60W	1
AXIS Q1951-E 13 mm 30 fps (includes integration)	1
SD Card for IP camera	1
Switch 8 Ports Gb PoE++ 90W	1
DDR 120A/48	1
Omniflow integrated power supply upgrade	1

Control/Server Room

In the updated plan, Omniflow added a server room equipped with Video Management Software (VMS) hardware and Omniflow software with an AXIS camera station Tower Recording Server. This control room is set up in a designated space inside the main office and will be connected to a wired internet provider to enable remote access to the server and in turn to the entire system. Using software, an operator can receive all notifications about power usage and generation, device status, and other alerts.

Equipment and Additional Devices Information

OmniLED 07

Omniflow's Smart IoT Lamppost, powered by wind and energy, is an IoT platform that can host applications like Surveillance, Computer Vision, Audio Alert Systems, Air Quality, and many other services.

Figure B.3: Pole 3 at Marysville yard with OmniLED 07 on top in addition to one PTZ camera, two thermal cameras, one radar, and one audio horn

PTZ Camera - AXIS Q6225-LE 50 Hz

- HDTV 1080p and 31x optical zoom
- 1/2" sensor and long-range optimized IR
- Electronic image stabilization
- MIL-STD-810G and NEMA TS-2 compliant
- AXIS Object Analytics preinstalled

Ideal for wide and long-distance surveillance, AXIS Q6225-LE is specially designed with high-precision PTZ and long-range Optimized Infrared (IR). It features a ½" sensor, 31x optical zoom, and built-in analytics to alert when needed. This heavy-duty PTZ camera meets the MIL-STD-810G standard, ensuring reliable operation in the toughest conditions. It offers HDTV 1080p resolution with 31x optical zoom. Thanks to long-range optimized IR up to 400 m (1312 ft) the camera's IR light-emitting diodes (LEDs) can automatically adjust to the camera zoom, so the entire field of view is always evenly illuminated. Plus, high-speed PTZ performance ensures exceptional coverage of large areas and great detail when zooming in.

This high-performance PTZ camera is packed with built-in analytics to alert when needed. It comes with AXIS Guard Suite analytics, including AXIS Motion Guard, AXIS Fence Guard, and AXIS Loitering Guard for detecting motion, intrusion, and loitering, respectively. It also features auto-tracking functionality, and Axis Gatekeeper automatically moves the camera to a preset position when motion is detected in a pre-defined area.

Thermal Camera - AXIS Q1951-E 13 mm 30 fps

- Reliable detection 24/7
- Built-in cybersecurity features
- Compact, robust, halogen-free design
- Support for AI-based analytics
- Electronic image stabilization (EIS)

Using thermal technology, the AXIS Q1951-E offers reliable detection and verification. This compact, robust, halogen-free camera is built on a powerful analytics platform so it is easy to add custom-made third-party analytics. AXIS Perimeter Defender with AI-based functionality for object classification is also available, providing detection and classification of humans and vehicles.

With a low false alarm rate, the AXIS Q1951-E Thermal Camera offers reliable detection and verification. It comes with AXIS Motion Guard, AXIS Fence Guard, and AXIS Loitering Guard preinstalled for proactive surveillance.

AXIS D2110-VE Security Radar

- Extensive 180° area coverage 24/7
- Built-in analytics
- Area and road monitoring profiles
- Smart coexistence functionality
- PoE-out to power additional device

This smart, network-based device uses advanced radar technology to offer extensive 180° area monitoring 24/7 and a low false alarm rate. Ideal in various outdoor installations, it offers two detection profiles for area and road monitoring.

Using advanced radar technology, the AXIS D2110-VE delivers the position of an object for accurate detection 24/7 in various weather conditions. Featuring built-in analytics developed using machine learning and deep learning, it can accurately detect, classify, and track humans and vehicles with a low false alarm rate. This results in cost-efficient operations so security personnel can focus on real threats.

Two profiles are available: area monitoring for detecting humans and low-speed vehicles, and road monitoring for detecting vehicles travelling at higher speeds. Furthermore, this functionality can be combined with AXIS Speed Monitor to seamlessly connect radar to a camera.

Horn Speaker - AXIS C1310-E Network Horn Speaker

- All-in-one speaker system
- Connects to standard network
- Simple installation with PoE
- Remote health testing
- Two General-Purpose Input/Output (GPIO)

The smart, easy-to-integrate AXIS C1310-E Network Horn Speaker can help deter unwanted activity and warn off intruders detected by your cameras. It also supports voice instructions. This rugged horn speaker is perfect for most outdoor environments in most climates.

The AXIS C1310-E is an all-in-one unit with built-in power amplifier and digital signal processing (DSP). Pre-configured DSP produces clear, understandable voice every time. Onboard memory supports pre-recorded voice messages. Alternatively, security personnel can respond to notifications or provide instructions with live audio. The AXIS C1310-E also has a built-in microphone for remote health testing.

This speaker plugs into standard IP networks. It supports PoE, so a single cable provides both power and connectivity. Because it is a stand-alone unit, you can place it anywhere. It is based on open standards, for easy integration with your VMS, Voice over IP (VoIP) telephony (using Session Initiation Protocol (SIP)), and analytics from Axis and its partners.

VMS Server - AXIS camera station S1232 Tower Recording Server

Figure B.4: AXIS VMS server and network switch inside the server room at Marysville yard

- Scalable and powerful solution
- Flexible storage options including RAID
- Available with 32 TB
- 32 AXIS Camera Station licenses included
- Extensive support and 5-year warranty

Omniflow does not have any third-party monitoring partners to monitor for false alarms and dispatch law enforcement when incidents occur. Hence, in the new design plan and price quote, this VMS server is added to be used in the control center and to facilitate false alarm management by Caltrans staff or a Caltrans-selected contractor. This system comes with the software support package described in the next section.

This ready-to-use reliable recording server comes preloaded with AXIS Camera Station licenses and preconfigured software, so there is no need to spend time selecting, configuring, and testing hardware. Use of Redundant Array of Independent Disks (RAID) provides flexible storage. Services such as Keep Your Hard Drive, Next Business Day Onsite Support, and 5-year warranty ensure reliability and support. The server comes with an intuitive installation wizard and AXIS Recorder Toolbox, AXIS S1232, eliminating installation problems to help ensure trouble-free customer installation.

Software Support

Software – AXIS Camera Station

AXIS Camera Station is powerful and easy to use with an intuitive interface so anyone can manage the system, handle incidents, and quickly export high-definition (HD) evidence. AXIS Camera Station matches Axis' other network video products and features to offer a complete, flexible, safe, and reliable system.

With AXIS Camera Station users can do more than manage cameras and control building access. It is easy to add features like network speakers to communicate with staff and deter intruders, network intercoms for audio-visual identification and remote entry control, body-worn solutions for private security and law enforcement, analytics to improve operator efficiency, radar to follow intruders, and strobe sirens for safety and deterrence. Axis Camera Station is regularly upgraded to better protect premises and make use easier. Tools for protection of privacy are core functions of a VMS. Users can mask objects and innocent bystanders in video to comply with regulations. Using video redaction in AXIS Camera Station, users can easily clean video when exporting. AXIS Camera Station has the following features:

- Easy and efficient operations

- Surveillance and physical access control
- Optimized for Axis network products
- Powerful feature set
- AXIS Site Designer for system design

Software – AXIS Perimeter Defender

AXIS Perimeter Defender reinforces physical access controls to provide an edge where security starts – at the site perimeter. Together with Axis cameras, it provides an effective edge-based system that automatically detects and responds to people and vehicles intruding on property. When combined with thermal and PTZ cameras, it is suitable even for high-security locations.

AXIS Perimeter Defender provides the elements needed for a fully integrated, scalable, and effective perimeter protection system. The software comprises an edge-based intrusion detection analytics app for outdoor fixed cameras, an optional PTZ auto-tracking app for PTZ cameras, and an efficient PC-based installation program that covers both apps. AXIS Perimeter Defender's Design Tool enables proper planning for site camera installations. This software has the following features:

- Edge-based intrusion detection system
- Humans and vehicle classification
- Multiple detection scenarios
- PTZ auto-tracking for automatic close-ups
- Bounding box metadata overlay

Software – AXIS Perimeter Defender PTZ Auto-Tracking

AXIS Perimeter Defender PTZ Auto-tracking helps obtain details on intruders by enabling a PTZ camera to automatically zoom-in on and follow alarm objects. It is available as an optional add-on application for use with AXIS Perimeter Defender analytics. When AXIS Perimeter Defender PTZ Auto-tracking is installed on a PTZ camera, the application allows a fixed thermal or fixed visual camera running AXIS Perimeter Defender analytics to automatically steer the PTZ camera for close-up views of alarm objects in the fixed camera's detection zone. The fixed camera sends the location data of the detected alarm objects to the PTZ camera and thereby controls the direction and zoom level of the PTZ camera. The PTZ camera automatically adjusts the zoom level to keep all alarm objects in view, including new ones that appear in the fixed camera's detection zone. This software has the following features:

- Syncs PTZ camera with fixed camera running AXIS Perimeter Defender
- Automatic zoomed-in views of alarm objects
- Edge-based application

Software – Audio Analytics for Car Alarm and Broken Glass Detection

The Glass Break Detector is the professional solution for any environment that needs alerts for intrusion, break-ins, or raids. The sound sensor detects laminated, single or double plate, tempered and wired glass breakage. The software easily integrates into VMS, eliminating the need for additional infrastructure and creating cost-savings for the end user.

The Car Alarm Detector accurately classifies the specific sound pattern produced in today's most common car alarm systems. The software will detect car alarm sound patterns up to 300 feet away. The detector allows security staff to improve reaction time to incidents, based on real-time alerts and location information. This software has the following features:

- Real-time alerts
- Easy integration with video surveillance solutions
- Adjustable sensitivity for various environments