

HAWKEYE[™]

RADAR EVOLVED

PRODUCT CATALOG

Version v12.0

www.hawkeyeradar.com

“

I've been a traffic engineer for nearly three decades now.

It's been a fun journey. Mostly.

I am grateful that I've been able to work with a bunch of crazy geeks to invent the In|Sync Adaptive Traffic Signal System. In|Sync is a rule-based Artificial Intelligence (AI) system with an eye and a brain.

We selected video detection as the eye (both optical and thermal), as In|Sync optimizes traffic based on real-time queue lengths at the stop bar.

Inductive loop detection or magnetometers could not provide queue lengths deep enough for the In|Sync model. Only cameras could provide queue lengths that were 100'-200' deep.

But, these cameras came with a price. They missed cars, generated false positives, and sun and inclement weather blinded them.

If the eye can't see, the brain can't process. The quality of vehicle detection limits the performance of any signal optimization system.

So, I was ecstatic when I stumbled across the new and evolved radar technology

(3D-UHD) that can accurately detect vehicles with near 100% accuracy.

The radar can not only detect vehicles at the stop bar, but also about 1000 feet away from the stop bar. If this is not enough, the radar can track and classify vehicles through individual lanes.

This kind of detection and data collection capability is unprecedented.

It means that we can have information about vehicles that are arriving at the intersection about 20 seconds ahead of time.

This information is a game-changer.

Radar detection is catapulting traffic modeling to a new era.

We can calculate HCM Stopped Delay, Level of Service (LOS), high-resolution data, and Purdue Metrics accurately out of the box.

We can tell you how many cars ran the red light (or sneaked through on amber) on any day, out of the box.

I am working feverishly with my team to develop a new and improved traffic signal optimization model (both for developing timing plans, and for In|Sync) based on the unprecedented breadth and accuracy of data provided by the radar.

So, my fellow traffic professional: it is with joy that I submit the Hawkeye 3D-UHD Radar for you to examine and consider for your use.

Very respectfully,

Reggie Chandra ..

Reggie Chandra, Ph.D., P.E.

President and CEO of Rhythm Engineering



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How Does It Work?



HAWKEYE is the evolution of radar technology originally developed for mission-critical operations of the military.

First developed in the 1800s, Radio Detection and Ranging (RADAR) has been continuously developed and refined. It all started with scientist Christian Doppler, whose name is synonymous with radar and weather technology the world over. The phenomenon he described was that when an observer and a source moved towards each other, the frequency of a wave (be it sound, light, or something else) would increase. As they moved farther away from each other, the frequency would decrease.

Germany's Heinrich Hertz later upped the ante by proving that radio waves would reflect off metallic objects back to their source, meaning they could be used to measure distances between objects.

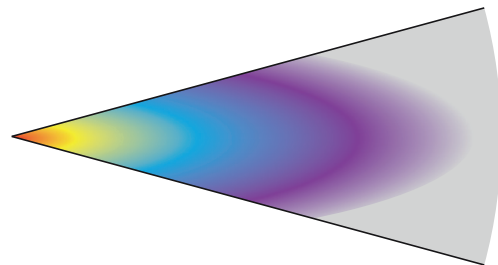
By the time of World War II, the Allies had gained enough command of the use of radar technology to determine the distance and angle of enemy targets. Since the end of WWII historians have opined that the use of radar may have been the biggest catalyst in the Allies' triumph.

There are two types of microwave radar sensors that can be used for vehicle detection.

The first is Continuous Wave (CW) Doppler radar. It has the limitation of not being able to detect vehicles that have stopped without the addition of an extra sensor. This limitation makes the second form, Frequency Modulated Continuous Wave (FMCW) radar, the favored choice for vehicle detection application.

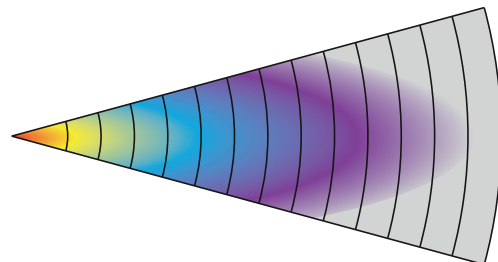
➤ **Standard Technology**

- Separation in Frequency
- Slow Speed Modulation



➤ **2D-HD**

- Separation in Speed
- Separation in Range
- High Speed Modulation



➤ **3D-UHD**

- Separation in Speed
- Separation in Range
- Separation in Angle
- High Speed Modulation
- Adaptive Beams

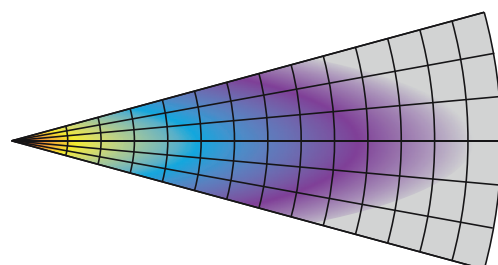


Figure 1. The three generations of radar vehicle detection



FMCW can accurately detect:

- Vehicle presence
- Vehicle speed
- Estimated time of arrival
- Vehicle occupancy
- Vehicle classification
- Queue length
- Traffic incidents
- Stopped vehicles
- Wrong-way travel
- Dilemma zone warning - the likelihood that a car will not be able to stop when the light changes from yellow to red

In FMCW radar, the wavelength frequency changes constantly with respect to time. A vehicle's speed is calculated by taking the lanes of a traveled way and dividing them into areas known as 'zones' or 'bins' that all have defined lengths. The distance between the leading edges of adjacent zones/bins is divided by the time between the vehicle's arrival at those leading edges to determine its speed.

The FMCW radar used to power **HAWKEYE** is a third generation radar vehicle detector and is known as 3D-UHD.

The first-generation standard technology detected vehicles using range and speed data, but it couldn't separate or classify two vehicles at the same speed with the same range.

The second generation (2D-HD) radar used high-speed modulation to separate speed and range; it could also be separated at the same range if they were traveling at different speeds.

3D-UHD gives the most accurate results due to three main upgrades. First, it separates vehicles by angle of travel as well as range and speed. Like 2D-HD, it uses high-speed modulation and adds adaptive beam formation to enhance the accuracy of detection.



Figure 2. HAWKEYE real-time vehicle classification visualization

HAWKEYE's antenna contains a 3D-UHD transmitter along with a matrix of receivers that both intercept and analyze the reflected waves. The beams, formed 24 or more at a time, comprise a simultaneous Digital Beam Formation (DBF) that is forward firing, can cover up to six lanes of traffic, and is accurate to and beyond a range of 1,000 feet (300 m).

HAWKEYE's beams are adaptive and work simultaneously in order to utilize the best form of detection that can possibly be captured from the footprint that each vehicle gives off via radar. The adaptive beams are sliced based on each vehicle's range and angle as a function of the radar's field of view. Once **HAWKEYE** detects a vehicle in its field of vision, the vehicle is assigned a unique identification. From there, **HAWKEYE**'s processors go to work, using tracking algorithms coupled with machine-learning based artificial intelligence (AI) to separate, classify, and track each vehicle. The tracking occurs on a continuous basis until the vehicle is out of the beam's range.

The original military application was built to identify humans but has since been reconfigured for vehicle detection. In addition, **HAWKEYE** recognizes that pedestrians and cyclists are a vital component to the flow of traffic and can identify, classify, and track both types of non-vehicular traffic to a very high degree of accuracy. Just like vehicles, **HAWKEYE** can identify cyclists and pedestrians 1,000 feet away from the intersection.

The ability to accurately detect vehicles and compile real-time data about what is happening in an intersection sets **HAWKEYE** apart from any other form of existing vehicle detection method. The lack of tools to collect data or a means to analyze this data renders between 70-90% of traffic signals in the US as either unsynchronized or not timed properly to correspond with traffic utilizing those streets.

This accuracy does not wane when the sun sets. Radar does not need visible light to operate and there is no drop-off in **HAWKEYE**'s performance from day to night.

Benefits

The overwhelming majority of traffic lights active in the US today are monitored and controlled using one of the following three categories:

- Inductive loop detection
- Wireless magnetometers
- Video detection technology

HAWKEYE, based on 3D-UHD Radar Detection Technology, outstrips them all as it's limited by none of their shortcomings and able to function around the clock in any weather condition, as well as avoiding wear and decay associated with poor road conditions, electrical interferences, battery lifespan, or camera obstruction. It's also unhindered by unpredictable events, such as vehicle color, extra bright sunshine, or shadows and clouds, which could be misread as vehicles.

HAWKEYE is the best vehicle detection system available. Its list of benefits for use at intersections controlled by traffic signals include the following:



Close to 100% detection accuracy. No machine is perfect 100% of the time, but 3D-UHD Radar Technology comes close. One of the most prevalent vehicle detection technologies was video detection, but something as simple as condensation on the lens could disrupt how data was interpreted. Neither weather, time of day, position of the sun, shadows on the ground, nor any other factor limits radar devices, as they separate and classify objects by their angle of travel, speed of travel, and range from the source.



Detection range of 1,000 feet. 3D-UHD Radar Detection Technology can identify vehicles approaching an intersection from around 1,000 feet (300m) away, regardless of weather conditions or time of day. The average driver using low-beam headlights at night has a range of vision of about 467 feet (140m). This means **HAWKEYE** can see vehicles approaching at night before the driver can see the traffic signals.



High accuracy of count detection. 3D-UHD Radar Detection uses at least 24 synchronous beams that track in three dimensions. Accurate vehicle detection is essential for traffic engineers to create manual signal timing plans and adaptive signal operations. Without proper data collection, it is impossible to accurately manage traffic flow. The constant collection and analysis of critical data points such as the highest volume time of day and highest volume days of the week for vehicle travel in specific directions can allow traffic engineers to be better equipped to synchronize multiple signals for optimum traffic flow.



Ability to track vehicles from entry point past the stop bar. 3D-UHD Radar Detection Technology isn't just about identifying vehicles. It's also about analyzing data at multiple points of the road in order to feed advanced traffic models which can identify and predict traffic patterns to improve traffic flow.



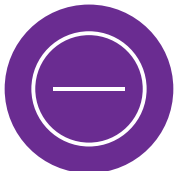
Speed estimation approaching 100%. 3D-UHD Radar Detection Technology is nearly perfect in its ability to detect vehicle speed and meets or exceeds the most severe requirements of speed enforcement radar. This includes detection and identification of dilemma zone incidents (where a vehicle is traveling too fast to stop before a light turns from yellow to red). This information can be used to modify traffic cycles or to help law enforcement monitor the intersection for lawbreakers.



Increased intersection safety. A report from the Federal Highway Administration says that one-half of serious injuries on American roadways occur at intersections, along with more than one-fifth of fatalities. By analyzing real-time data to expose flaws in traffic cycles and other areas that can be improved, these percentages can drop dramatically. A study conducted by Texas A&M University on the use of advanced detection methods in the Texas Department of Transportation system found that red-light violations fell by 58% and intersection crashes dropped by 39%.



Track, identify and classify vehicles by lane. **HAWKEYE** has a built-in lane model that can track vehicles by lane throughout the field of view. It can also precisely track vehicle lane-changing maneuvers. This lane-specific advance detection provides extremely useful data to real-time adaptive traffic signal systems like In|Sync. **HAWKEYE** is the only vehicle detection system that can provide and analyze such information.



Wrong way detection. Whether vehicles are sliding on- or off-ramp, wrong way driving can be equally perilous. Catch the violations well ahead of any dangerous incident with **HAWKEYE's** Wrong Way report, and see where the points of confusion are located. With Hawkeye statistics at hand you can consider simple actions like adding clear marking or re-directing the wrong-way drivers early enough, to avoid delay or even worse - fatalities.



Incident detection over freeways. 3D-UHD Radar Detection Technology can quickly assess when vehicles have stopped for purposes other than the natural progression. This allows for quick identification and reporting of stalls or traffic accidents which can impede the flow of traffic and lead to safety hazards.

Performance

For all of its acclaims and superior use of technology, the real test of the **HAWKEYE** system lies in its performance.

Compared to its three main competitors — inductive loops, video detection, and thermal detection — **HAWKEYE** crushes the field.

All four methods can successfully detect vehicle presence, but that's where the comparison ends. **HAWKEYE** is the only method available that offers speed measurement, pedestrian detection, incident detection, vehicle detection range up to 1,000 feet, and more.

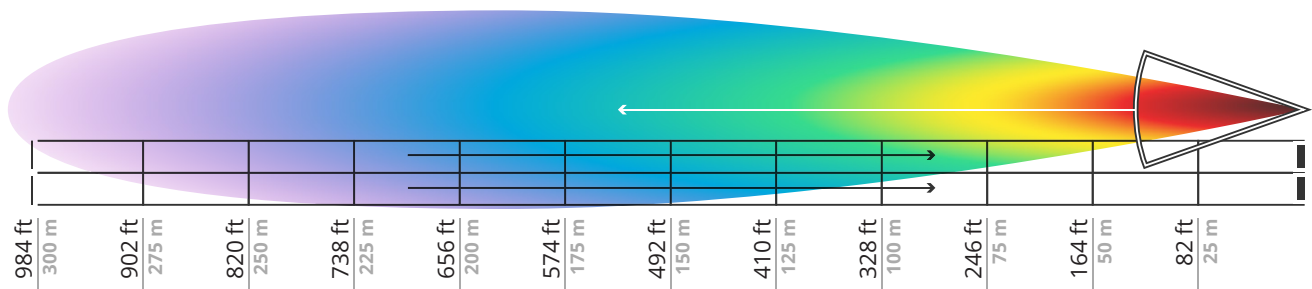


Figure 3. HAWKEYE operational range exceeds 1,000 ft.

These performance features are the foundation of a revolution in vehicle detection systems that will form the bedrock of a new age of traffic management systems. These systems will allow for drastically lowered inefficiencies in traffic flow while also reducing the rate of injuries and accidents occurring at intersections.

According to a study by the National Transportation Operations Coalition, some 70%-90% of all US traffic signals are not functioning correctly. **HAWKEYE** can change that.

HAWKEYE steals a page from the old US Postal Service motto: working without issue whether in snow, rain, heat, or gloom of night. The system can function under extreme weather conditions — both hot and cold — as well as with a complete absence of light or under inclement weather conditions.

Weather conditions can wreak havoc on other types of sensors. Magnetometers lose their battery life in cold weather. Video detection cameras can be blinded by fog, rain, and sunlight. Because waves bouncing off cars and back to the source are unaffected by weather or light conditions, **HAWKEYE's** performance is unchanged by weather variables.

When it comes to bicycle accidents, 45% of those involving a car take place at intersections. Approximately 1,100 pedestrian fatalities occur at intersections each year, making up nearly one-quarter of all pedestrian deaths.

HAWKEYE is not only the sole vehicle detection system that can detect and track cyclists and pedestrians accurately, but it can do so at up to 1,000 feet away from the intersection. This gives traffic engineers the opportunity to modify systems to account for the presence of both varieties of travelers who don't have the protection of a car.

One of the most perilous moments at an intersection occurs when a driver enters the dilemma zone - that is, the area where they cannot safely stop before a yellow light turns to red. The Insurance Institute for Highway Safety (IIHS) reports that there were more than 900 deaths and close to 2,000 injuries in 2016 as a result of vehicles running red lights at intersections, with about 50% of the fatalities being people in other cars or pedestrians struck by vehicles trying to beat a light. **HAWKEYE** has dilemma zone detection, but can also identify wrong-way driving, incidents, and stopped vehicles. Not only can this assist in potential injury situations, but it can also provide traffic engineers with real-time data on how frequently these incidents are occurring, and how individual traffic signals or a sequence of signals can be adjusted to lower the risk involved.

The use of 3D-UHD Radar Detection Technology allows **HAWKEYE** to record high-resolution data, something no other current vehicle detection system can replicate. Prior to this form of technology being available for use in vehicle detection at intersections, traffic engineers were limited to occasional traffic studies that provided a brief snapshot of data obtained through manual recordings. The high-resolution data that **HAWKEYE** is able to collect can be used to fine-tune traffic signal timing and evaluate performance of individual intersections, entire corridors, as well as performance of the network itself.

The value of the **HAWKEYE** vehicle identification system goes way beyond more efficient use of an intersection. It can save lives, slash budgets, and expose bottlenecks while providing traffic engineers with the type of real-time data sets they've craved for decades, opening up pathways to safer, more efficient intersections of the future. Because of its extensive data collection capability, **HAWKEYE** can report a vast array of performance measures including real-time delay (intersection and approach delay using the Highway Capacity Manual [HCM] method) and Signal Performance Measures (SPMs) including Purdue Coordination Diagrams, arrivals on green and red, etc.

Hardware



Radar Sensor

Features

- Stop Bar + Advance detection in a single sensor
- 3D Object Tracking with UHD Resolution, differentiating and tracking objects in speed, range, and angle
- Up to 8 lanes of detection (depending on the mounting location)
- Selectable Maximum Detection Range of 558 ft. (170m) or 1115 ft. (340m)
- Selectable Minimum Detection Range of 1.5m or 3.0m
- < 54ms refresh rate of up to 126 tracked objects
- -50 degree to +50 degree Azimuth Angle field of view
- Range Accuracy: < +/- 9.8 in. (0.25 m)
- Speed Accuracy: < +/- 0.63 mph (0.28 m/sec)
- Frequency: 24 to 24.25GHz K Band

Specs

- Power: 13-32 VDC, 12W typical
- Weight: 2.8 lb. (45.5 oz.), 1290g
- IP67 enclosure
- Temperature: -40°C to +74°C (operating)
- Dimensions: 212.6 x 154.6 x 38.15mm
- Communication: Ethernet, Cat6e or better

Features

- Starlight Ultra-low Light Technology captures color details in low light down to 0.007 lux
- True Wide Dynamic Range (WDR) optimizes bright and dark areas of the scene simultaneously
- 1920 x 1080 resolution video at up to 60 fps
- Integrated wiper provides visibility against rain, sleet, snow, and fog at all times
- Pan: 0 to 360 degrees, Tilt: 0 to 78 degrees, Rotation: 0 to 360 degrees
- Up to 3 defined streams of output
- H.265 video compression
- Enhanced night vision
- Digital Zoom: 16x
- PoE



Monitoring Camera

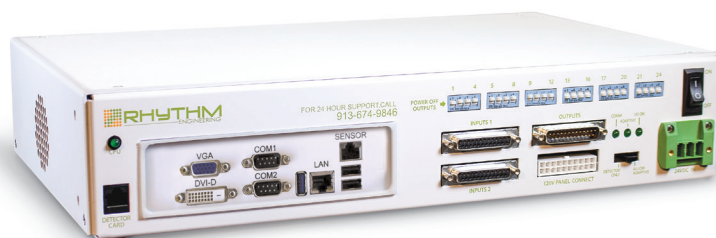
Specs

- Power: 12 VDC or PoE (802.3af, Class 0), <5 W typical
- Weight: 1.0 lb / 0.5 kg
- IP67 enclosure
- Temperature: -40°C to +74°C (operating)
- Dimensions: 4.17" diameter x 3.69" (106.0 mm diameter x 93.70 mm)
- Communication: Ethernet, Cat6e, or better



NEMA-STYLE

Hawkeye Processor



330s-STYLE

Features

- Computer processing of connected detectors (i.e., radar or radar/camera unit)
- Remote monitoring/configuration via a web interface
- Tied to the cabinet, enabling monitoring of light status
- Password protection for access on shared networks with multiple levels of credentials
- Automatic per-phase and per-lane traffic counts
- Advanced emergency/fog mode based on historical data for In|Sync integrated installation
- VGA video port for monitoring at cabinet
- 2 USB ports for keyboard/mouse and field upgrades
- 10/100 Mbps Ethernet port
- Compatible with all types of traffic controllers and cabinets for fast, easy installation
- Flexible and extensive input/output options
- In|Sync Adaptive Traffic Control ready

Specs

- 24VDC, min 150 W
- Weight: 7.0 lbs. (3.2 kg)
- Temperature: -40°C to +74°C (operating), -40°C to +85°C (storage)
- Relative Humidity: 10 - 90% (non-condensing)
- Dimensions:

332-STYLE

19" STANDARD RACK MOUNTABLE
16.75" W x 9.5" D x 3.25" T
(426mm W x 241mm D x 82.6mm T)

NEMA-STYLE:

SHELF MOUNTABLE
5.9" W x 9.5" D x 10.8" T
(150mm W x 241mm D x 275.5mm T)

Hawkeye Automated Performance Measures

Benefits of Hawkeye ASPM/AFPM Measures for Intersections and Freeways

Solution

- High-definition data on Presence and Advanced detection zones
- Real-time and period-based data with enforcement credence
- Data intelligence module included with every radar purchase
- Benchmarked to HCM 2016

Application

- Intuitive user interface
- Multi-metrics integration
- Flexible multi-tab dashboard system
- Enhanced data readability
- Fully customizable per intersection and freeway segment
- Automatic data range alerts

Data Features

- Bespoke reporting for Intersections and Freeways
- Advanced **HAWKEYE** statistics
 - In-depth platoon progression tracking (individual vehicle Time/Space diagram)
 - Multiple time period data analysis
- Dynamic data refresh

User Experience

- Performance snapshot at a glance
- Quick data comparison
- Flexible drag-and-drop arrangements
- Live view
- Powerful visualization export
- Configurable on the fly
- Real-time and historical data

Hawkeye ASPM

HAWKEYE radar technology delivers nearly 100% vehicle detection accuracy while introducing a new universe of data granularity. **The Hawkeye Automated Signal Performance Measures (ASPM)** module is a powerful reporting and visualization tool. It is cost-free and provides an array of metrics that help traffic professionals in their efforts to improve the travel experience of motorists. Advanced data processing mechanism details the measurements per lane, movement, phase, approach, intersection, and corridor.



Arrivals

- Arrivals on Red/Green
- Purdue Coordination Diagram

Volume

- Volume Approach/Lane/Phase
- Composition/Approach

Delay and LOS

- Delay/Vehicle/Phase
- Total Delay/Vehicle/Phase
- Level of Service/Approach
- Level of Service/Intersection

Others

- Average Speed
- Passed on Red
- Occupancy
- Headway

Hawkeye AFPM

HAWKEYE Automated Freeway Performance Measures (AFPM) is a cost-free data intelligence module for collecting and visualizing high-resolution data from the wider road network. The radar detection captures vehicle movements and incidents on a selected freeway segment or multiple segments from the jurisdiction of interest. Then traffic data gets digested into industry standard metrics. No other system on the market provides such an extensive array of dedicated freeway performance measures in an easy-to-view, use, and customize dashboard.



Volume/Flow

- Volume/Lane/Direction
- Total Volume
- Composition
- Heavy Vehicles %
- PHF/Lane/Direction
- Flow Rate/Lane/Direction

Traffic Events

- Wrong Way
- Traffic Interruptions

Density

- Density/Lane/Direction
- Occupancy
- Headway
- Gap

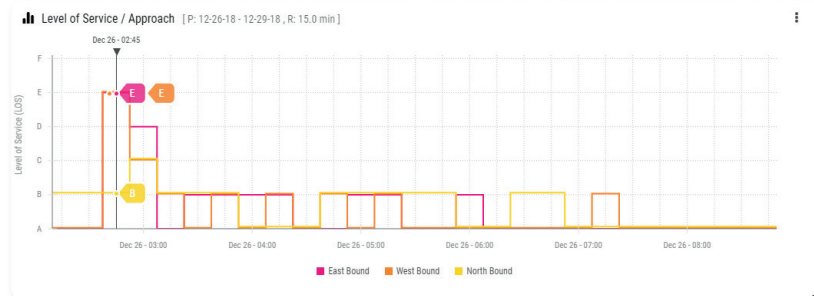
Speed

- Time Mean Speed
- Free Flow Speed
- Speed - Volume Variation

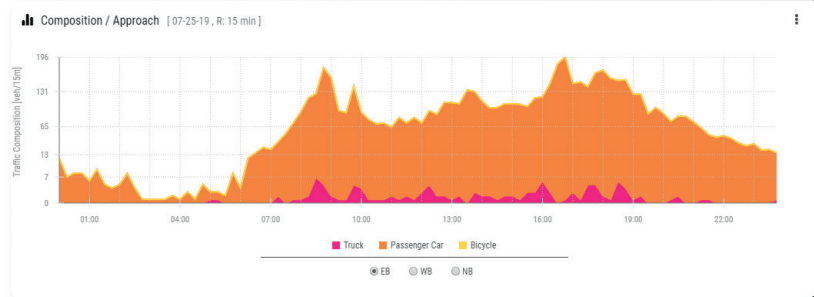
Level of Service (LOS)

Advanced Data Charts

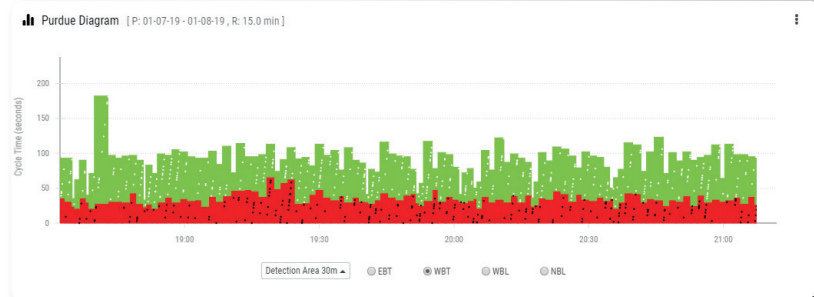
Level of Service/Approach



Vehicle Composition/Approach



Purdue Coordination Diagram



Traffic Interruptions

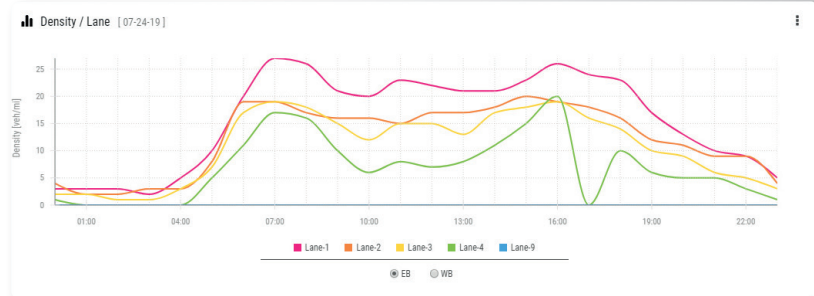
Traffic Interruptions [P: 07-17-19 - 07-24-19]

#	Date	Time	Direction	Time Mean Speed (mi/hr)	Lane	Number of vehicles
357	07-24-2019	08:25	EB	4	Lane-3	2
358	07-24-2019	08:55	EB	5	Lane-3	7
359	07-24-2019	08:58	EB	5	Lane-2	8
362	07-24-2019	09:16	EB	4	Lane-4	5
360	07-24-2019	09:20	WB	4	Lane-5	1
361	07-24-2019	09:25	EB	5	Lane-3	5
363	07-24-2019	09:31	EB	5	Lane-4	8
368	07-24-2019	12:57	EB	5	Lane-3	3
367	07-24-2019	12:57	EB	4	Lane-4	3
369	07-24-2019	12:57	EB	5	Lane-2	2
366	07-24-2019	12:59	EB	5	Lane-1	1
364	07-24-2019	13:02	WB	5	Lane-5	1
365	07-24-2019	13:08	WB	5	Lane-5	1

☒ All ☒ Lane-1 ☒ Lane-2 ☒ Lane-3 ☒ Lane-4 ☒ Lane-5 ☒ Lane-7 ☒ Lane-8

Total: 102

Density/Lane



Warranty

HAWKEYE is shipped with an included two (2) years hardware, one (1) year software warranty, and one (1) year 24/7/365 remote technical support. For the sake of clarity, the options available from Rhythm Engineering, have been expressly described in the table below.

Services / Goods	Term	Amount	Level of Support
Standard Warranty	1 year from Purchase	Free (Included in the product purchase)	Phone and Email Support; Software Upgrades
	2 years from purchase		Hardware Warranty
Optional Support Post Warranty	Annually	\$250	All Software Upgrades and License
		\$250	Remote Technical Support: <ul style="list-style-type: none"> • Phone and Email • Hardware Support • Software Upgrades
Hardware Warranty Extension	Annually* (available for up to a three-year maximum)	\$2,500	Hardware diagnostics, and repair or replacement
Hourly Support Option	Upon Request	Hourly Rate Technician: \$110	Remote Technical Support: <ul style="list-style-type: none"> • Phone and Email • Simple Config Changes** • Hardware Support
		Hourly Rate Engineer: \$150	
Field Services	Upon Request	Daily Rate: \$2000	On-site Visit: <ul style="list-style-type: none"> • Hardware Adjustments • Troubleshooting • On-site Consultation • Other, as required

* Prices are given per intersection. The annual fee is available for purchase in one-year increments, payable in advance. If desired, accommodations can be made to pro-rate these fees, to be coincident with an agency's budget cycle.

** Check the definition of Simple Configuration Changes in the Detailed Description section of the warranty sheet.

References

Klose, Bill. "What are the Differences Between Vehicle-Detection Technologies?" Retrieved from: <http://www.machinedesign.com/motion-control/what-are-differences-between-vehicle-detection-technologies>

Varaiya, Dr. Pravin. "High-res traffic data provides planners with the big picture." Retrieved from ITS International website: <http://www.itsinternational.com/categories/detection-monitoring-machine-vision/features/high-res-traffic-data-provides-planners-with-the-big-picture/>

Goguen, David, J.D. "Bike Accidents: Collisions with Cars at Intersections" Retrieved from: <https://www.nolo.com/legal-encyclopedia/bike-accidents-collisions-with-cars-29549.html>

Intersection Safety Issue Briefs. Federal Highway Administration, U.S. Department of Transportation. Retrieved from the FHA Office of Safety website: https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa10005/brief_9.cfm

"Cost of Auto Crashes & Statistics". Rocky Mountain Insurance Information Association. Retrieved from: http://www.rmiiia.org/auto/traffic_safety/Cost_of_crashes.asp

Intersection Safety (December 2015). Federal Highway Administration, U.S. Department of Transportation. Retrieved from the FHA Office of Safety website: <https://safety.fhwa.dot.gov/intersection/>

Martin, Dr. P.T., Dharmavaram, G. & Stevanovic, A. (December 2004). *Evaluation of UDOT'S Video Detection Systems: System's Performance in Various Test Conditions*. Salt Lake City, UT: Department of Civil and Environmental Engineering, University of Utah Traffic Lab.

Mimbela, L.E.Y., Klein, L., et al. (August 2017). *A Summary of Vehicle Detection and Surveillance Technologies use in Intelligent Transportation Systems* (updated version). Retrieved from <https://www.fhwa.dot.gov/policyinformation/pubs/vdstits2007/>

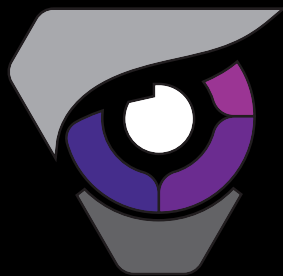
Minge, E. (September 2010). *Evaluation of Non-Intrusive Technologies for Traffic Detection* (technical report). Minneapolis, MN: SRF Consulting Group. Traffic Detector Handbook, 3rd ed. Vol. 1 (October 2006). Retrieved from <https://www.fhwa.dot.gov/publications/research/operations/ITS/06108/06108.pdf>

2012 National Traffic Signal Report Card: *Strategic Investments Make a Difference* (May 2012). Retrieved from <http://www.ite.org/reportcard/>

Schrank, D. & Eisele, B, et al. (August 2015). *2015 Urban Mobility Scorecard*. Inrix, Kirkland, WA & Texas A&M Transportation Institute, The Texas A&M University System, College Station, TX. Retrieved from <https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-scorecard-2015-wappx.pdf>

Scholler, J. & Wu, J. (June 2017). *Design Vehicle Detection System for Better Data Accuracy* (presentation). 2017 Florida Department of Transportation Design Training Expo. Retrieved from the FDOT website, <http://www.fdot.gov/design/training/DesignExpo/2017/Presentations/2017-JillianScholler-DesignVehicleDetectionSystemforBetterDataAccuracy.pdf>

Wang, Y. & Araghi, B.N., et al. (June 2014). *Error Assessment for Emerging Traffic Data Collection Devices* (research report). Department of Civil and Environmental Engineering, University of Washington, Seattle, WA. Retrieved from the Washington State Department of Transportation website, <https://www.wsdot.wa.gov/research/reports/fullreports/810.1.pdf>



HAWKEYETM

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