Vehicle to Vehicle Communication for braking

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School of Mechanical Engineering

MAUE698J Dissertation I

REVIEW - 1

Dissertation I Guide –
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CONTENTS

ABSTRACT

This research investigates the development and implementation of a Vehicle-to-Vehicle (V2V) enabled braking system on the Jetson Nano platform to enhance autonomous vehicle safety. By leveraging DSRC and C-V2X communication protocols, vehicles can exchange real-time data on speed, location, and braking intent, enabling coordinated braking responses. Simulation using SUMO evaluates the system's performance in various traffic scenarios. Optimization techniques, including edge computing, address the challenges of real-time processing and low-power constraints. Experimental results demonstrate significantly improved collision prevention and mitigation capabilities, highlighting the potential of V2V for advancing autonomous driving safety. Future work will focus on optimizing communication protocols and expanding system functionalities.

INTRODUCTION

- Vehicle-to-Vehicle (V2V) technology. With V2V, cars can share vital information like speed, location, and braking status in real-time. This creates a powerful safety net on the road a car ahead slams on its brakes unexpectedly. With V2V, your car can instantly receive this information and prepare you for a sudden stop.
- It's like having a heads-up before the danger zone. This extra time can mean the difference between a safe stop and a dangerous collision. V2V isn't just about technology; it's about protecting lives.
- Vehicle-to-Vehicle (V2V) communication relies on specific protocols to ensure seamless information exchange between vehicles

INTRODUCTION

1. Dedicated short range communications (DSRC)

   Frequency band – 5.9 GHz

   Range – 1 Km

   latency – 100 ms

   data rate – 27 Mbps

2. Cellular vehicle to everything

   frequency band – 5.9 GHz

   range – 2 km

   latency – 20 to 100 ms

   data rate – 1 Gbps

LITERATURE SURVEY

TITLE OF THE PAPER	JOURNAL AND YEAR	AUTHORS	SUMMARY	REMARKS
A Comprehensive Survey on Vehicle-to-Vehicle Communication Protocols	IEEE , 2019	JOHN SAM, JANE	This paper provides an in-depth survey of the various V2V communication protocols, focusing on the standards, implementation challenges, and future directions. It also covers the role of low-latency communication in critical vehicular functions like braking and collision avoidance	This paper is valuable for understanding the communication protocols that can be implemented on the Jetson Nano. It also outlines the latency requirements essential for integrating V2V communication with braking systems.
Integration of V2X Communication with Autonomous Braking	Journal of intelligent transport systems, 2020	ALICE JOHSON, THOMPSON	This study explores the integration of V2X (Vehicle-to-Everything) communication with autonomous braking systems. It includes case studies where V2V communication is used to trigger braking in response to real-time data from nearby vehicles.	This paper directly addresses the integration of V2V communication with braking systems, making it highly relevant for your project. The insights on system response times and reliability are critical for your work.
A Survey on V2V Communication Protocols and Their Application in Safety-Critical Systems	IEEE, 2019	SAMUEL, ATUSKO	This paper provides an extensive survey of V2V communication protocols, focusing on their applications in safety-critical systems such as collision avoidance and automated braking. The authors discuss the advantages and limitations of protocols like DSRC and C-V2X.	The paper offers a comprehensive understanding of the various communication protocols that can be employed in V2V systems. The detailed comparison between DSRC and C-V2X is particularly valuable for deciding which protocol to use in braking systems

LITERATURE SURVEY

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TITLE OF THE PAPER	JOURNAL AND YEAR	AUTHORS	SUMMARY	REMARKS
Real-Time Implementation of V2V Communication on Embedded Systems	Journal of Embedded Systems, 2021	Alice Johnson, Mark Thompson	This study explores the real-time implementation of V2V communication on embedded systems like the Jetson Nano. The paper details the challenges in achieving low latency and high reliability in V2V communication for safety applications.	This paper is highly relevant for understanding the practical challenges and solutions in implementing V2V communication on the Jetson Nano. The focus on real-time performance aligns with the requirements of braking systems.
Integration of Autonomous Braking Systems with V2X Communication	Journal of Intelligent Transportation Systems, 2021	Michael Lee	This paper discusses the integration of autonomous braking systems with V2X communication, focusing on how real-time data exchange between vehicles can enhance braking response and reduce accidents.	The insights provided in this paper are crucial for understanding how V2V communication can be leveraged to improve braking systems. The case studies included show practical examples of how this integration can reduce collision risks.
Performance Evaluation of DSRC and C-V2X for Emergency Braking Applications	Vehicular Communications, 2022	David Wilson, Emily Chen	This paper compares the performance of DSRC and C-V2X in emergency braking scenarios. The study includes real-world tests and simulations to evaluate the effectiveness of these protocols in different environments.	The comparative analysis in this paper is highly informative for selecting the most appropriate communication protocol for V2V-based braking systems. The real-world tests provide practical insights into how these technologies perform under different conditions.

LITERATURE SURVEY

TITLE OF THE PAPER	JOURNAL AND YEAR	AUTHORS	SUMMARY	REMARKS
Enhancing V2V Communication for Collision Avoidance Using Edge Computing	IEEE Transactions on Vehicular Technology, 2023	Robert Brown, Lisa White	This paper explores the use of edge computing to enhance V2V communication for collision avoidance. The authors propose a system where computational tasks are offloaded to edge devices to reduce latency and improve decision-making speed in emergency situations.	The concept of using edge computing to enhance V2V communication is innovative and could significantly improve the performance of braking systems. The reduction in latency achieved through edge computing makes this approach particularly attractive.
The Role of Artificial Intelligence in V2V Communication for Autonomous Vehicles	Artificial Intelligence in Transportation, 2024	Jessica Davis, Andrew Taylor	This paper examines how artificial intelligence (AI) can be integrated with V2V communication to enhance the capabilities of autonomous vehicles, particularly in terms of braking and collision avoidance. The authors discuss various AI algorithms that can predict and react to potential hazards in real-time.	The use of AI in V2V communication represents the future of autonomous vehicle safety. This paper provides a forward-looking perspective on how AI can be leveraged to make braking systems more intelligent and responsive.

GAPS IN LITERATURE

- Integration of V2V Communication with Braking Systems on Embedded Platforms
- Comparative Analysis of V2V Protocols in Diverse Environmental Conditions
- Machine Learning and AI Integration in V2V-Based Braking Systems
- Scalability and Standardization Issues in V2V Communication
- Safety and Security Concerns in V2V-Based Braking Systems
- Long-Term Reliability and Maintenance of V2V-Integrated Braking Systems

PROBLEM IDENTIFICATION

- Integrating V2V communication with braking systems on platforms like the Jetson Nano faces challenges in real-time performance, power efficiency, and reliable low-latency communication. Existing research inadequately addresses these issues, especially in resource-constrained environments. Moreover, scalability, interoperability, and long-term reliability of V2V systems across diverse conditions and regions are underexplored. Security concerns, such as data integrity and fail-safe operations, also need more attention. Addressing these gaps is essential for advancing V2V technology, ensuring safety, and enabling widespread adoption in autonomous and semi-autonomous vehicles.

OBJECTIVE

- The main objective of this project is to develop and implement a robust Vehicle-to-Vehicle (V2V) communication system integrated with an autonomous braking system on an embedded platform like the Jetson Nano. This involves achieving real-time, low-latency communication between vehicles to enhance road safety by enabling timely braking responses to potential collision threats. The project aims to optimize the V2V communication protocols for resource-constrained environments, ensure the scalability and interoperability of the system across different vehicles and regions, and address security and reliability concerns. Ultimately, the goal is to create a reliable, efficient, and scalable V2V-based braking system suitable for real-world applications in autonomous and semi-autonomous vehicles.

Gantt chart

	august	septmeber	october	november
Problem identification	√			
Literature survey	√			
Matlab simulation		√		
Hardware simulation		√		
Draft paper submission			√	
Seminar photo ready format			√	
Oral paper presentation				√

HARDWARE DETAILS

- **JETSON NANO**
  - ai capabilities
  - Powerful gpu
  - Compact design
  - Multiple connectivity

Technical details

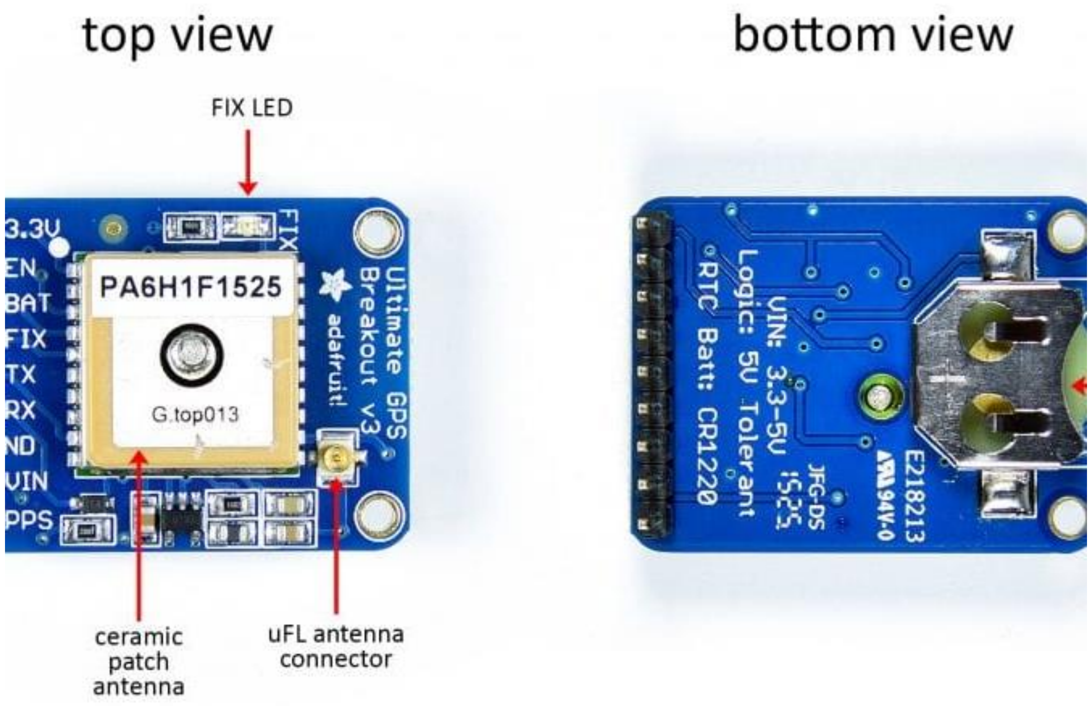
- Gpu- 128 core architecture
- Cpu arm cortex a57
- Memory – 4gb
- Connections – usb and ethernets

HARDWARE DETAILS

- IMU (INERTIAL MEASUREMENT UNIT)
  - Measurement capabilities – linear acceleration and angular velocity using accelerometer and gyroscopes
  - Motion tracking and stabilization
  - Sensor fusion with the Gps and camera
  - Low power consumption

Gps (global positioning sensor)

- Gps is used to determine exact geographic location
- Accuracy is around 3 to 5 meters
- Global coverage
- Speed and time calculations
- Integration with the sensors
- 1. frequency band – dual band L1 and L2 which improves the accuracy
- 2. refresh rate every 10 seconds



Transmitter and receiver

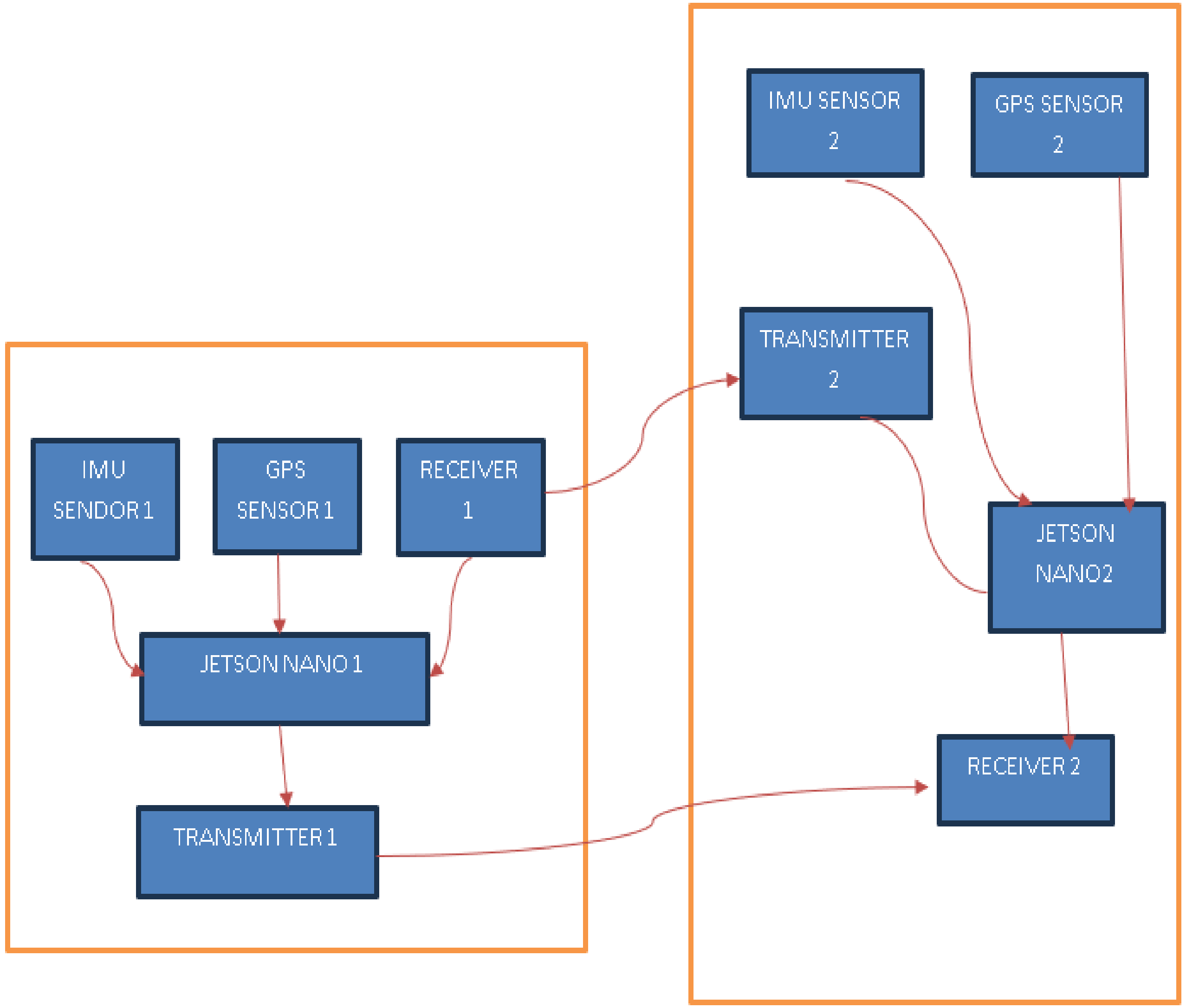
- Transmitter converts the information into signals sends them to receiver using electromagnetic waves
- Receiver captures these signals and decodes the information and converts backs to its original form

METHODOLOGY

- MATLAB ANALYSIS
- SUMO AND MATLAB ANALYSIS
- HARDWARE OUTPUT AND ANLAYSIS

METHODOLOGY

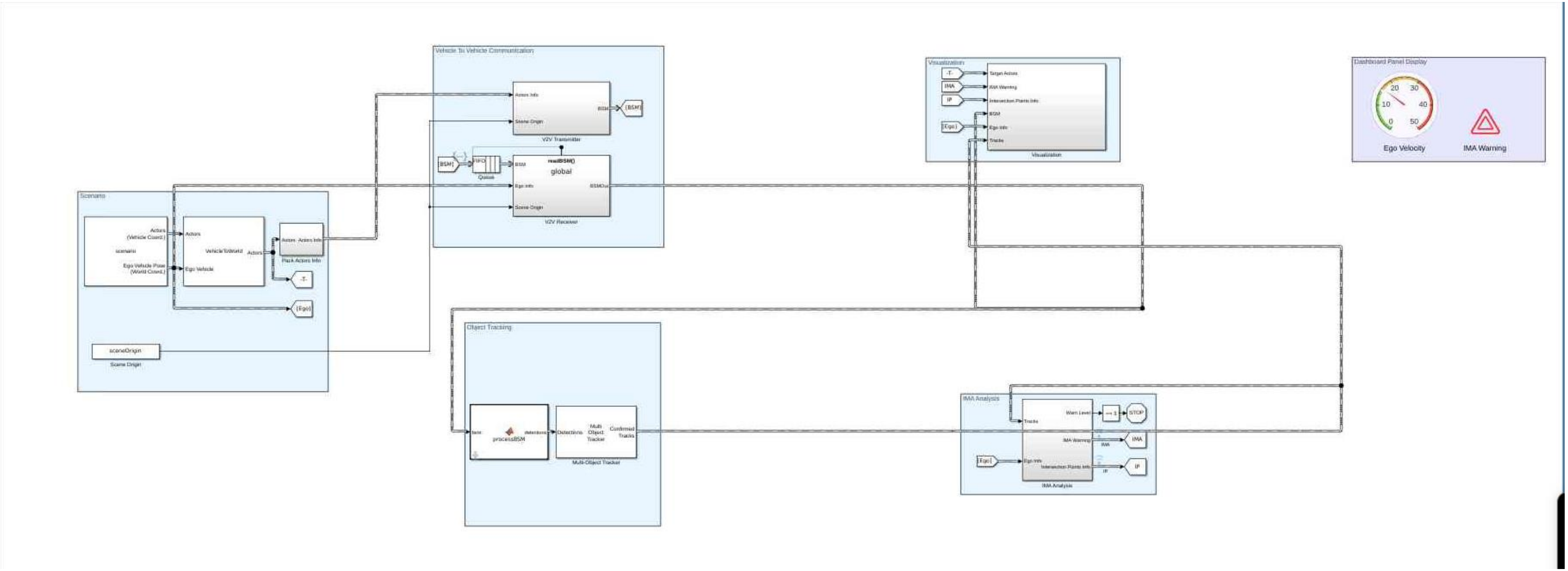
- HARDWARE SETUP



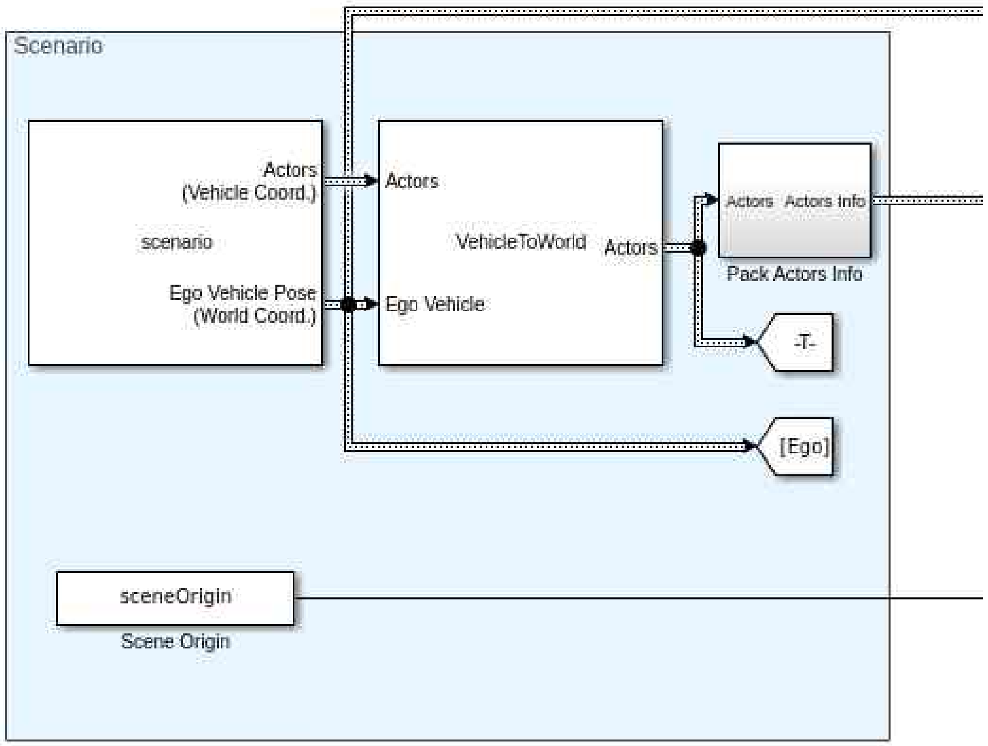
Matlab model

- Scenario (intersection movement assist system)
- Vehicle to vehicle communication
- Object tracking
- Imas analysis
- Dashboard panel display

Matlab model

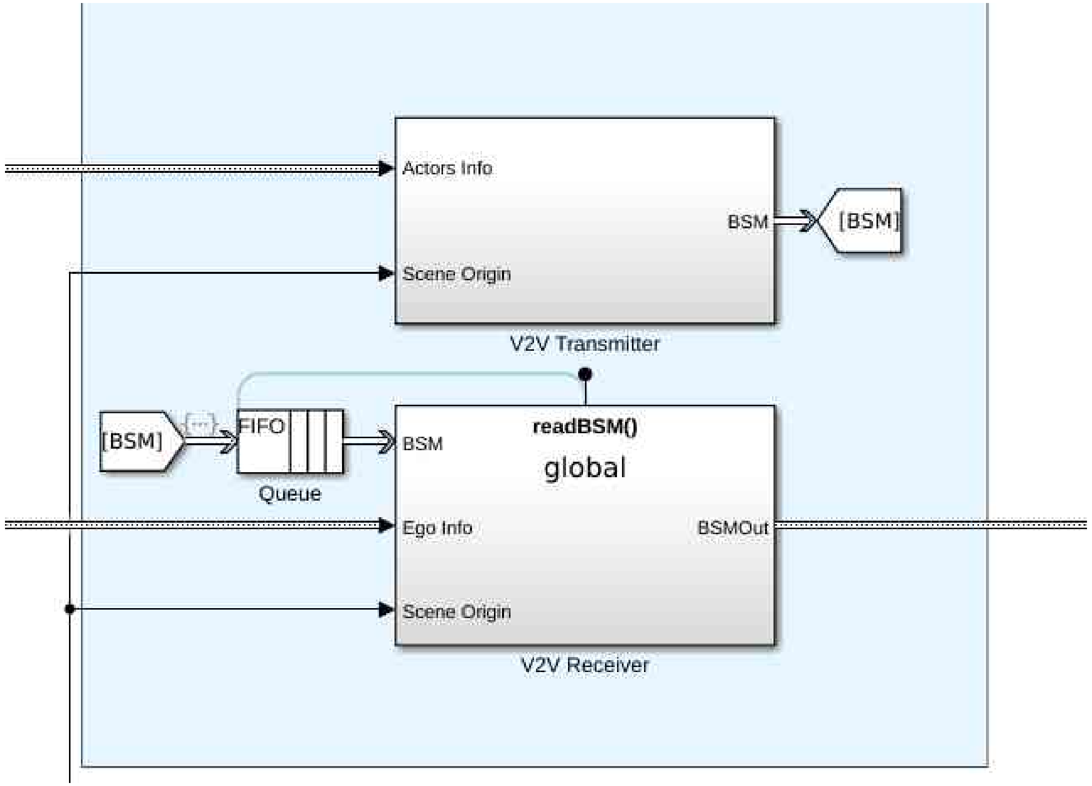


Scenario blockset

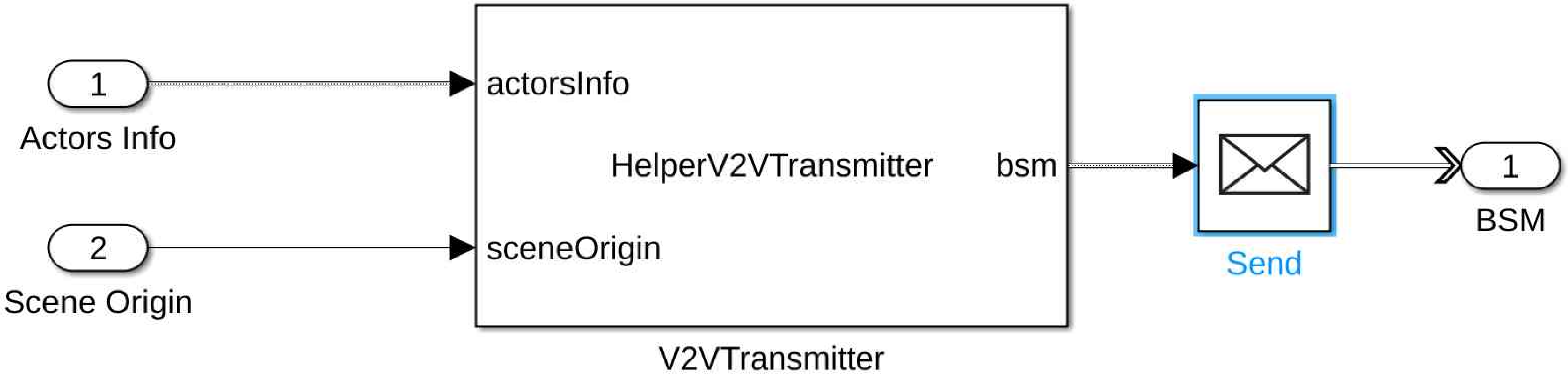


Vehicle to vehicle communication

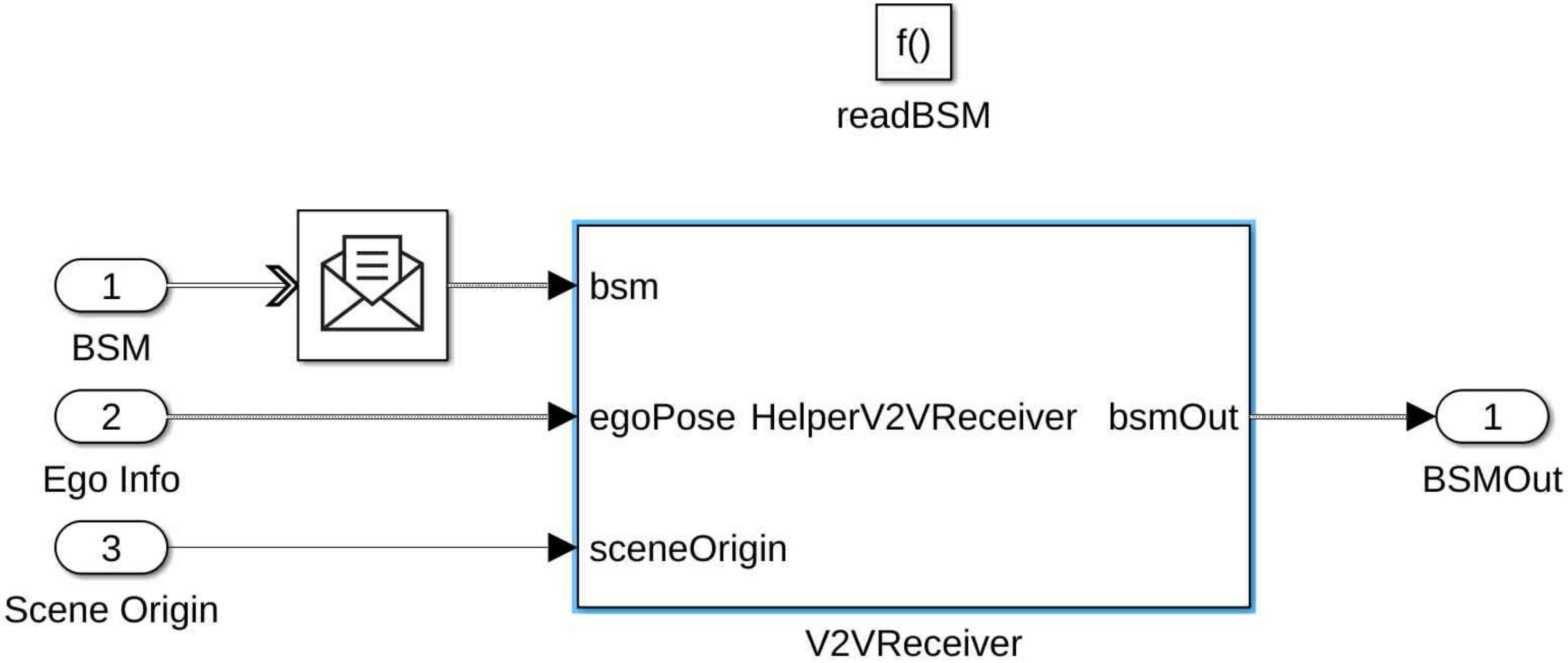
- Msg count
- Temporary id
- Latitude
- Longitude
- Elevation
- Positional accuracy
- Speed
- Heading (directions)
- Acceleration
- Brake
- Vehicle size



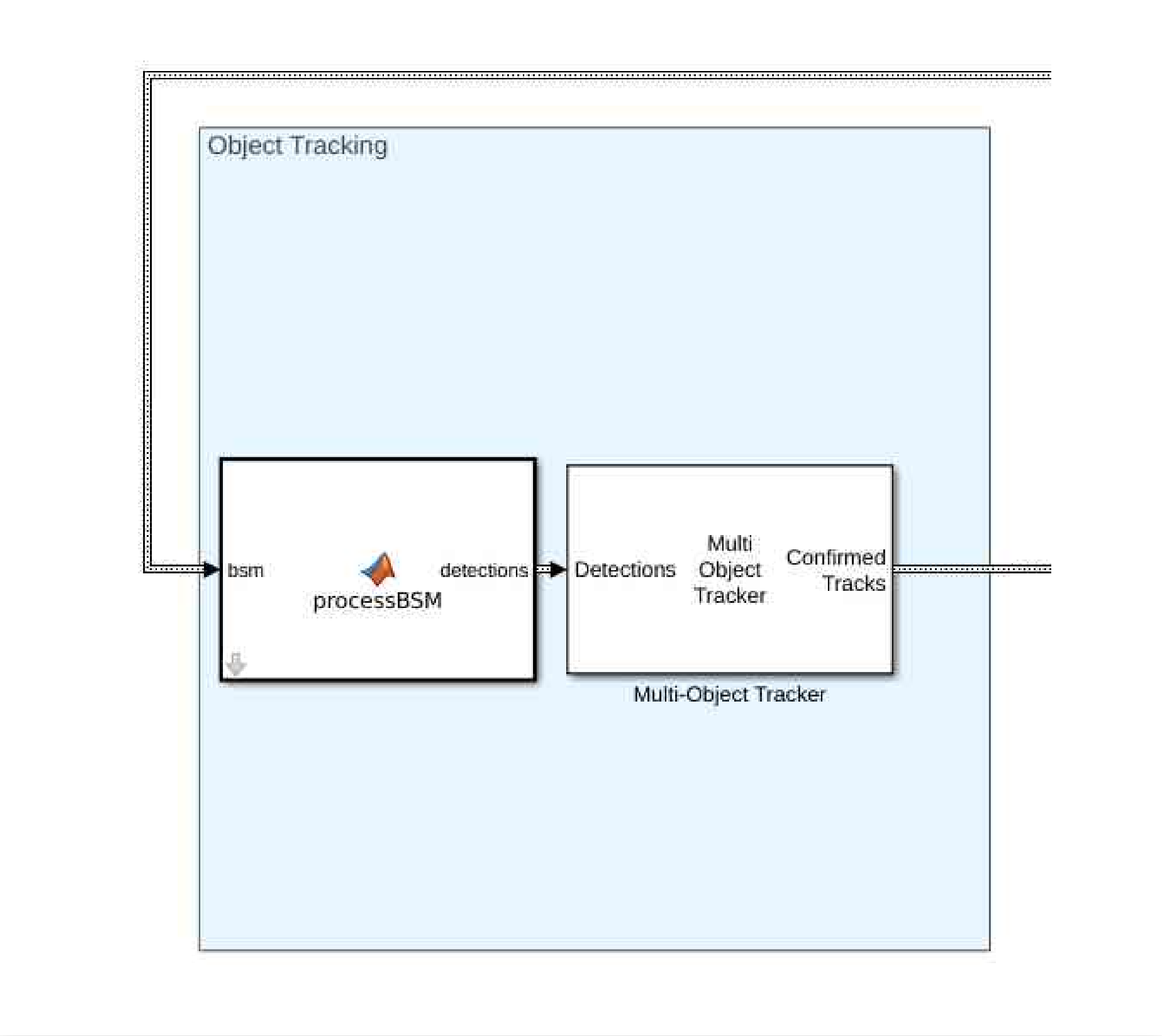
Vehicle to vehicle communication (message transmitter blockset)



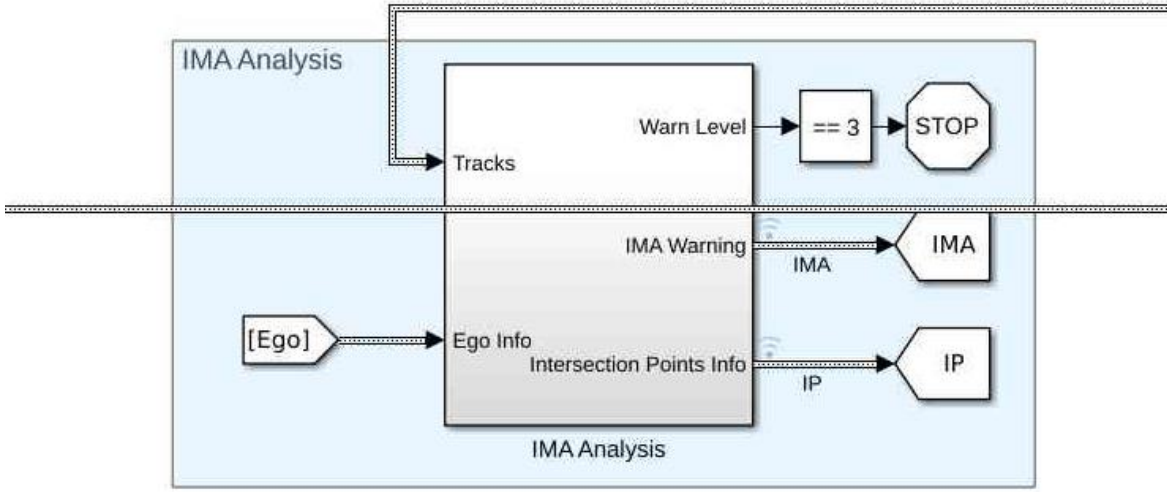
Vehicle to vehicle communication (receiver blockset)



Object tracking blockset



Intersection movement assist system



Intersection movement assist system

- Ego arrival time
- Time gap
- Minimum time = set to radius around 1 to 0.1 meter of the vehicle to give warning

EGO ARRIVAL TIME CONDITION	TIME GAP	WARNING LEVEL
EGO < MIN TIME	TIME < MIN TIME	HIGH
EGO < MIN TIME	TIME > MIN TIME	MODERATE
EGO > MIN TIME	TIME GAP < MIN TIME	LOW

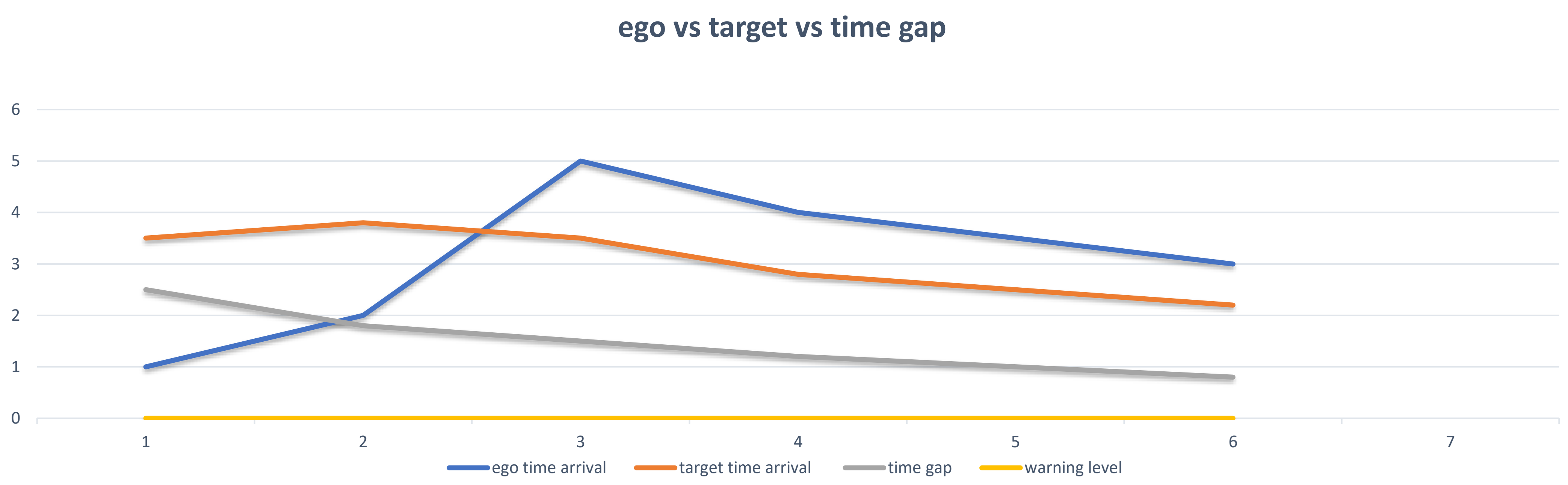
Dashboard panel and warning system

- Green = no collision risk
- Yellow = low collision risk
- Orange = moderate collision risk
- Red = high collision risk

Readings and Graph for warning level

TIME	EGO ARRIVAL TIME	TARGET ARRIVAL TIME	TIME GAP	WARNING LEVEL
0	1.0	3.5	2.5	LOW
1	1.5	3.7	2.2	LOW
2	2.0	3.8	1.8	LOW
3	5.0	3.5	1.5	MODERATE
4	4.5	3.2	1.3	MODERATE
5	4.0	2.8	1.2	MODERATE
6	3.5	2.5	1.0	MODERATE
7	3.0	2.2	0.8	HIGH

Graph


ego vs target vs time gap
6
5
4
3
2
1
0
1
2
3
4
5
6
7
ego time arrival
target time arrival
time gap
warning level

Results and discussion

1.Imas warning system

- actors (vehicles) track id 3
- ego to intersection point distance = 15.93m
- ego arrival time to intersection = 0.98
- warning level = high

2. Intersection points

- Track id 3
- Intersection point = 19.10.152.31
- Ego arrival time to intersection = 0.98 sec
- Target arrival time to intersection = 1.23 sec
- Time gap = 0.24 sec

Track id 3 warning level

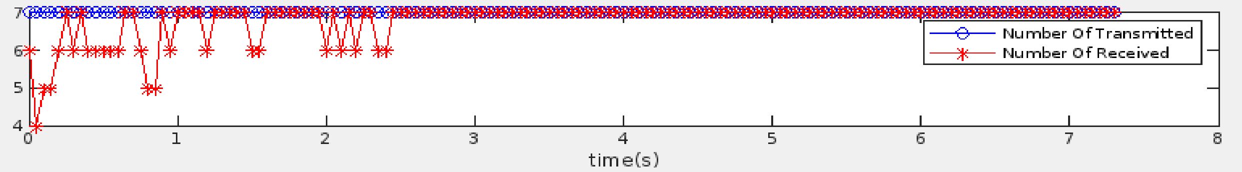
IMA Warning

Track ID	Ego to Intersection Point Distance (m)	Ego Arrival Time to Intersection (sec)	Warning Level
3	15.93	0.98	High

Intersection Points

Track ID	Intersection Point (m)	Ego Arrival Time to Intersection (sec)	Target Arrival Time to Intersection (sec)	Time Gap (se
3	19.10, 152.31	0.98	1.23	0.24

Message Transmitted vs Received



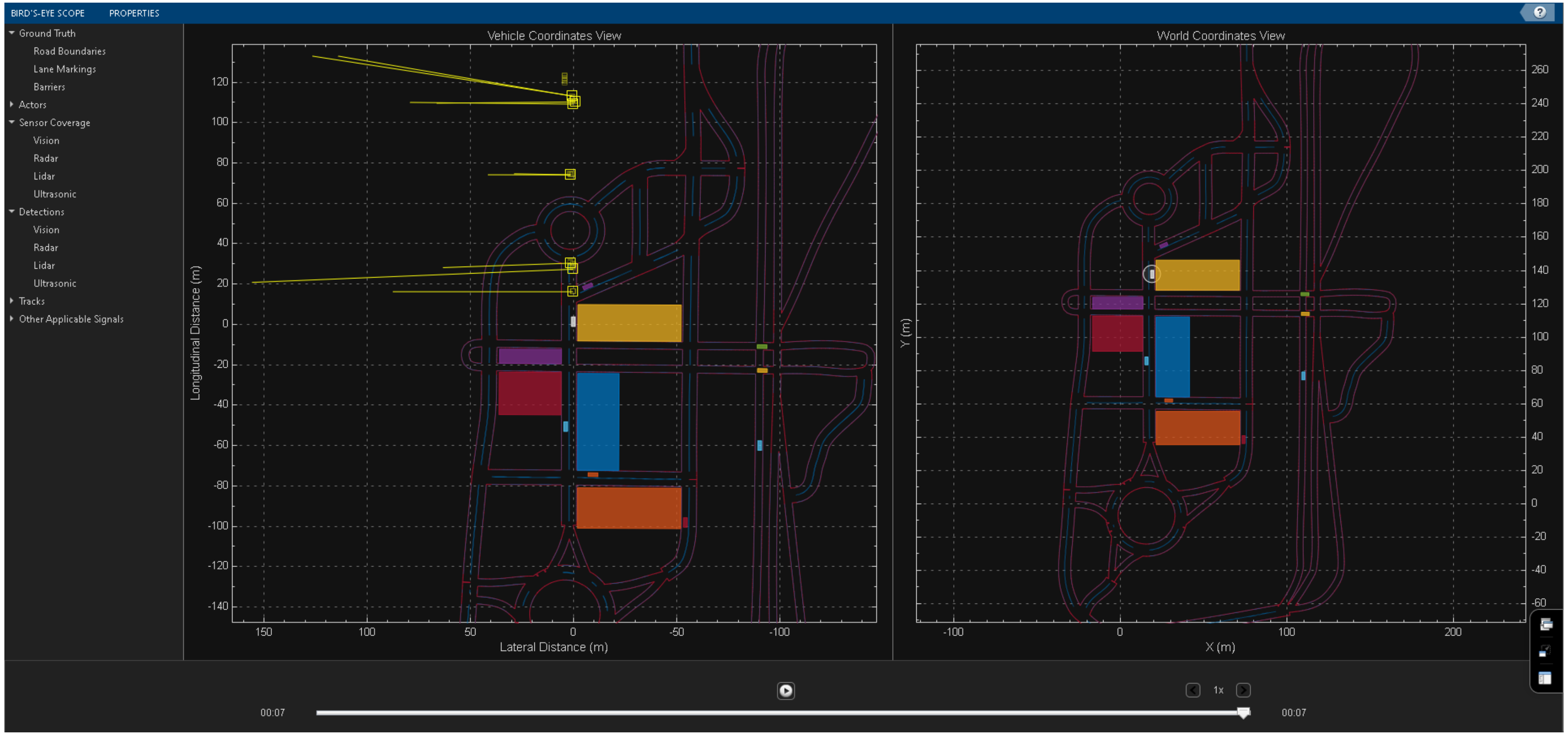
V2V Communication Data

Target ID	Message Transmitted by	Message Received by Eg	Target-Ego Distance (m)	Received Message SNR (dB)
2	✓	✓	76.2019	4.8438
3	✓	✓	94.2839	3.2995
4	✓	✓	20.9199	14.2198
5	✓	✓	91.7486	3.4972
6	✓	✓	106.5908	2.4097
7	✓	✓	109.6364	2.2053
13	✓	✓	48.7184	8.0883

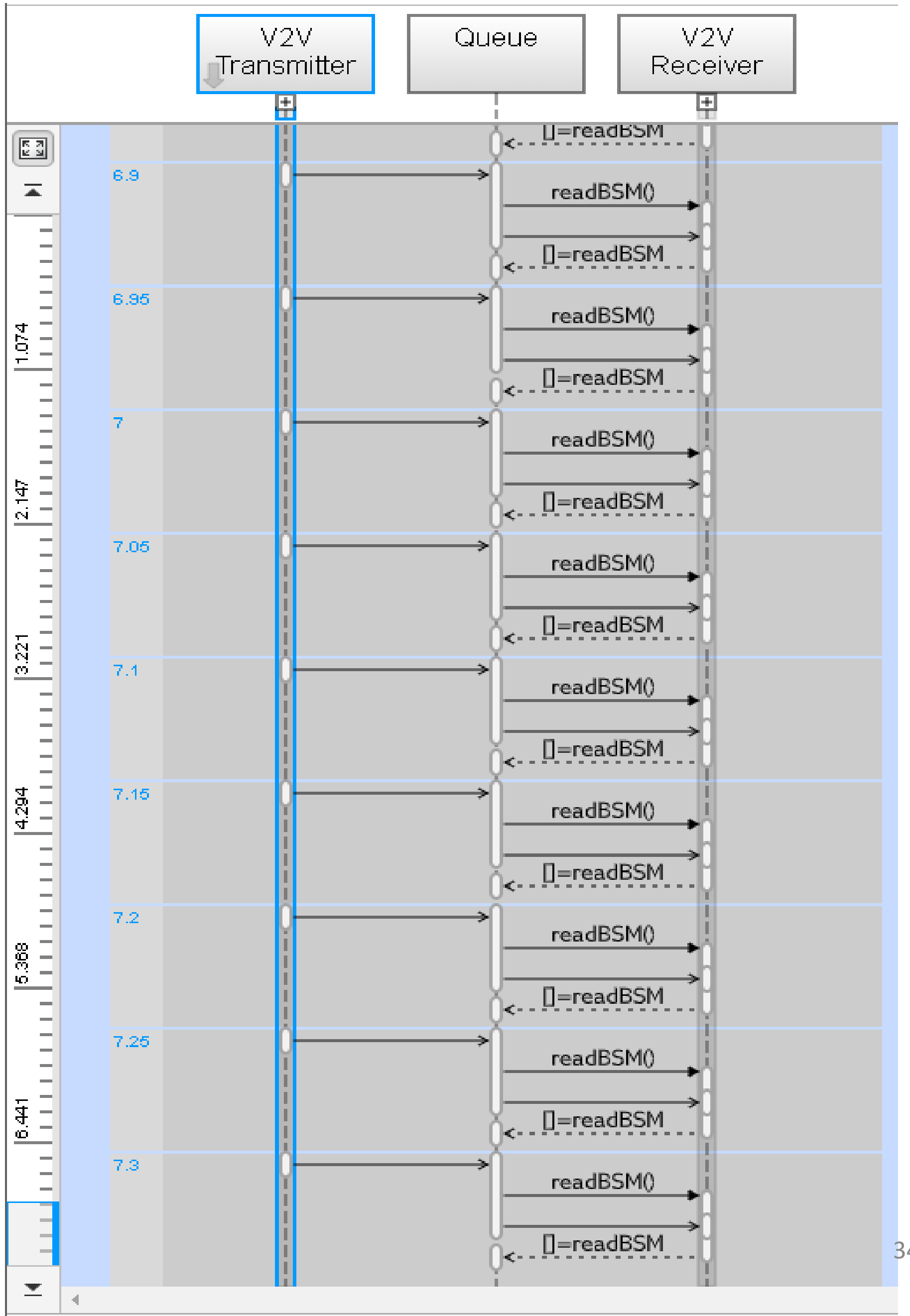
Received BSM Message

Target ID	Latitude (deg)	Longitude (deg)	Speed (m/s)	Heading (deg)	Width (m)	Length (m)
2	42.300049	-83.698633	2.2	271.7	1.8	4.7
3	42.300532	-83.697655	20.1	92.2	1.8	4.7
4	42.300906	-83.698687	7.0	246.3	1.8	4.7
5	42.300614	-83.697665	19.9	91.1	1.8	4.7
6	42.300211	-83.697678	30.0	178.4	1.8	4.7
7	42.299867	-83.698116	19.9	179.8	1.8	4.7
13	42.300290	-83.698813	10.0	179.3	1.8	4.7

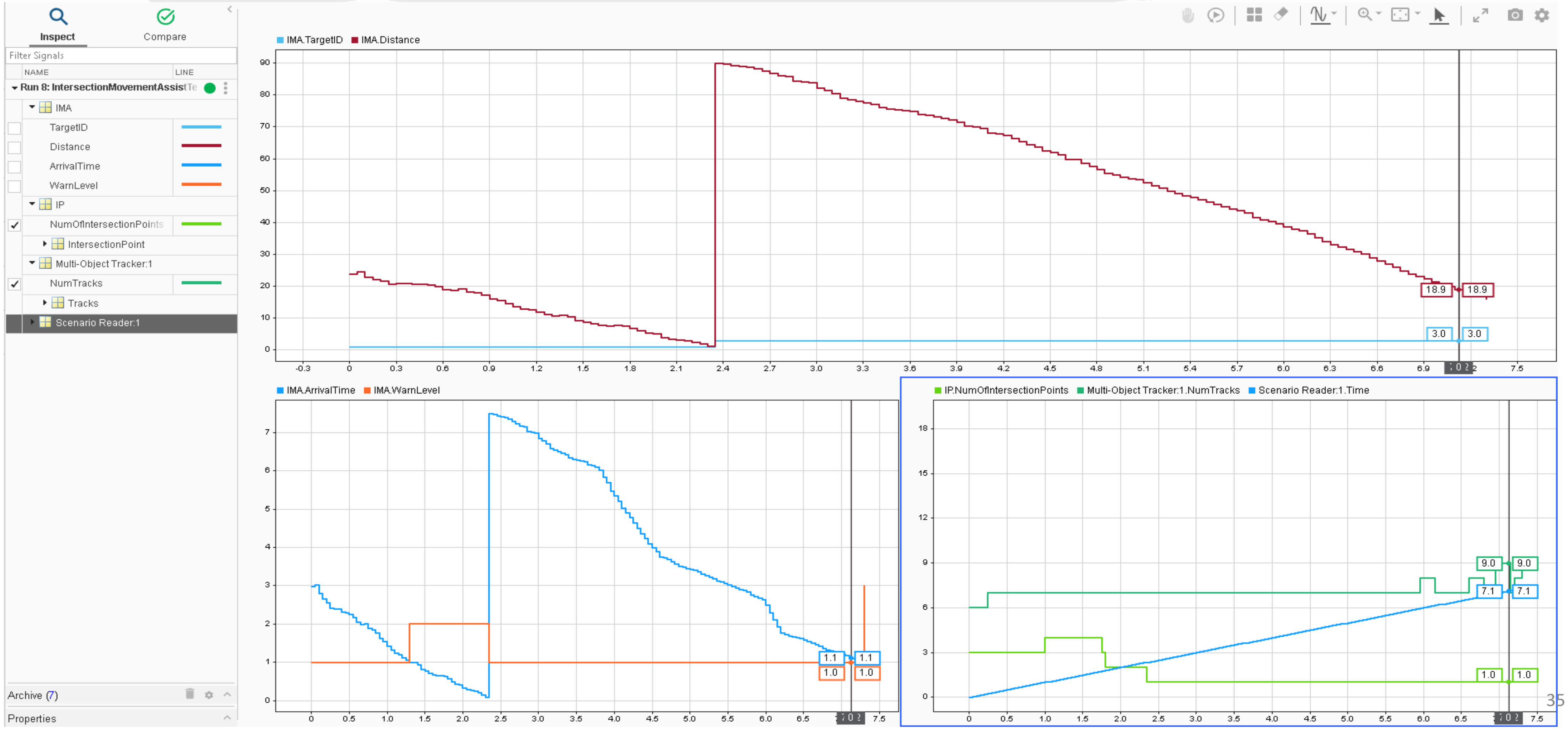
Results and discussions
(bird eye view and gps coordinate)



transmitter and receiver queue message exchange



Warning level zone



Results & Discussion

RESULTS

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Expected Outcomes from the Capstone Project

- Conference Publication
- Journal Publication
- Product Development
- Patent
- Copyrighted material
- Others

Sustainable Development Goals Focused / Achieved

- Provide the details of the sustainable development goals focused / achieved from your capstone project

Acknowledgements

- VIT Management
- Parents
- Organization which has given you permission to pursue the project work
- Internal and External Guides
- Staff members
- Specific people helped you in accomplishing the project work


THANK YOU