Team Aware – Perception System using Stereo Vision and Radar

System Development Review

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Project Description

- Develop a standalone perception system to assist autonomous vehicle sensor systems with detection and tracking of pedestrians and vehicles in real-world traffic environment.

Functional Requirements

The system shall:

- Conduct full-range perception
- Perceive in real-time
- Use multiple sensors
- Detect and identify objects (pedestrians and vehicles)
- Classify objects (pedestrians and vehicles)
- Estimate external vehicle motion and egomotion
- Be self-contained

Performance Requirements

The system shall:

M.P1. Detect objects (pedestrians & vehicles) up to ~~**150**~~ **50 m**

M.P2. Unify sensor data up to **50 m**

M.P3 Acquire sensor data at up to **20 Hz**

~~M.P4 Detect object size with an accuracy of up to **60%**~~

M.P5 Detect object distance with an accuracy of up to **60%**

M.P6 Detect object with an accuracy of up to **60%**

M.P7 Classify objects (pedestrians & vehicles)with an accuracy of up to **80%**

~~M.P8 Estimate vehicle motion with an accuracy of up to **90%**~~

Current System Status

Functional Descriptions:

Stereo Vision: near range

- Object detection
- Object classification
- Object tracking

Radar: full-range

- Object detection
- Object tracking

Current System Status

Computer Vision

- Object detection: Achieved
- Stereo vision: Achieved
- Object tracking: In progress

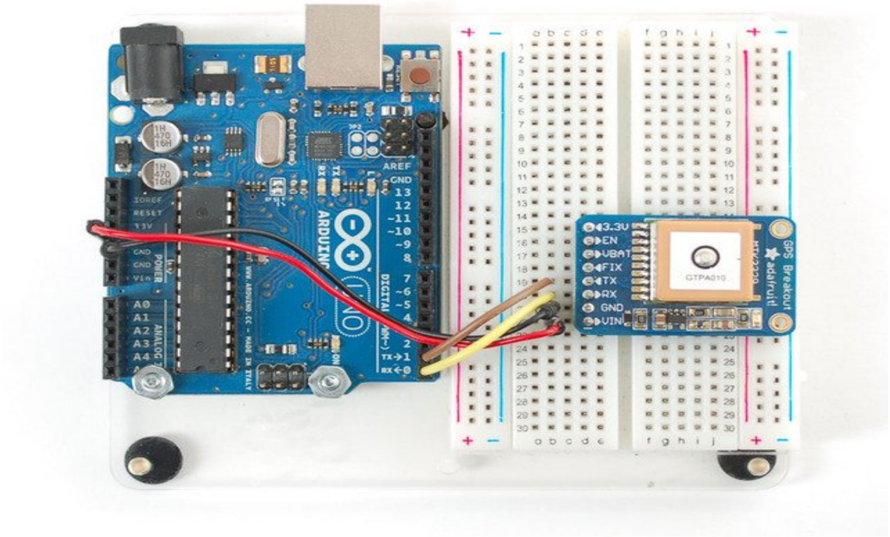
Radar

- Data acquisition: Achieved
- Data filtering and visualization: In progress
- Object tracking: Not started

System Integration: In progress

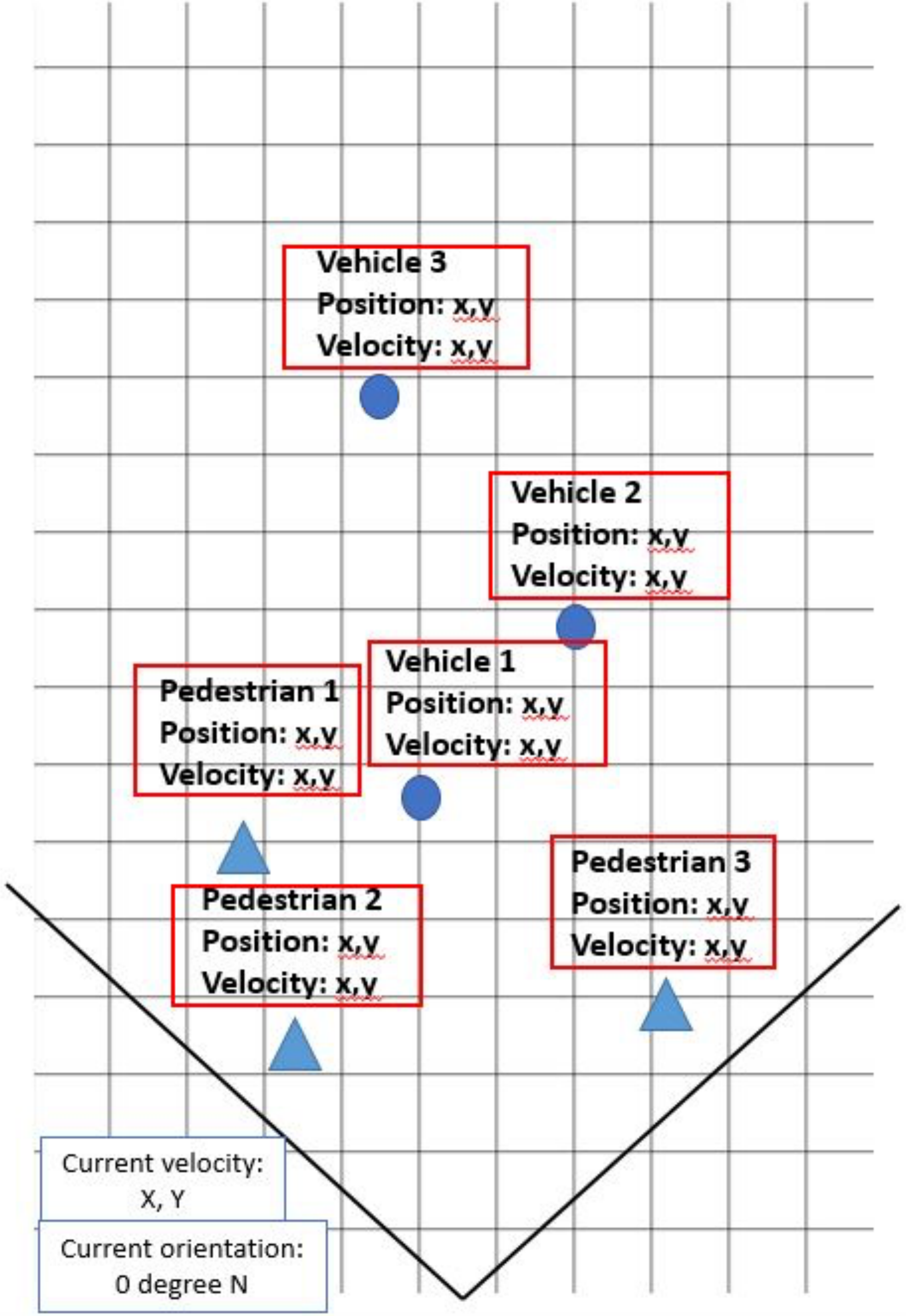
GPS

- Adafruit Ultimate GPS
  - -165 dBm sensitivity
  - Up to 10 Hz updates
  - Available information:
    - Time
    - Location (longitude, latitude)
    - Speed
    - Track Angle
    - Altitude



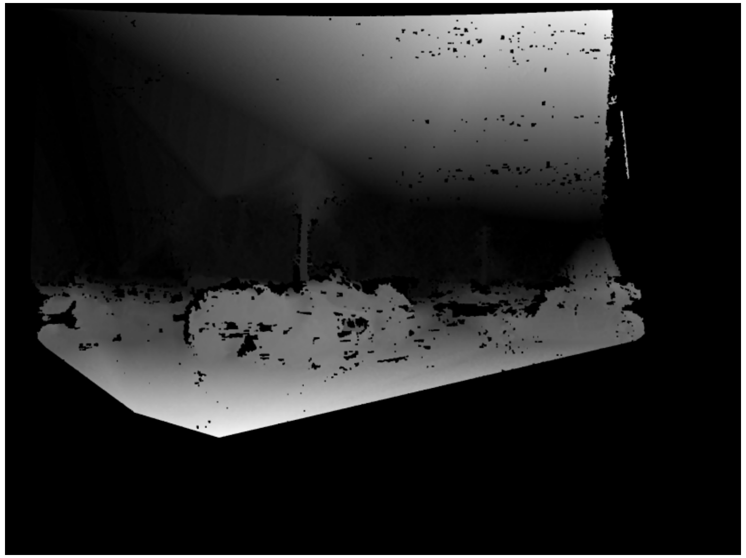
Visualization

- Written in C++
- Ready to be integrated
- Currently using sample values
- Data Fields
  - Classification
  - ID
  - Position
  - Velocity



Stereo Vision

- ELAS Stereo Vision
  - Faster
  - Smoother Data
  - Denser Map

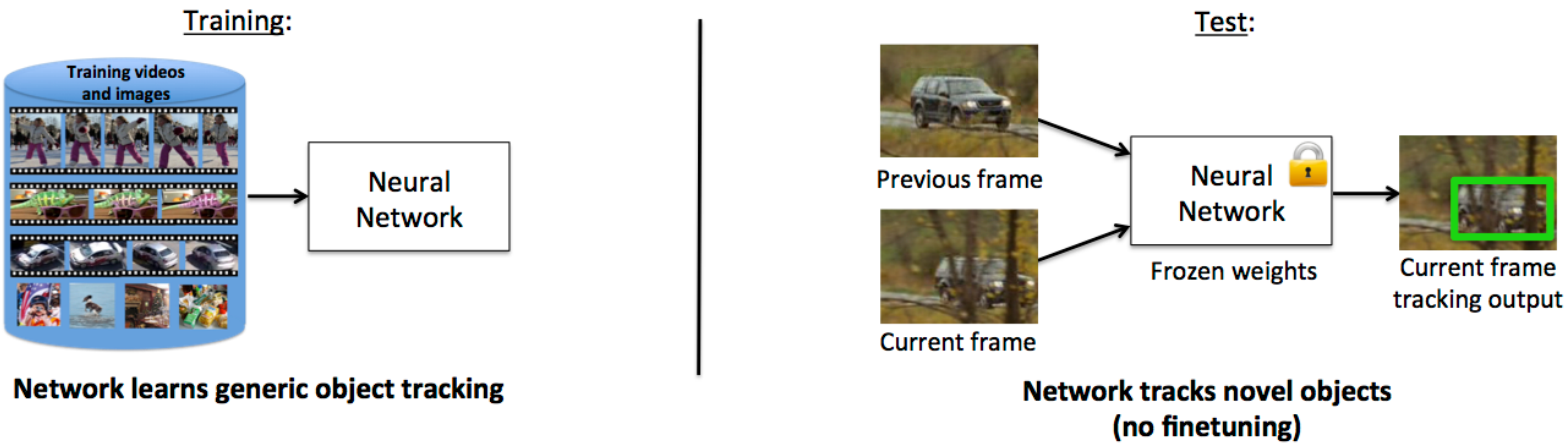


New

Old

Object Tracking

- GOTURN Algorithm
- 100+ FPS
- Generic objects (includes People/Vehicles)
- High Accuracy
- *Problem: Single object tracking*



Radar

- Data can be saved to a text file for an instant.
- We need continuous data and need it to get parsed.
- WireShark not working anymore.

Modeling, Analysis, and Testing Plan

- Examine components' **dimensions on the testing vehicle** for designing sensor mounts
- Determine **baseline** for stereo vision system through calculation and experiment
- Conduct **outdoor testing** to verify effectiveness of mounting design and basic sensor functionalities
- Analyze performance of **object detection** using testing data

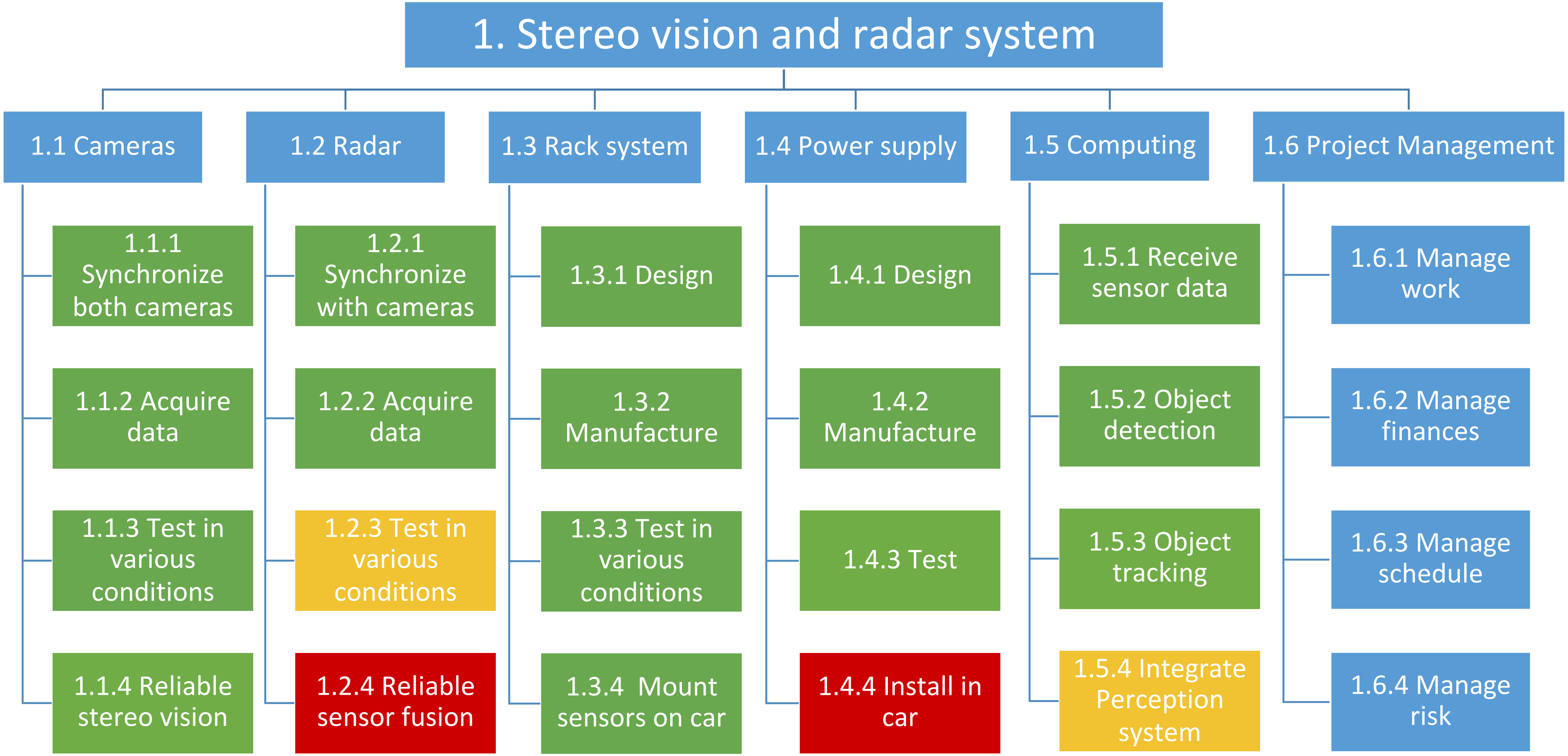
Challenges faced

- Limited system knowledge by sponsor and team
- Defective radar unit
- Ineffective team communication
- Vehicle trouble

Major remaining challenges

- Radar visualization and tracking
- Real time performance
- Power system
- Better communication

Project Management



Budget

- Total budget left: $5000 - $4541 = $459
- Big-ticket items (Sponsored)

Grasshopper3 3.2 MP Color USB3 Vision (GS3-U3-32S4C-C)	$975
Delphi ESR 2.5 24V Radar	$3300
Tamron M118FM08, 8mm, 1/1.8", C mount Lens	$210

- Big-ticket items

High Performance Computer	$3430

- Total spent to date: $4541

Risk Management

Risk title:	Risk owner:	Date submitted:	Date updated:
RADAR	Amit Agarwal	February 7, 2017	March 6, 2017

Description of risk:

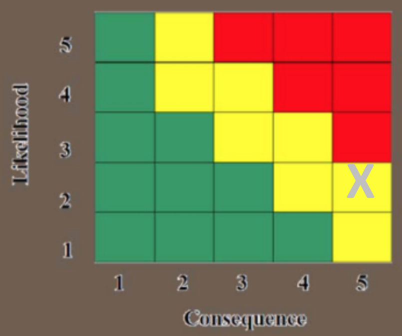
The Radar is far behind schedule and may create problems in system integration.

Consequences if risk is realized:

Project delay if Radar is not on schedule by PR 10. Projects risks failure if Radar is behind schedule at PR 11.

Risk type

- X Technical
- X Schedule
- X Cost
- ☐ Programmatic



Risk Reduction Plan Summary

Action/milestone	Date	Success Criteria	Risk Level	Comments
1. Dedicate more time	Feb 21, 2016	PR 10 Goals achieved		
2.				
3.				

Risk Management

Risk title:	Risk owner:	Date submitted:	Date updated:
Running out of budget	Team A / Delphi	March 2, 2017	March 5, 2017

Description of risk:

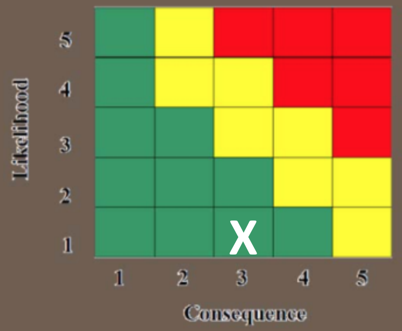
Given our limited remaining budget, there is a small chance we may run out of our budget if we buy additional items for the car

Consequences if risk is realized:

The system might be developed with cheaper parts and/or reduced scope. We might have to spend out of pocket

Risk type

- ☐ Technical
- ☐ Schedule
- X Cost
- ☐ Programmatic



Risk Reduction Plan Summary

Action/milestone	Date	Success Criteria	Risk Level	Comments
1. Judiciously spend remaining budget	NA	Budget is left over after project	50%	None
2.				
3.				

Risk Management

Risk title:	Risk owner:	Date submitted:	Date updated:
Object Detection Time Delay	Yihao Qian	November 7, 2016	March 5, 2017

Description of risk:

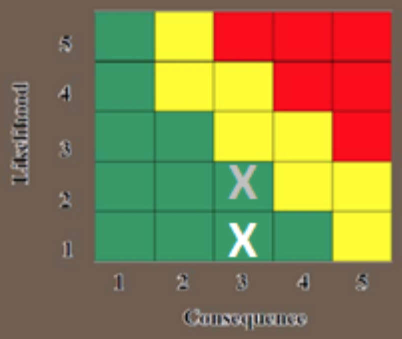
The Object Detection algorithms are computationally expensive and take a lot of time to process images

Consequences if risk is realized:

The system might end up with a time delay not small enough for real time perception of data. This will cause issues with meeting a mandatory requirement of the system working in real time. Code base might need rewriting.

Risk type

- X Technical
- X Schedule
- ☐ Cost
- ☐ Programmatic



Risk Reduction Plan Summary

Action/milestone	Date	Success Criteria	Risk Level	Comments
1. Used Faster R CNN	Nov 10, 2016	Increased FPS	50%	Increased to 5 FPS
2. Used SSD Detection	Nov 16, 2016	FPS > 20	30%	Paper promises 50 FPS
3. Use high performance GPU	Mar 10, 2017	FPS > 20		On delivery

Test Plan

Name	Deliverable Functionality	Method to Test
A. PR 10: March 22nd	-Object tracking system validation -Radar filtered data visualization	-Compute tracking accuracy-number of valid tracker/ total number of objects -Compute accuracy of detected objects
B. PR 11: April 5th	-Object detection & stereo vision system integration -Radar and camera egomotion integration	-Compare ROIs' depth information with ground truth provided by laser measurement unit -Egomotion comparison of radar system with ground truth
C. PR12: April 17th	-Object detection & stereo vision & tracking system integration -Complete system integration	-Compare ROIs' velocity information with ground truth provided by GPS -Real time display of information

Experiment	Spring Validation Experiments
Objective	Demonstrate and verify functionality of the integrated system
Location	Major streets around campus with moderate traffic flow in favorable weather conditions
Elements	Integrated perception system with the stereo cameras, radar, power devices, and computer on the testing vehicle (Volvo S60)
Procedure	- Mount all sensors and place power and computing devices properly on the testing vehicle - Drive the car around the campus for about 15 minutes - Detect and classify pedestrians and vehicles on road. Display their relative positions and velocities in the customized GUI. - Track pedestrians and vehicles on road continuously with label.
Verification Criteria	- The ID, relative position, velocity, and class (pedestrian or vehicle) of each detected object should be clearly displayed in the GUI in real time. - The absolute position (longitude and latitude) and velocity of the testing vehicle should also be displayed clearly in the GUI in real time. - Criteria for Experiment A, B, C, D should be all be met successfully.

Questions?