Caltrans EQASI Material Evaluation

Code|Green Cyclops Vehicle Detection by Rhythm Engineering

4/7/2025

Introduction

Overview of Code|GREEN

Code|GREEN is an integrated trafic management solution developed by Rhythm Engineering designed to streamline the process of trafic signal timing and operations. Per Rhythm Engineering, this system aims to combine data collection, timing plan generation, and detection into a single software platform to enhance trafic flow and reduce congestion. Code|GREEN collects real-time vehicle data, processes it to generate customized timing plans, and can deploy those plans to trafic signal control software. The Caltrans CTSCP does not currently support real time importing of timing plans. Code|GREEN advertises optimizing timing and the entire trafic management process through making data-driven decisions that improve road safety, minimize delays, and optimize trafic operations in various settings. Whether applied to regular trafic patterns or special events, Code|GREEN aims to create a more eficient and responsive transportation system. Detection accuracy is anticipated to be 90% or more for clear weather conditions but may vary under adverse weather like rain, snow, or fog.

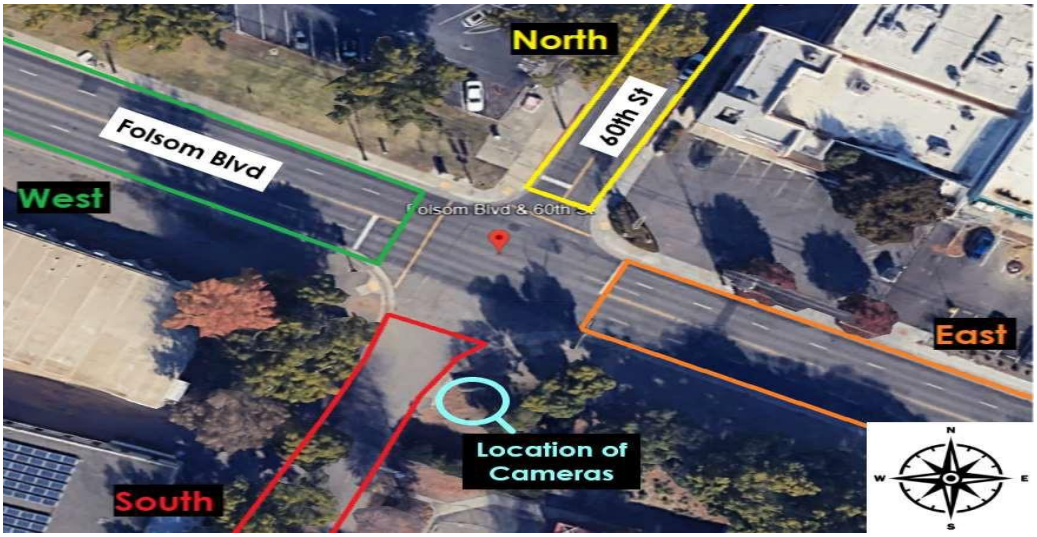
This evaluation focuses on the system's performance in a controlled testing environment, to compare detection capabilities against the Caltrans statewide Non-Standard Special Provisions (NSSP) for Video Detection and timing optimization interface.

Testing Details

Where/When:

- Intersection: Folsom Blvd and 60th Street in Sacramento, CA 95819
- Dates and Times:
  - January 30th, 2025 at 02:00 – 02:15, 07:45 – 08:00, 14:00 – 14:15, 17:00 – 17:15, 21:00 – 21:15
  - March 8th, 2025 at 07:45 – 08:00
- A full test procedure is outlined in Appendix A

Intersection Layout



Equipment Used:

- The Cyclops Processor, data processor for the system, installed in the trafic cabinet, connected to the controller via C1Y cable for integration with Caltrans 2070LX controller and 342 LX cabinet. A lightbox trafic signal simulator was used.
- Axis P3738-PLE Panoramic Camera mounted on a telescoping tower shaft, acting as the intersection trafic pole.
- Telescoping tower was used as the mounting solution for the camera.

Standards Used:

- Caltrans Non-Standard Special Provision (NSSP) for video detection systems and an accompanying checklist, shown in Appendix B.

Evaluation Plan

- Detection Accuracy: The method of accuracy verification was through processed videos of the system which would change the zone color to green if a vehicle triggered the detection zone.
    - Processed view videos provide an overlay of the detection zones and turning movement vectors.
- Timing Plan Evaluation: A timing plan were generated, and the auto-generated TMC data tabs were viewed. The evaluation of this portion was subjective with reasonable methods. This evaluation includes examining the interface's ease of use, the software's ability to process peak and of-peak hour data, and how readily available trafic management data is within the system.
    - Turning Moving Count Accuracy: Processed view videos were recorded on the Cyclops processor to playback and manually count vehicles compared to the automated counts collected by the Code|Green system to assess accuracy.

Issues Encountered:

- During the initial evaluation a power supply failed. This paused the evaluation briefly, but the issue was resolved quickly with a replacement power supply provided by the vendor
- Videos slowly started recording earlier times instead of on the :00, :15, :30, and :45 minute marks
- For configuring directions, there is a movement vector that represents the expected motion of trafic (for example, northbound right turn or southbound left turn). The vehicle's actual direction arrow must fall within +/- 30 degrees of the configured arrow to be counted for that direction. This can be adjusted to diferent degrees, but it can only be done universally. Having this option per movement vector or per established camera view would be more beneficial

Evaluation Approach, Requirements, and Results

Section 1: Setup

The AXIS camera was mounted on a telescoping tower to provide video footage to the processor. The Code|Green system was installed into the 342LX cabinet which is pictured below including: cyclops processor, power supply, unmanaged switch (unused), and fusion module. The image below represents how much cabinet space this system requires in its simplest setup, however the din rail mounting capabilities do allow for better utilization of cabinet space. The vendor provided guidance for the initial configuration of the system through a video call. Configuration includes setting up detection zones and the expected movement from trafic flow to detect turning movements. After the initial configuration, the vendor was available for review of the system through email and phone call. Configuration needed adjustment after the initial setup before it was

viable for testing.

Northbound Detection Zone

Southbound Detection Zone

Westbound Detection Zone

Eastbound Detection Zone

Northbound Movement Tracking

Southbound Movement Tracking

Eastbound/Southbound Movement Tracking

Westbound Movement Tracking

Eastbound Right Turn Movement Tracking

Section 2: Data Collection

During the testing period, various timeframes during a day were selected to evaluate the system's performance under diferent trafic conditions. The data collection times were:

- 2:00 AM – 2:15 AM: Minimal activity in dark conditions, testing how the system handles false positives and its ability to detect minimal trafic.
- 7:45 AM – 8:00 AM: Peak morning elementary school trafic.

- 2:00 PM – 2:15 PM: Peak afternoon school dismissal trafic.
- 5:00 PM – 5:15 PM: Evening rush hour, with rapidly changing lighting conditions as the sun sets.
- 9:00 PM – 9:15 PM: Nighttime conditions with moderate trafic activity in low lighting.

Data collected during these timeframes was exported in .CSV or .VOL formats. Each timeframe provided insight into the system's response to varying trafic and environmental conditions shown below.

Folsom Blvd and 60th St — Export Data: .csv

Approach	NB			SB			EB			WB		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
00:00	0	0	0	0	0	0	0	17	0	0	23	0
00:15	0	0	0	0	0	0	0	10	0	0	22	0
00:30	0	0	0	0	0	0	0	9	0	0	16	0
00:45	0	0	0	0	0	0	1	5	0	0	17	0
01:00	0	0	0	0	0	0	0	8	0	0	20	0
01:15	0	0	0	0	0	0	0	5	0	0	6	0
01:30	0	0	0	0	0	0	0	6	0	0	11	0
01:45	0	0	0	0	0	1	0	13	0	0	8	0
02:00	0	0	0	0	0	0	0	13	0	0	8	0
02:15	0	0	0	0	0	0	0	7	0	0	15	0
02:30	0	0	0	0	0	0	0	3	0	0	11	0
02:45	0	0	0	0	0	0	0	2	0	0	11	0
03:00	0	0	0	0	0	0	0	4	0	0	10	0

15 Minute Turning Movement Count

Reference # a4ef528f-38d7-4a20-948c-0ac431d1138a - Folsom Blvd at Folsom Blvd and 60th St: 2025-01-10

a4ef528f-38d7-4a20-948c-0ac431d1138a

DATE	TIME	INTID	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
1/10/2025	0:00	a4ef528f-3	0	0	0	0	0	0	0	17	0	0	23	0
1/10/2025	0:15	a4ef528f-3	0	0	0	0	0	0	0	10	0	0	22	0
1/10/2025	0:30	a4ef528f-3	0	0	0	0	0	0	0	9	0	0	16	0
1/10/2025	0:45	a4ef528f-3	0	0	0	0	0	0	1	5	0	0	17	0
1/10/2025	1:00	a4ef528f-3	0	0	0	0	0	0	0	8	0	0	20	0
1/10/2025	1:15	a4ef528f-3	0	0	0	0	0	0	0	5	0	0	6	0
1/10/2025	1:30	a4ef528f-3	0	0	0	0	0	0	0	6	0	0	11	0
1/10/2025	1:45	a4ef528f-3	0	0	0	0	0	1	0	13	0	0	8	0
1/10/2025	2:00	a4ef528f-3	0	0	0	0	0	0	0	13	0	0	8	0
1/10/2025	2:15	a4ef528f-3	0	0	0	0	0	0	0	7	0	0	15	0
1/10/2025	2:30	a4ef528f-3	0	0	0	0	0	0	0	3	0	0	11	0
1/10/2025	2:45	a4ef528f-3	0	0	0	0	0	0	0	2	0	0	11	0
1/10/2025	3:00	a4ef528f-3	0	0	0	0	0	0	0	4	0	0	10	0
1/10/2025	3:15	a4ef528f-3	0	0	0	0	0	1	0	1	0	0	8	0
1/10/2025	3:30	a4ef528f-3	0	0	0	0	0	0	0	1	0	0	12	0
1/10/2025	3:45	a4ef528f-3	0	0	0	0	0	0	0	4	0	0	20	0
1/10/2025	4:00	a4ef528f-3	1	0	1	0	0	0	0	4	0	1	12	1
1/10/2025	4:15	a4ef528f-3	0	0	0	0	0	0	0	3	0	0	20	0
1/10/2025	4:30	a4ef528f-3	0	0	0	0	0	0	0	5	0	0	15	0

Section 3: Data Evaluation

The analysis of the collected data revealed that detection accuracy varied based on sample size and day/nighttime counts. Smaller sample sizes were less reliable, leading to increased inaccuracies in vehicle counts. Furthermore, the system struggled with detecting vehicles moving in directions opposite to the configured trafic flow, notably westbound through trafic being counted in southbound right turn counts. This discrepancy can be seen throughout the data tables below. Additionally, the system had dificulty detecting vehicles during nighttime in comparison to daytime.

Detection Tracking

January 30th, 2:00 AM -- 2:15 AM				
Movement	**Manual**	**Detected**	**Difference (Absolute Error)**	**Percent Accuracy**
NB	0	0	0	N/A
SB	0	0	0	N/A
WB	4	1	3	25
EB	4	3	1	75

January 30th, 7:45 AM -- 8:00 AM				
Movement	**Manual**	**Detected**	**Difference (Absolute Error)**	**Percent Accuracy**
NB	2	2	0	100
SB	76	77	1	98.68
WB	195	194	1	99.49
EB	192	192	0	100

January 30th, 2:00 PM -- 2:15 PM				
Movement	**Manual**	**Detected**	**Difference (Absolute Error)**	**Percent Accuracy**
NB	0	0	0	N/A
SB	5	7	2	60
WB	156	153	3	98.08
EB	141	141	0	100

January 30th, 5:00 PM -- 5:15 PM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB	1	1	0	100
SB	25	29	4	84
WB	190	181	9	95.26
EB	176	176	0	100

January 20th, 9:00 PM -- 9:15 PM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB	0	0	0	N/A
SB	2	4	2	0
WB	88	48	40	54.55
EB	63	55	8	87.30

March 8th, 7:45 AM -- 8:00 AM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB	0	0	0	N/A
SB	0	0	0	N/A
WB	56	58	2	96.43
EB	41	42	1	97.56

Turning Movement Counts

January 30th, 2:00 AM -- 2:15 AM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB Through	0	0	0	N/A
NB Left	0	0	0	N/A
NB Right	0	0	0	N/A
SB Through	0	0	0	N/A
SB Left	0	0	0	N/A
SB Right	0	1	1	#REF!

WB Through	4	3	1	75
WB Left	0	0	0	N/A
WB Right	0	0	0	N/A
EB Through	4	2	2	50
EB Left	0	0	0	N/A
EB Right	0	0	0	N/A

January 30th, 7:45 AM -- 8:00 AM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB Through	2	2	0	100
NB Left	0	1	1	N/A
NB Right	0	0	0	N/A
SB Through	0	0	0	N/A
SB Left	36	36	0	100
SB Right	40	49	9	77.5
WB Through	135	134	1	99.25
WB Left	0	0	0	N/A
WB Right	59	58	1	98.30
EB Through	135	139	4	97.04
EB Left	53	51	2	96.23
EB Right	2	0	2	0

January 30th, 2:00 PM -- 2:15 PM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB Through	0	0	0	N/A
NB Left	0	1	1	N/A
NB Right	0	1	1	N/A
SB Through	0	0	0	N/A
SB Left	3	8	5	-66.67
SB Right	2	13	11	-450
WB Through	151	143	8	94.70
WB Left	0	0	0	N/A
WB Right	5	5	0	100
EB Through	135	127	8	94.07
EB Left	9	10	1	88.8
EB Right	0	0	0	N/A

January 30th, 5:00 PM -- 5:15 PM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB Through	0	0	0	N/A
NB Left	0	0	0	N/A
NB Right	1	3	2	-100
SB Through	0	0	0	N/A
SB Left	11	14	3	72.73
SB Right	14	25	11	21.43
WB Through	191	181	10	94.76
WB Left	1	1	0	100
WB Right	7	8	1	85.71
EB Through	153	151	2	98.69
EB Left	26	25	1	96.15
EB Right	0	0	0	N/A

January 20th, 9:00 PM -- 9:15 PM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB Through	0	0	0	N/A
NB Left	0	0	0	N/A
NB Right	0	0	0	N/A
SB Through	0	0	0	N/A
SB Left	1	3	2	-100
SB Right	1	3	2	-100
WB Through	91	84	7	92.31
WB Left	0	0	0	N/A
WB Right	0	0	0	N/A
EB Through	65	52	13	80
EB Left	2	2	0	100
EB Right	0	0	0	N/A

March 8th, 7:45 AM -- 8:00 AM				
Movement	Manual	Detected	Difference (Absolute Error)	Percent Accuracy
NB Through	0	0	0	N/A
NB Left	0	0	0	N/A
NB Right	0	0	0	N/A
SB Through	0	0	0	N/A
SB Left	0	0	0	N/A
SB Right	0	54	54	N/A
WB Through	61	57	4	93.44
WB Left	0	0	0	N/A
WB Right	1	1	0	100
EB Through	45	40	5	88.89
EB Left	2	2	0	100
EB Right	0	0	0	N/A

Section 4: Vendor Support

Rhythm Engineering provided remote help desk support throughout the configuration and testing process. Technical support is available anytime by phone at (913) 674-9846, and they are reachable by email at support@rhythmtrafic.com.

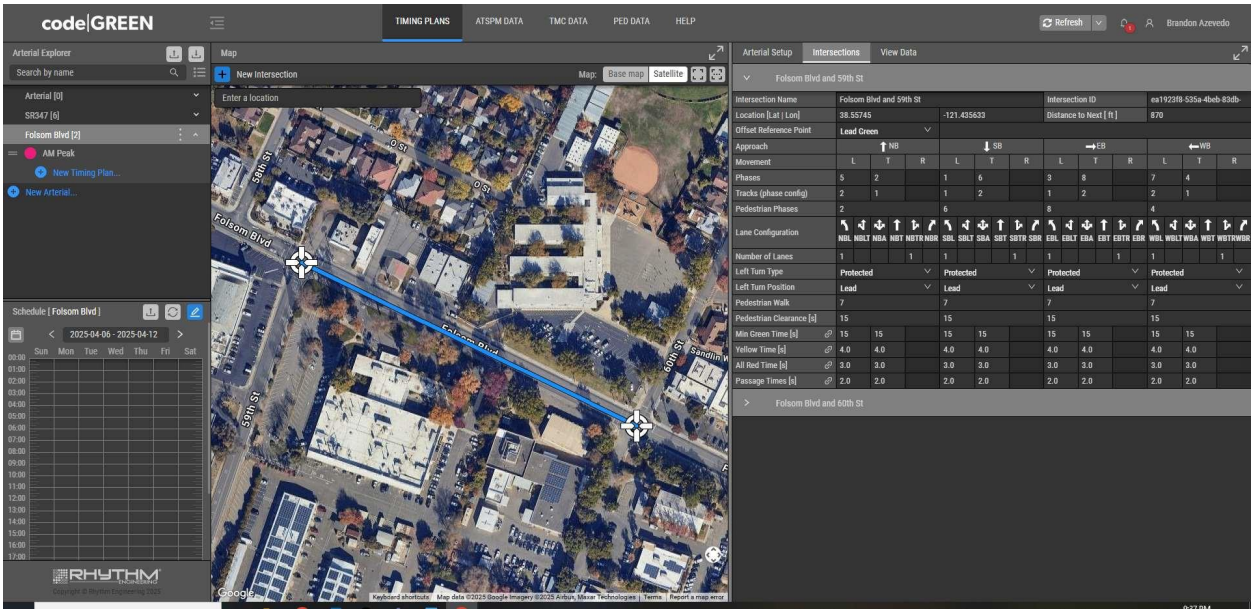
Section 5: User Interface Evaluation

Code|GREEN is equipped with two user interfaces: one for system configuration (Cyclops Processor) and another for data access (Code|Green GUI). Both interfaces can be browser-based, allowing users to interact with the system remotely.

- Configuration Interface: This interface requires multiple IP addresses to access diferent elements of the system.
- Data Access Interface: This interface provides options for accessing and downloading trafic data. TMC and ATSPM data can be viewed in a format shown below calculating peak and of-peak travel times, and the system allows for export of collected data (e.g., .CSV, .VOL).

Cyclops Processor

Code|Green GUI



Conclusion

While vendor specifications suggest high performance, especially in clear weather conditions, testing highlighted areas where accuracy could be improved, particularly with smaller sample sizes, irregular trafic flow directions and nighttime detection and counts.

Problems and Limitations:

- Sample Size Impact: Detection accuracy decreased with smaller sample sizes, which can be an issue in periods with low trafic.
- Limited Weather Testing: Most of the testing occurred under clear weather conditions, and performance may vary under more challenging weather scenarios such as rain or fog.
- Configuration Limitations: While the system's configuration interface is functional, it could benefit from a more intuitive design, particularly in terms of accessing diferent configuration elements with fewer steps.

Future Evaluation Considerations:

- Deployment to intersection with higher pedestrian and bicycle volume
- Consider that performance may vary under adverse weather conditions, and further testing may be necessary for environments with challenging weather patterns.
- The automatic upload of timing plans generated by the system to the controller was not tested.
- Accuracy may fluctuate in areas with higher volumes of trafic, including stop-and-go trafic.
- Intersections with additional lanes may see a diference in the performance of the system.

Final Thoughts: Overall, Code|GREEN meets many aspects of Caltrans statewide NSSP for video detection. See Appendix B for details.