Fort Collins Intelligent Traffic Light System (ATMS) MBSE

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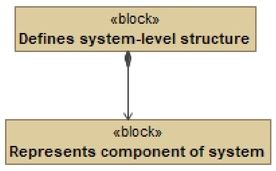
Introduction

- The purpose of this system is to optimize traffic flow and improve safety in Fort Collins through intelligent traffic signals and real-time monitoring.
- It will also compare the impact of adding a preemptive system for emergency vehicles, assessing how it enhances response times and intersection efficiency.
- The scope covers the Fort Collins traffic network, including a centralized TMC, vehicle sensors, pedestrian signals, and fiber-optic communication, with an evaluation of the preemptive system's effect on emergency vehicle prioritization.

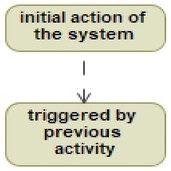
Methods

- This project was created through CATIA Magic Systems of Systems Architect tool, using the Systems Modeling Language, a graphical language for analyzing, designing, and validating complex systems and integrating diverse components.
- The use of block, activities, and requirements were utilized to model the relationship of behavior and structure of the Fort Collins traffic system.

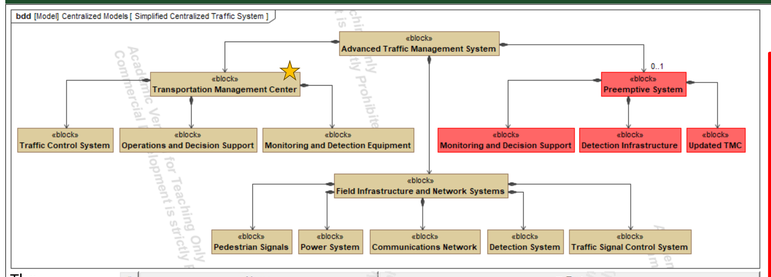
Blocks have the following relationship:



Activities have the following relationship:



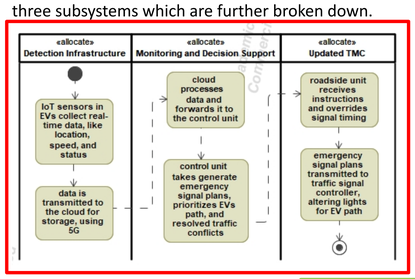
Results



The requirements table to the right illustrates how the higher-level requirements contain more specific requirements.

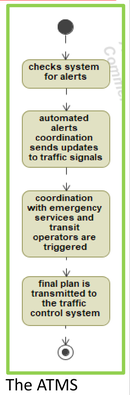
#	Name	Text
1	14 Decision Alerts	The TMC shall process traffic data and generate alerts for responding to emergencies
2	27 Signal Control Cabinet Durability	The signal control cabinets shall be built to withstand bad weather, meeting IP65 standards for ingress protection
3	28 Fort Collins Traffic System	The advanced traffic management system (ATMS) for Fort Collins shall optimize traffic flow, improve safety, and enhance the coordination of traffic signals across the city
4	28.3 Traffic Signal Control	The traffic signal control system shall adjust signal timing based on traffic data to optimize flow
5	28.3.2 Signal Timing Adjustments	The TMC shall adjust signal timing based on traffic flow data to ensure optimal green light durations
6	28.3.1 Signal Head and Pedestrian Timing	The signal timing for vehicle lanes shall be adjustable in real time to ensure that pedestrian crossing have a sufficient time while not delaying traffic
10	28.2 Communication Network	The communication system shall operate from a hybrid communication network, using fiber-optic cables and wireless links to relay and control signals between intersections and TMC
14	28.1 Traffic Monitoring and Control	The ATMS shall enable real-time monitoring and adaptive control of traffic to optimize flow and reduce congestion using sensors, radar, and CCTV cameras

The block diagram to the left shows the ATMS with three subsystems which are further broken down.



The activity diagram above illustrates the expanded diagram of the Emergency Vehicle (need preemptive system installed).

The activity diagram to the right illustrates the expanded diagram of the Signal Override Coordination activity (for system without the preemptive system).



The ATMS activity diagram is to the left. Actions are grouped by the block that performs them.

Discussion

It is important to note that the models of this Fort Collins Traffic System are not fully complete. There is some information in the requirements diagram that was assumed using what is expected from general traffic system knowledge that may not be specific to this system. The preemptive system that could be added to the Fort Collins Traffic System would not be necessary at every intersection, but it could be added to intersections with heavier traffic.

Conclusion

- This Traffic System model illustrates the relationships between blocks, activities, and requirements through many perspectives and conveys the significance of the addition of a preemptive system to the current Traffic Management System.
- There are clear requirements that this system and its subsystems must meet that are defined.
- This consists of many diagrams that connect varying functions to the physical structure that those functions would be performed by.
- This model visualizes the integration of a preemptive system that allows emergency vehicles to safely pass through intersections by prioritizing their passage with automatic signal adjustments.

References & Acknowledgements

[1] Fort Collins (Colo.). Traffic Operations Dept. and United States. Joint Program Office for Intelligent Transportation Systems, editors. *City of Fort Collins Advanced Traffic Management System : Final Report*. 2009. *ROSA P*, https://rosap.ntl.bts.gov/view/dot/3260.

[2] *Advanced Traffic Management System || Traffic Operations*. https://www.fcgov.com/traffic/eng-atms.php. (Accessed 31 Mar. 2025)

[3] Audat, et al. "Traffic Light Control Systems: Requirements Engineering." International Journal of Network Security & Its Applications, doi: 10.5121/ijnsa.2024.16101.

[4] Leveridge, et al. "Renal Colic: Current Protocols for Emergency Presentations." European Journal of Emergency Medicine, doi: 10.1097/MEJ.0000000000000324.

[5] S. Friedenthal, A. Moore, and R. Steiner, A Practical Guide to SysML, 3rd ed. Elsevier, 2015, doi: 10.1016/C2013-0 14457-1.

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Applying what I've learned from SURE

I plan to apply the diagramming skills that I have learned by having a more systematic approach for planning and proposing innovative solutions to the civil engineering problems that are present today. By modeling the different levels of systems for a traffic light, it has given me the skills to more cohesively understand the complexities of this engineering system, which I can apply to my future career in civil engineering.

Benefits gained from SURE

Being part of the SURE program, I have learned many skills about how to model, using the basic diagrams of CATIA Magic Systems of Systems Architect. I was able to model a topic of my choosing (traffic light system) and gained a new perspective on how a system such as this would interact within itself and with external factors. I have gained a better understanding of how systems are structured and how we can model them in the most complete sense.