Project Overview

Mapping Technology Assessment for Connected Vehicle Highway Network Applications

CGSIC, Austin, TX
6/13/2012

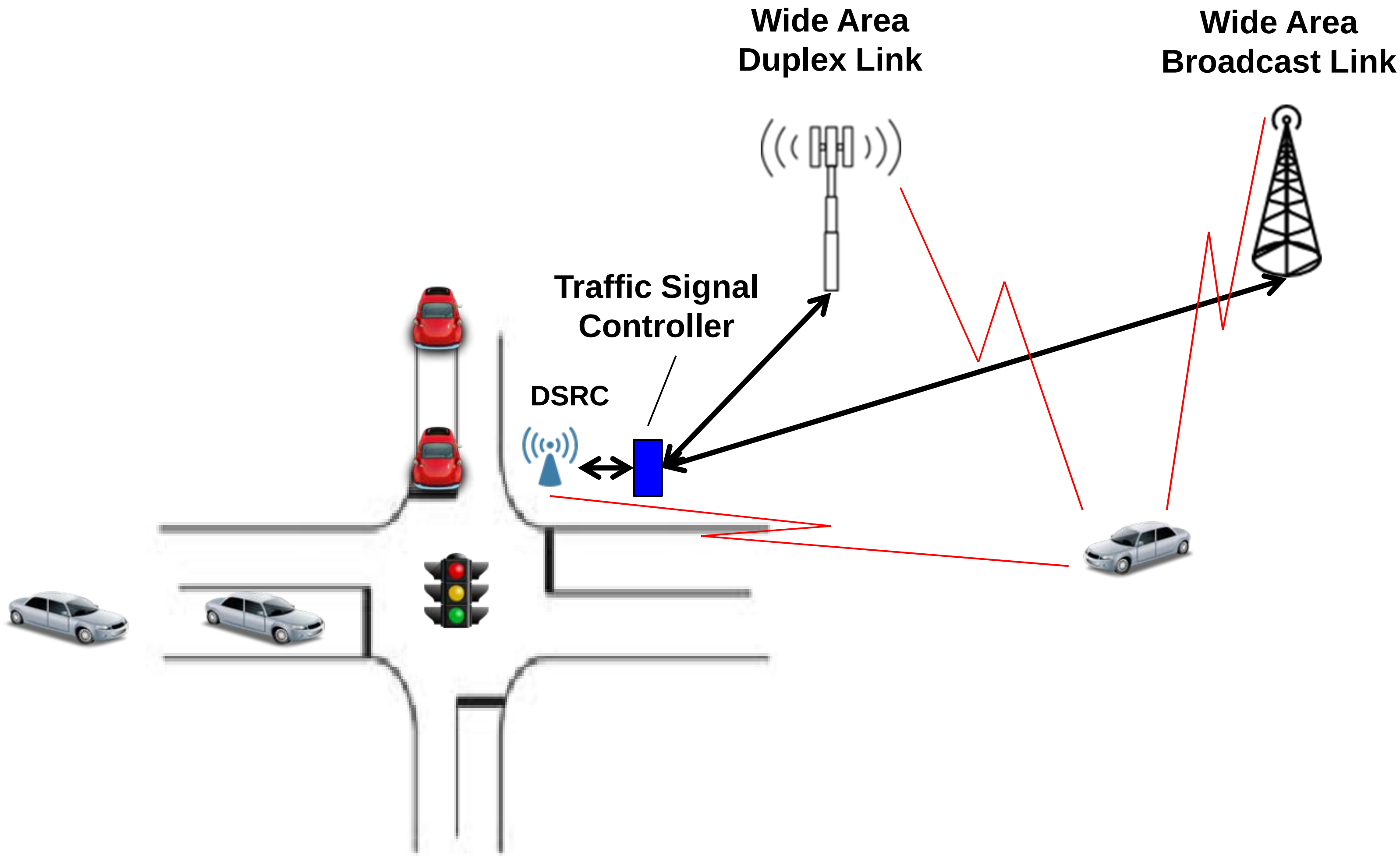
Table Of Contents

- Connected Vehicle Program Goals
- Mapping Technology Assessment Approach
- Field Test

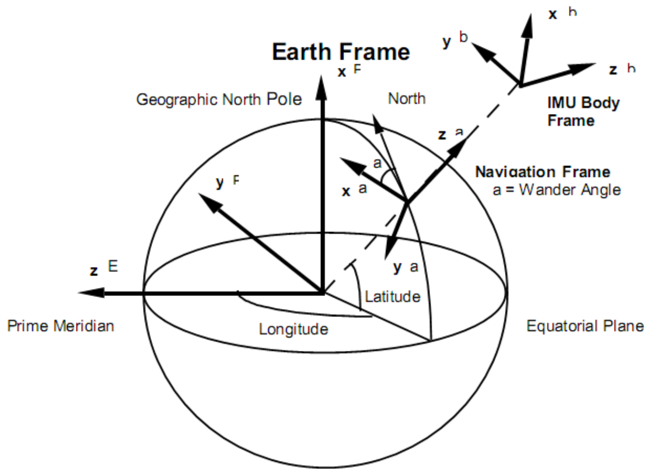
Connected Vehicle Program Goals and Objectives

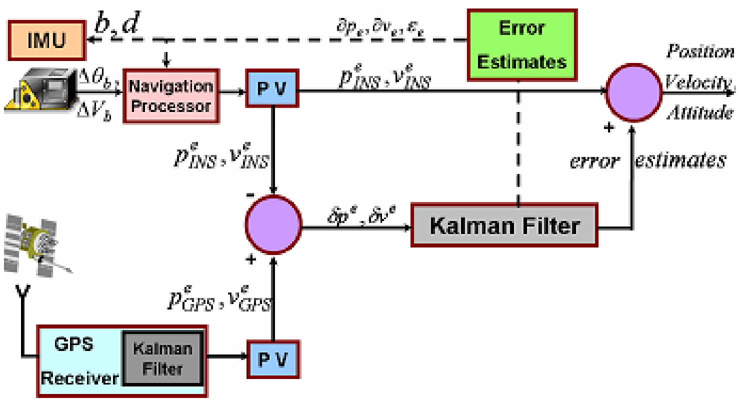
- FHWA's Connected Vehicle Program was established to facilitate the implementation of applications related to vehicles and/or infrastructure for helping to enhance safety, mobility, and the environment.
- These applications will utilize mapping, positioning, and communication technology for their operations to provide information on the location of vehicles in relation to the roadway, other vehicles, and pedestrians.
- Connected Vehicle is a large, multi-faceted program managed by the ITS Joint Program Office of the Research and Innovative Technology Administration (RITA)

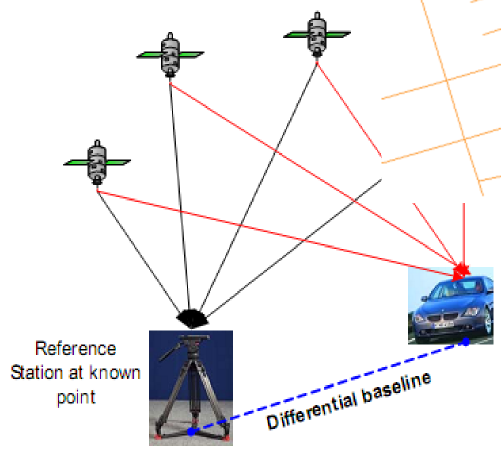
Communications Technologies

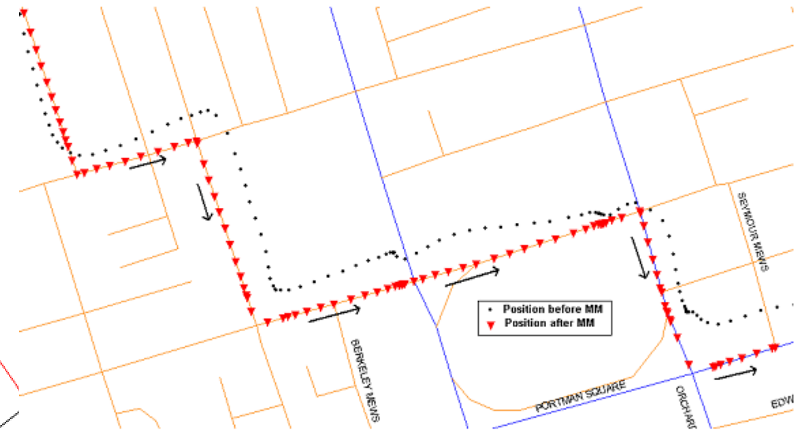


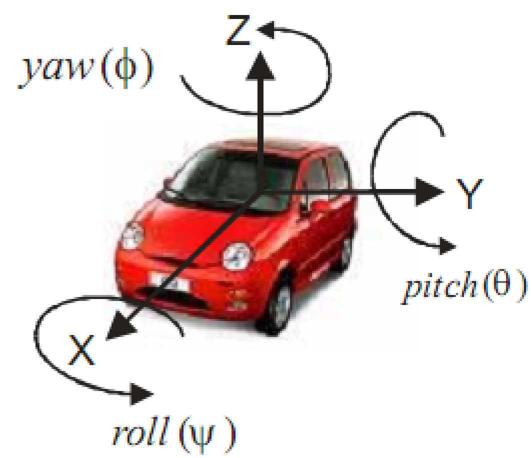
Positioning Technologies





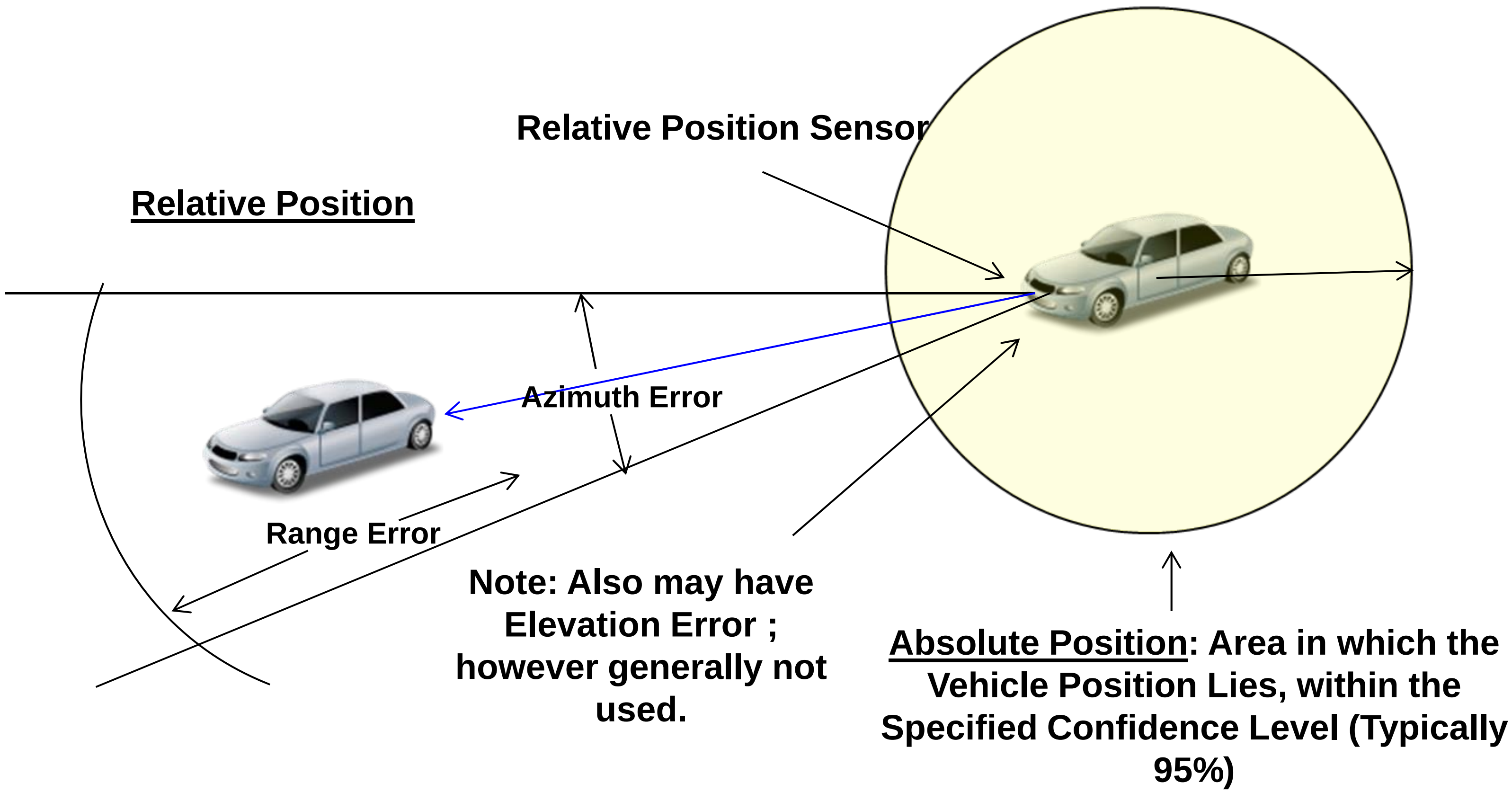






U.S. Department of Transportation
Federal Highway Administration

Relative Position of Targets Referenced to Absolute Position Provided by GPS



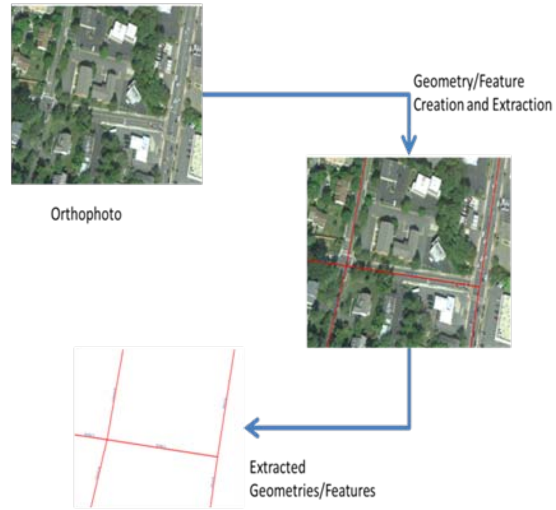
Mapping Technologies

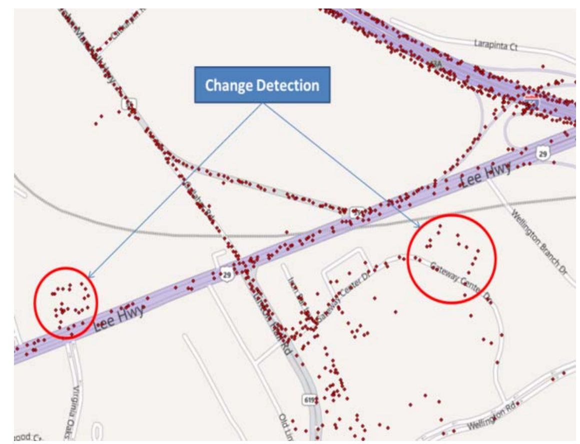
- As one of the main supporting technologies of the Connected Vehicle Program, **Mapping Technologies** provide critical support across safety, mobility, and environment applications through the provision and update of roadway data

- The mapping of roadways involves developing an accurate geometric representation of the roadway and attribution of those geometries with application relevant data

- Roadways are usually represented in GIS databases as linear features. Lane configuration and connectivity may also be represented in the form of additional geometries in the database or through attribution

- The development of maps supporting Connected Vehicle applications requires the initial creation of the maps as well as ongoing, timely update of these maps





Mapping Technology Assessment Project

- The ***Mapping Technology Assessment for Connected Vehicle Highway Network Applications*** project aimed to analyze and determine the best current and anticipated geospatial technologies and mapping approaches to support intelligent transportation systems (ITS)

- This assessment is fundamental to providing solutions that allow connected vehicle network applications to bring about transformational improvements in the safety, mobility, and environmental performance of our nation's transportation systems

- Mapping Technologies are a key enabler for the Program and its applications
  - Vehicles need to know where they are in relation to other vehicles (relative position)
  - Vehicles need to know where they are in relation to the roadway (absolute position)

- The focus of the project is across 3 major areas:
  - Assess what mapping technologies meet the requirements of Connected Vehicle applications
  - Test relevant technologies in lab and in the Connected Vehicle Highway Testbed (CVHT)
  - Develop a data management framework for compilation, storage, and update of collected data

- The goal of the connected vehicle vision is high, but the potential benefits are significant as implementation of connected vehicle network applications can have far reaching impacts on transportation

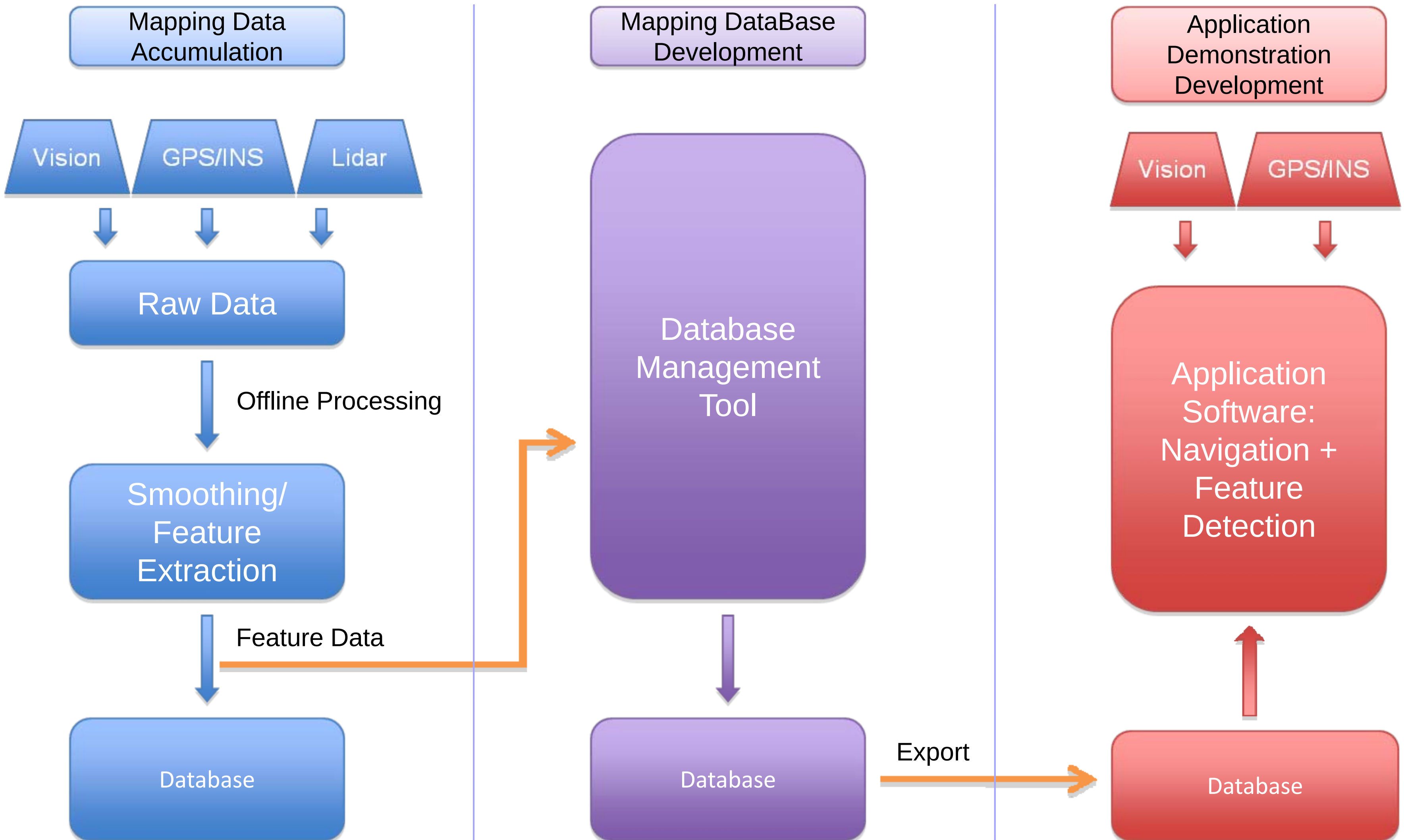
Mapping Technology Assessment Approach

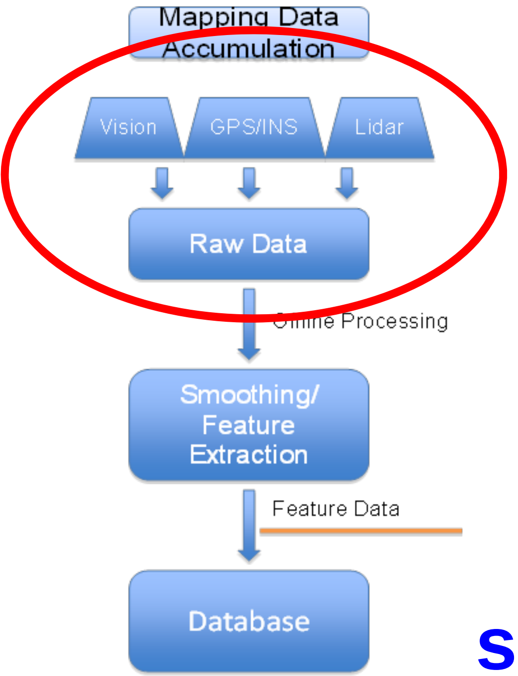
Task 1 **Project Planning**	• Ongoing project planning and management through the course of the project.
Task 2 **Identify Mapping Parameters**	• Definition of mapping technology requirements through existing documentation review, stakeholder interviews, and participation of the Industry Advisory Board (IAB).
Task 3 **Analyze Mapping Technologies**	• Analyze characteristics of five candidate mapping technologies – ***As-Built Designs, Aerial Based Imagery, Vehicle Mounted Technologies, Data Fusion,*** *and* ***Probe/Crowd Sourced Data****.*
Task 4 **Develop Capability Matrix**	• Analyze requirements generated in Task 2 against the technologies characterized in Task 3 to develop performance capabilities of each mapping technology.
Task 5 **Technology Field Test**	• Demonstration and testing of specific mapping technologies, including vehicle mounted technology solutions.
Task 6 **Data Management**	• Develop a data management framework guiding data collection, storage, and maintenance for use during Field Test and other related Connected Vehicle activities.
Task 7 **Final Report**	• Integration of all task findings into a consolidated Final Report.

Current Project Status

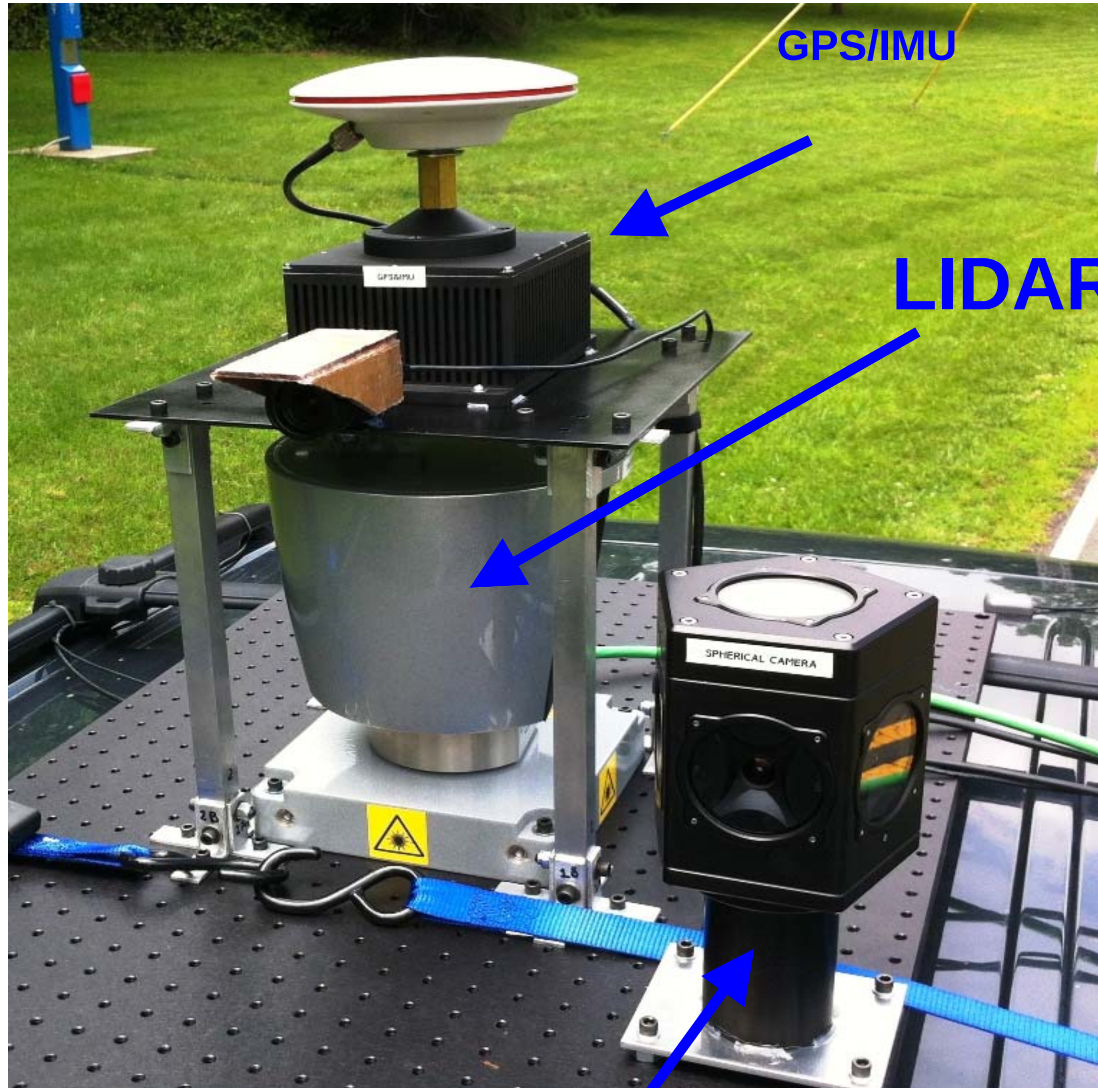
- Final Interim Reports have been completed for several tasks.
  - Task 2: ***Stakeholder Feedback Summary Report***
  - Task 3: ***Mapping Technology Report***
  - Task 6: ***Data Management Report***
  - Task 4: ***Mapping Technology Evaluation***
- Field Testing was completed in May 2012
  - Purchase and configuration of equipment to support vehicle mounted technology test
  - Initial configuration of the equipment on test vehicle
  - Installation of road signs and road markings at test facility
  - Limited data collection
- Upcoming activities include:
  - Final As-Built Documentation Development
  - Development of Final Findings Report

Overview of Field Test Data Flow Process



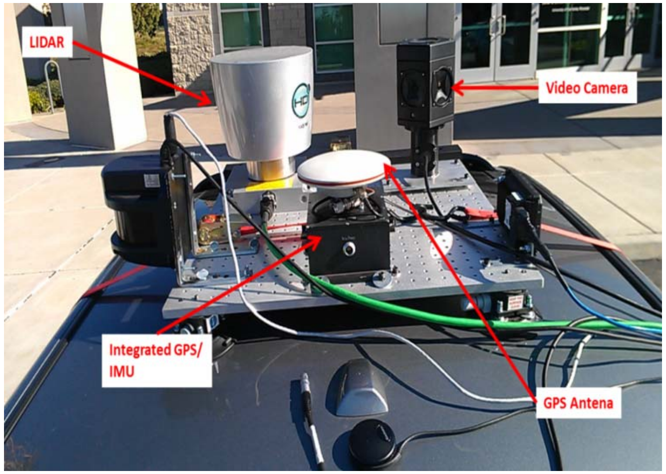


sensor platform

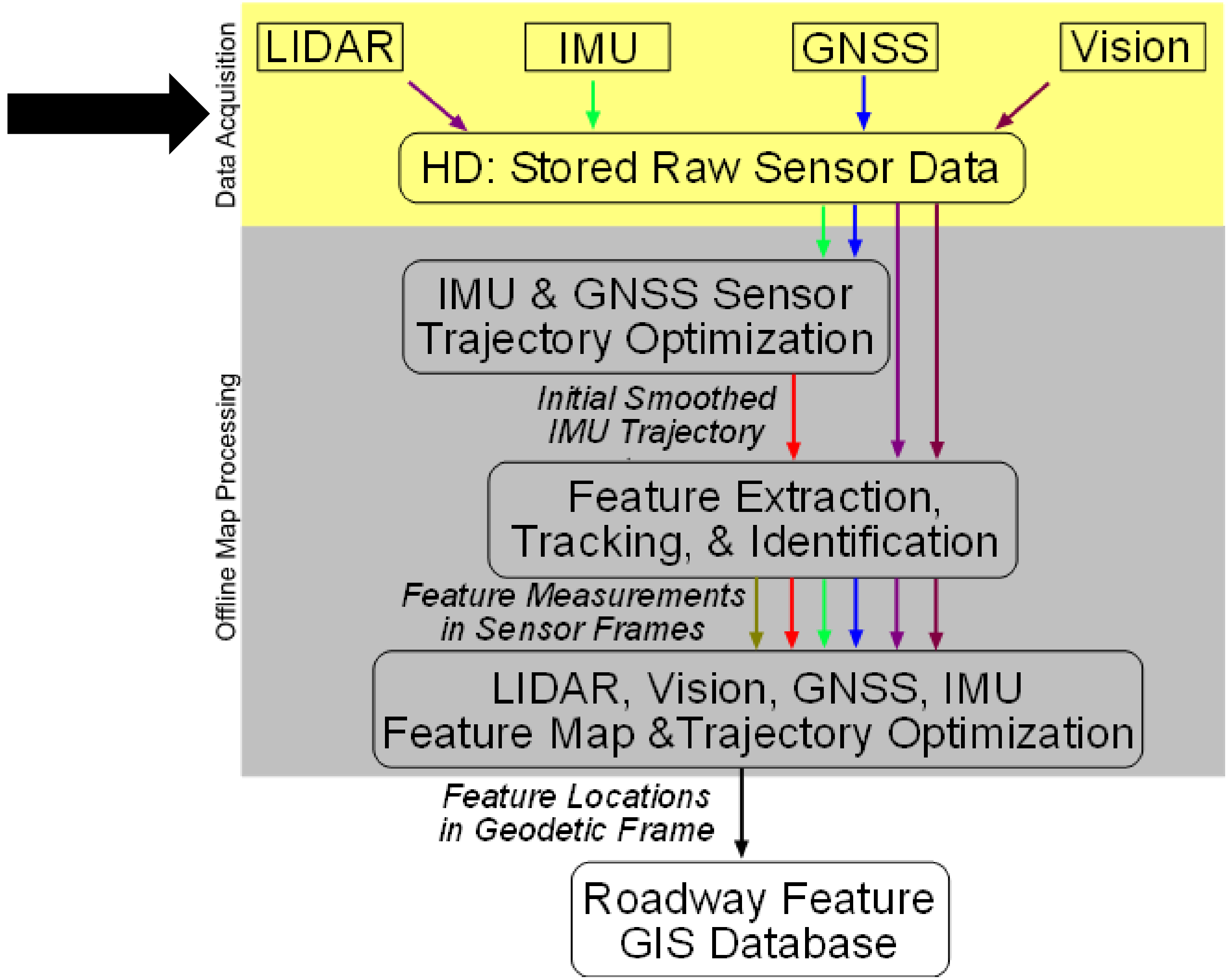


Panoramic camera

Equipment Configuration for Field Test

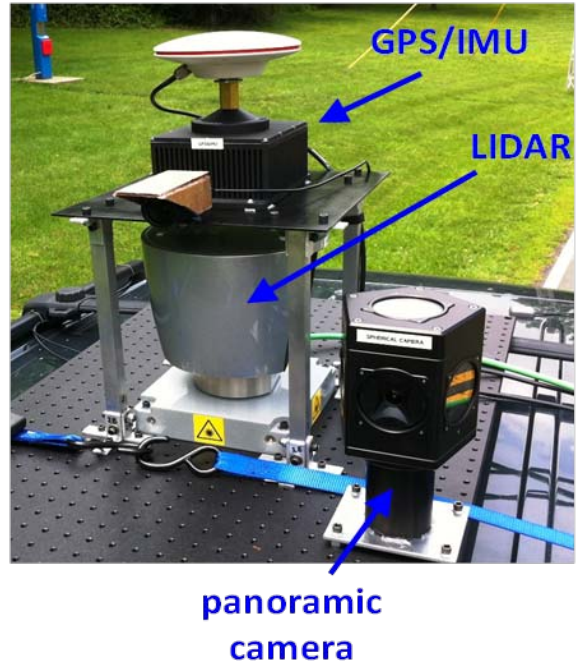


Vehicle Mounting of Equipment



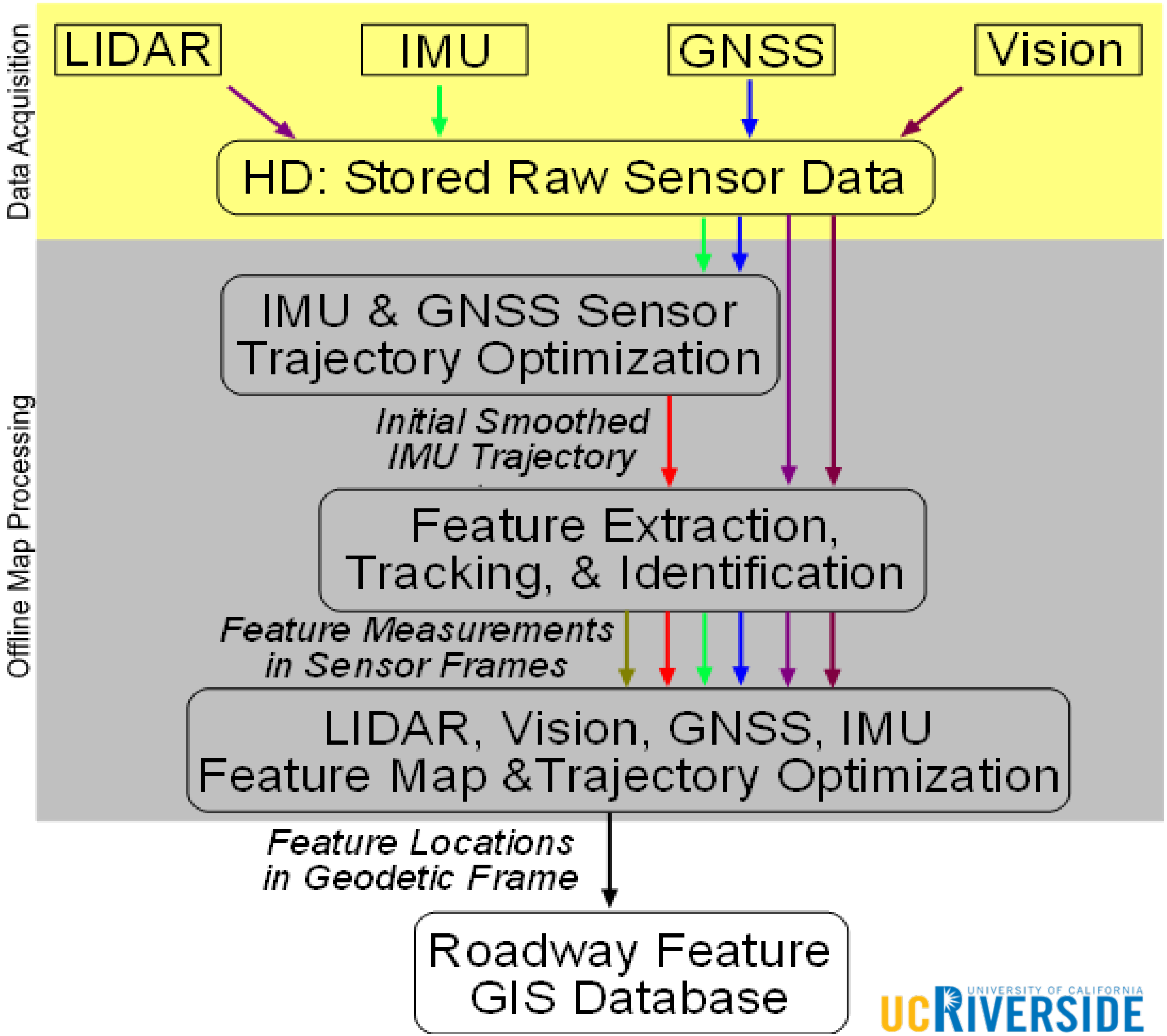
Mapping Sensors and Data Rates

- LIDAR
- Camera set
- IMU
- GNSS Receiver
- High capacity HD
- Roof Platform
- Power supply
- CPU



Sensor	Bytes/Msg.	Msgs./sec	Bytes/Sec	GB/Hr	GB/Hr (with timestamp overhead)
IMU	19	200	3800	0.013	0.232
LIDAR	1206	3473	4,188,438	15.08	15.278
Camera	35,836,416	7.5	268,773,120	967.583232	967.583
GPS measurement data	612	1	612	0.002	0.0374
GPS Ephemeris data	256	.002	.512	1.8432e-6	3.13344e-5
DGPS data	1071	1	1071	0.0038	0.0039
Total:			273 MB /sec	982 GB/Hr	983 GB/Hr
Hrs. of collection per TB:					≈1 Hr.
Miles of coverage per TB (assuming a speed of 30 mph):					≈30 miles

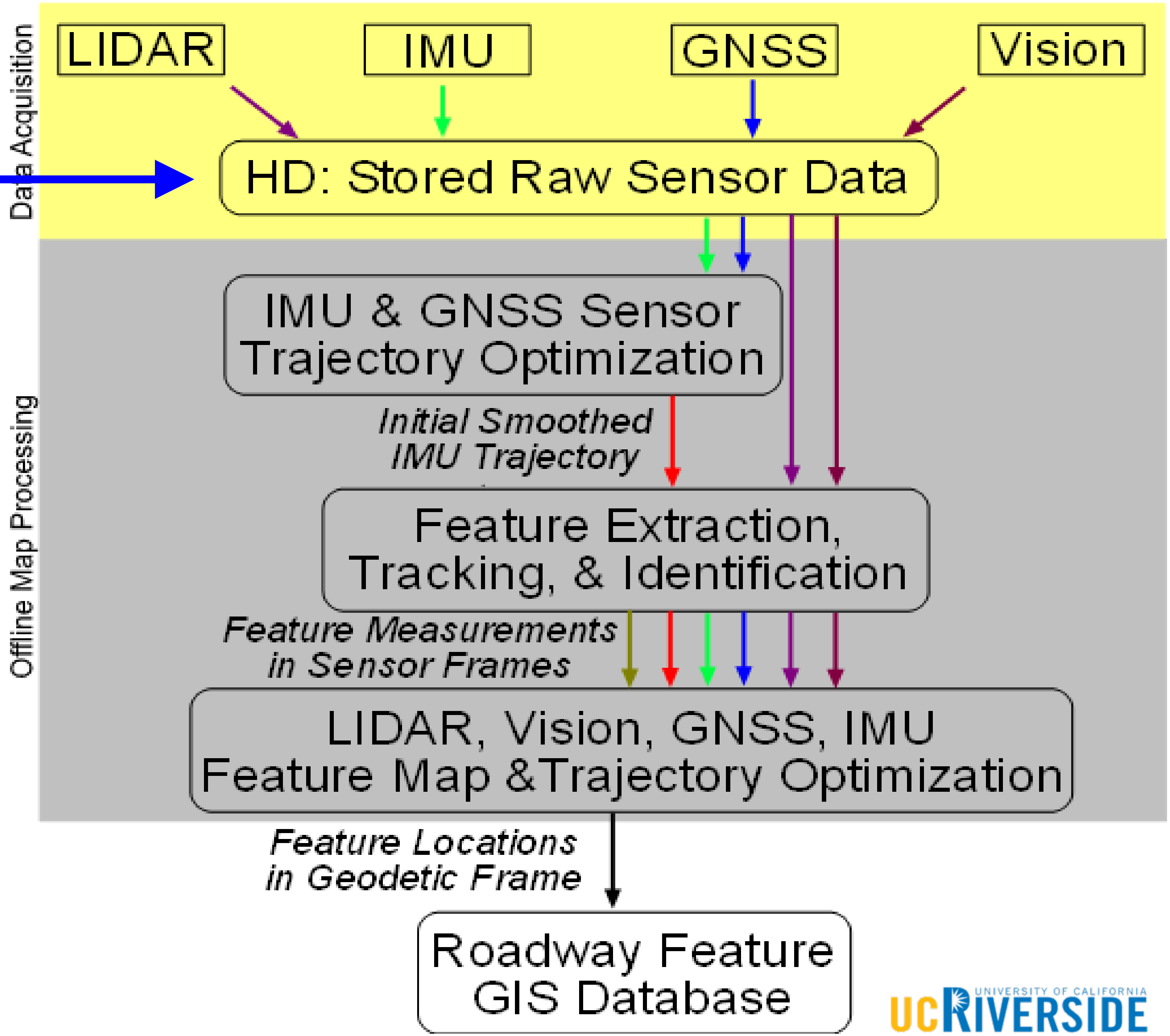
Mapping Process



Equipment:

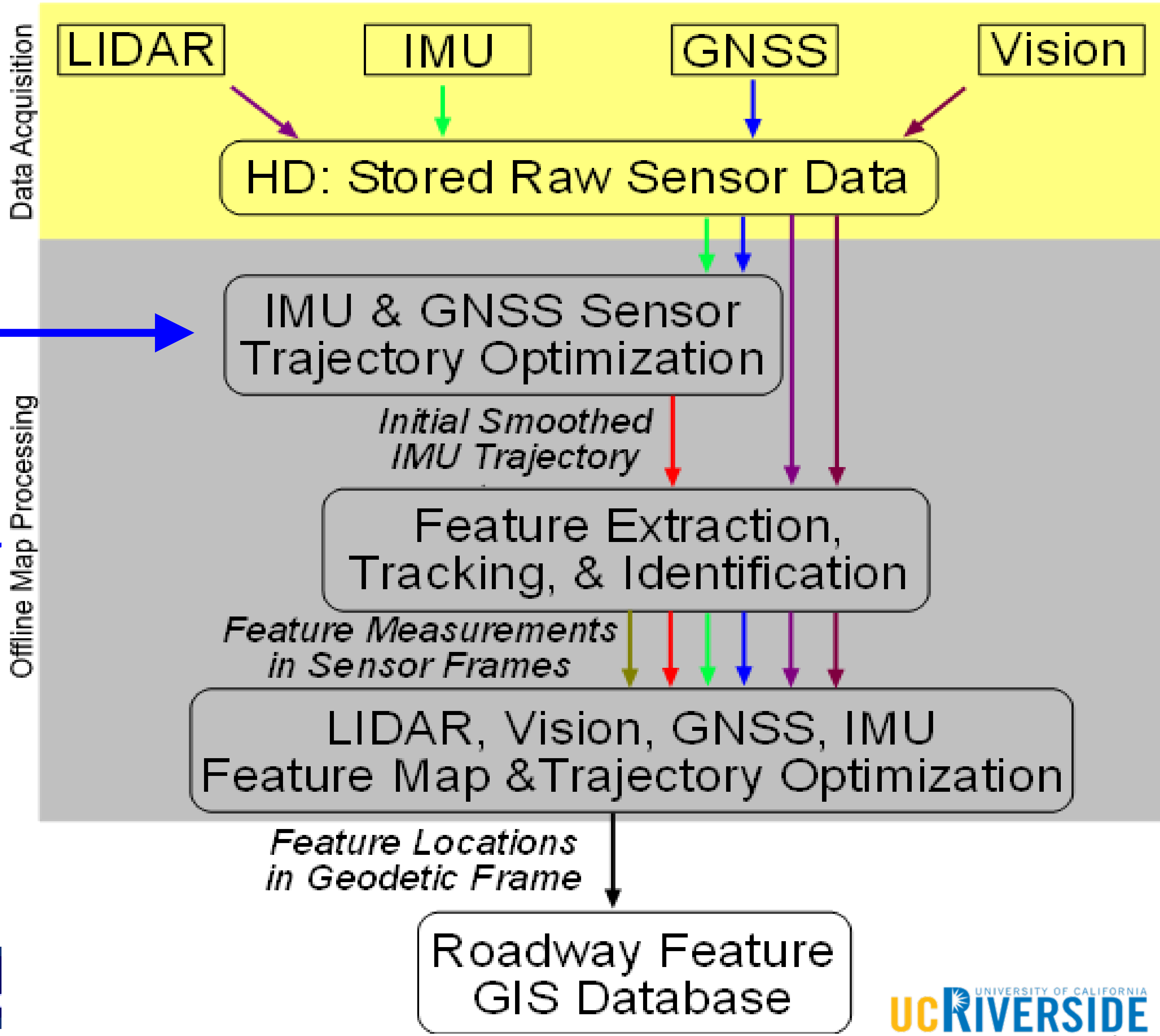
- LIDAR
- Camera set
- IMU
- GNSS Receiver
- High capacity HD
- Roof Platform
- Power supply
- Matlab
- DGPS station
- Data Communication
- GIS
- High Performance CPU

Vehicle is driven and data are collected



UC RIVERSIDE
UNIVERSITY OF CALIFORNIA

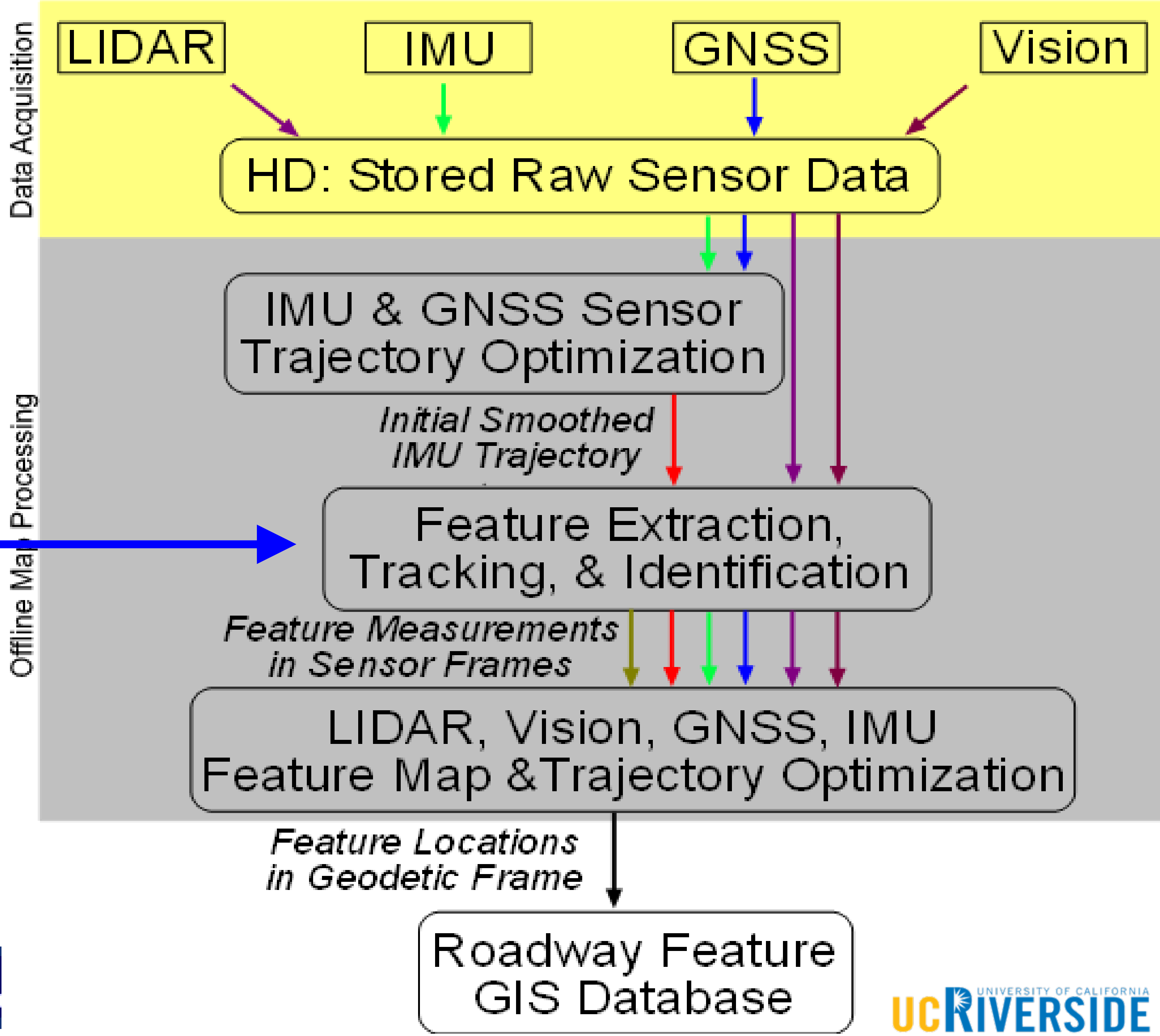
IMU and GPS data are smoothed providing a continuous smooth trajectory



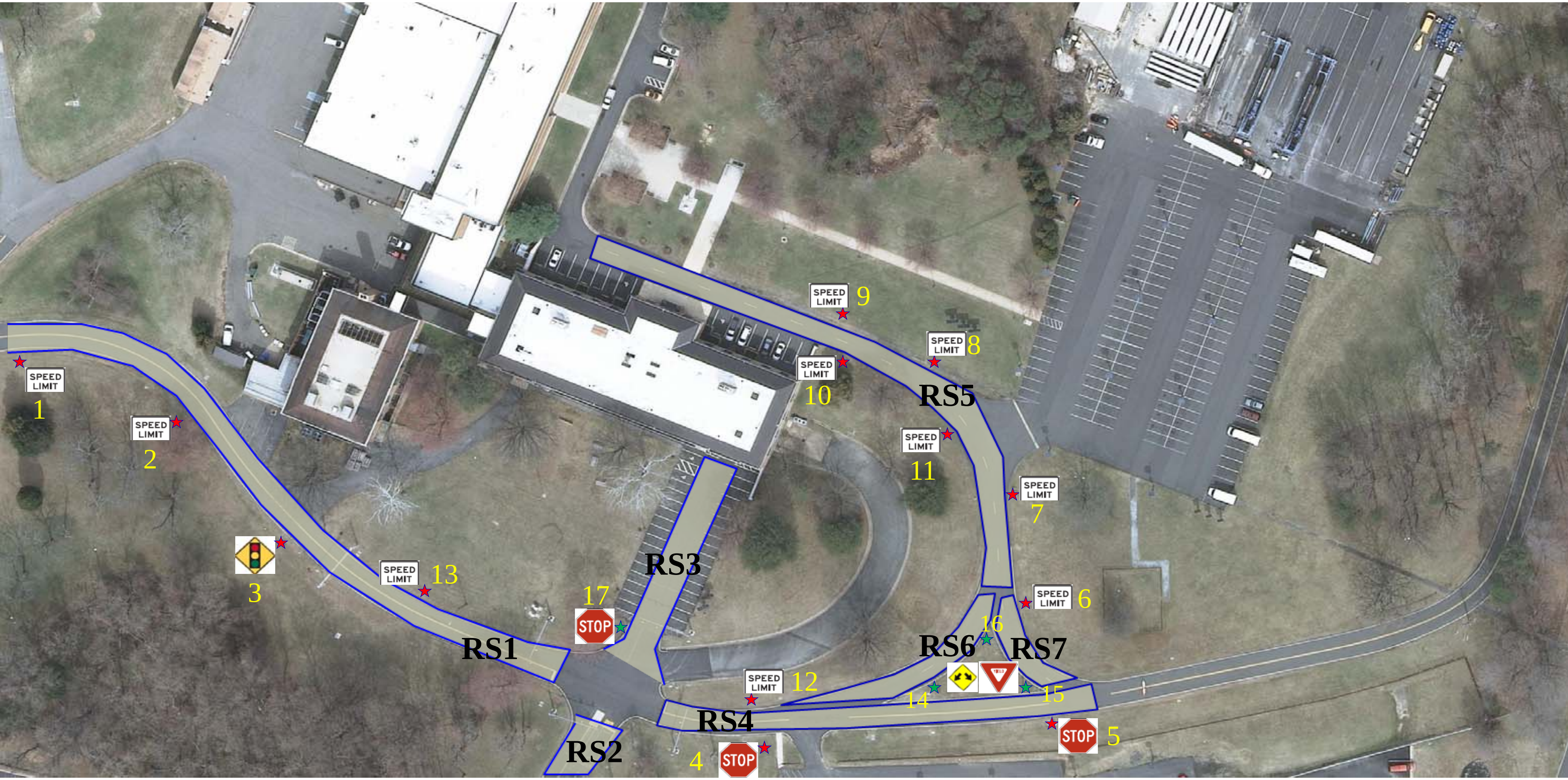
U.S. Department of Transportation Federal Highway Administ

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

Features (e.g., road signs, lane markings, road curves, etc.) are extracted and identified from the raw data



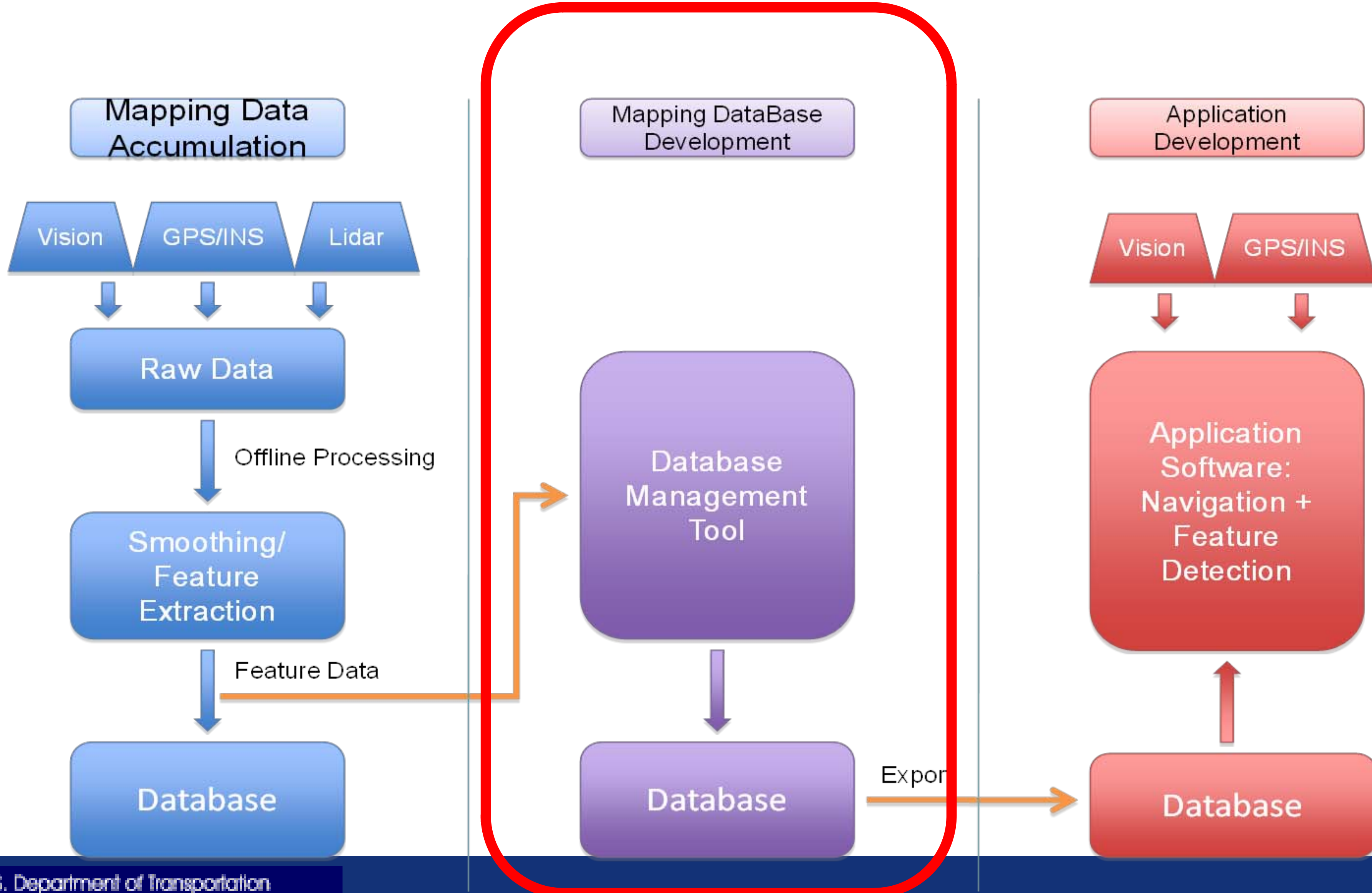
Road Signs Locations



Estimated vs. ~~Surveyed~~ Accurately Mapped Points

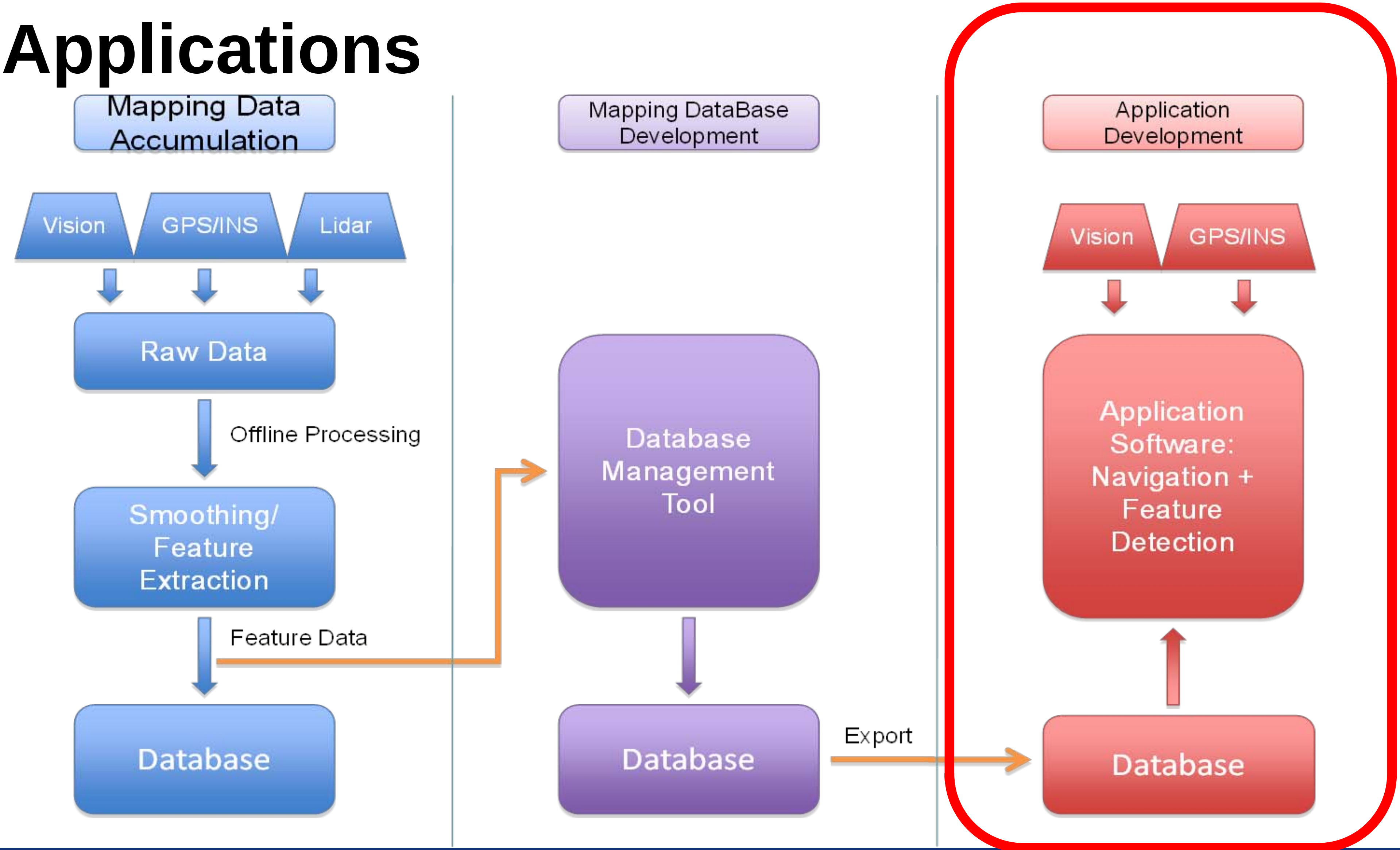
- estimated
- X ~~Surveyed~~ Accurately Mapped

Map Database



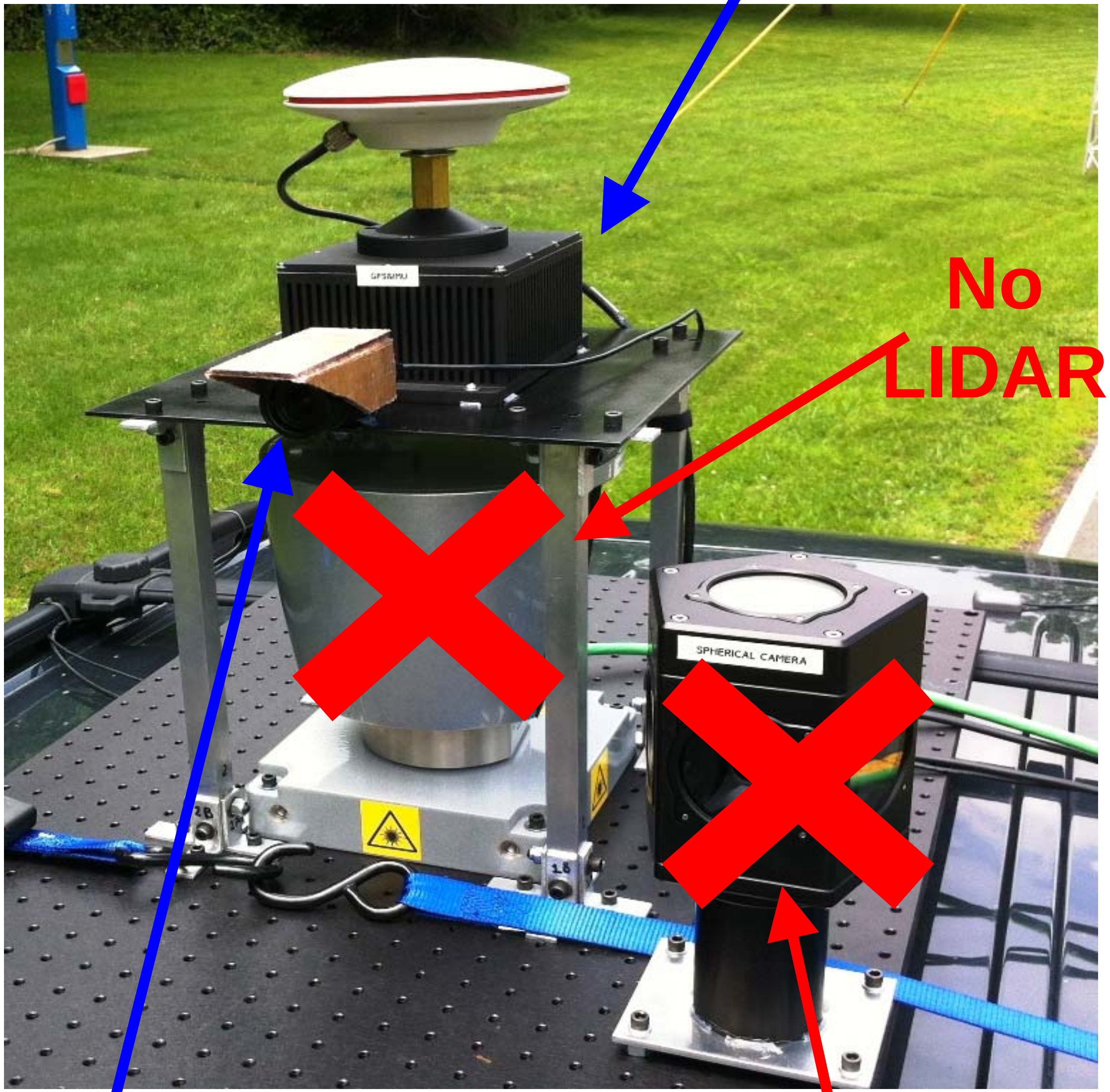
Bing Map, TFHRC Aerial Image, LIDAR-based intensity image overlay

Applications



inexpensive GPS/IMU

Sensor platform for *positioning*



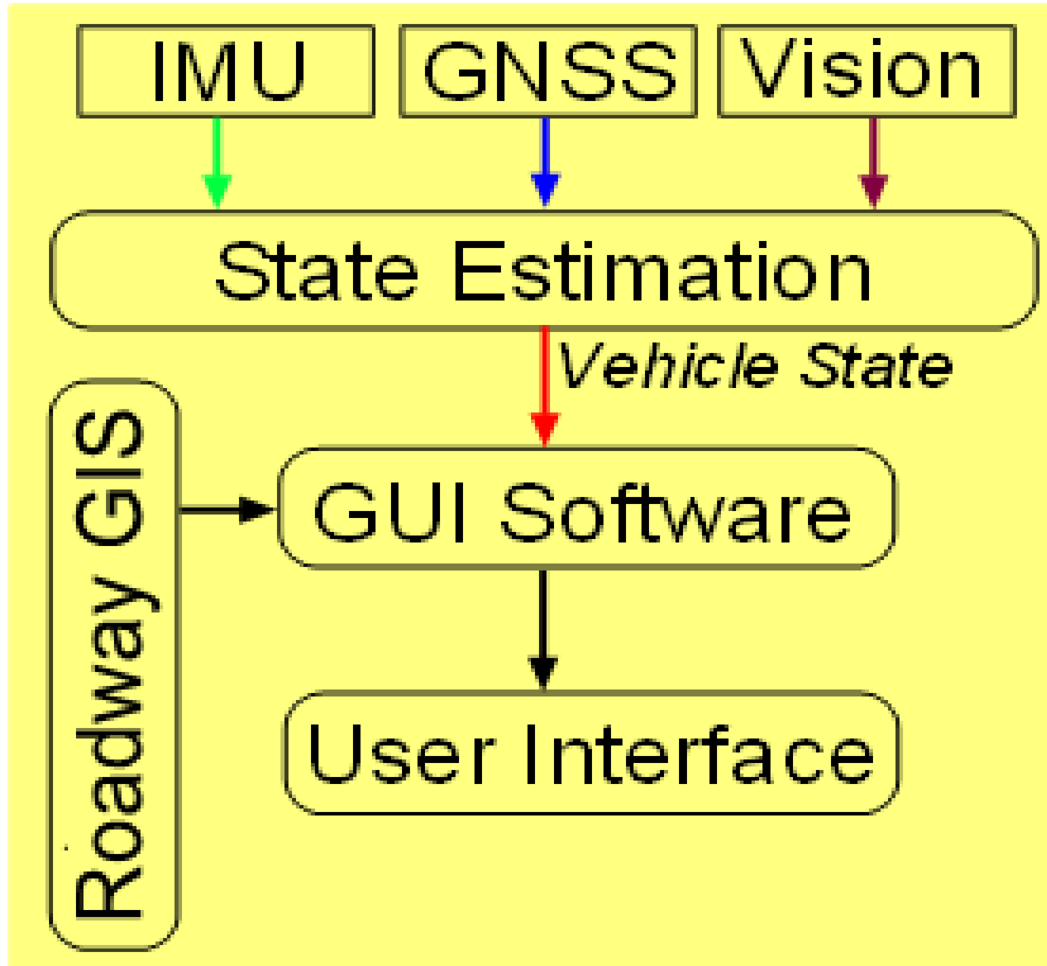
No LIDAR

sensor platform

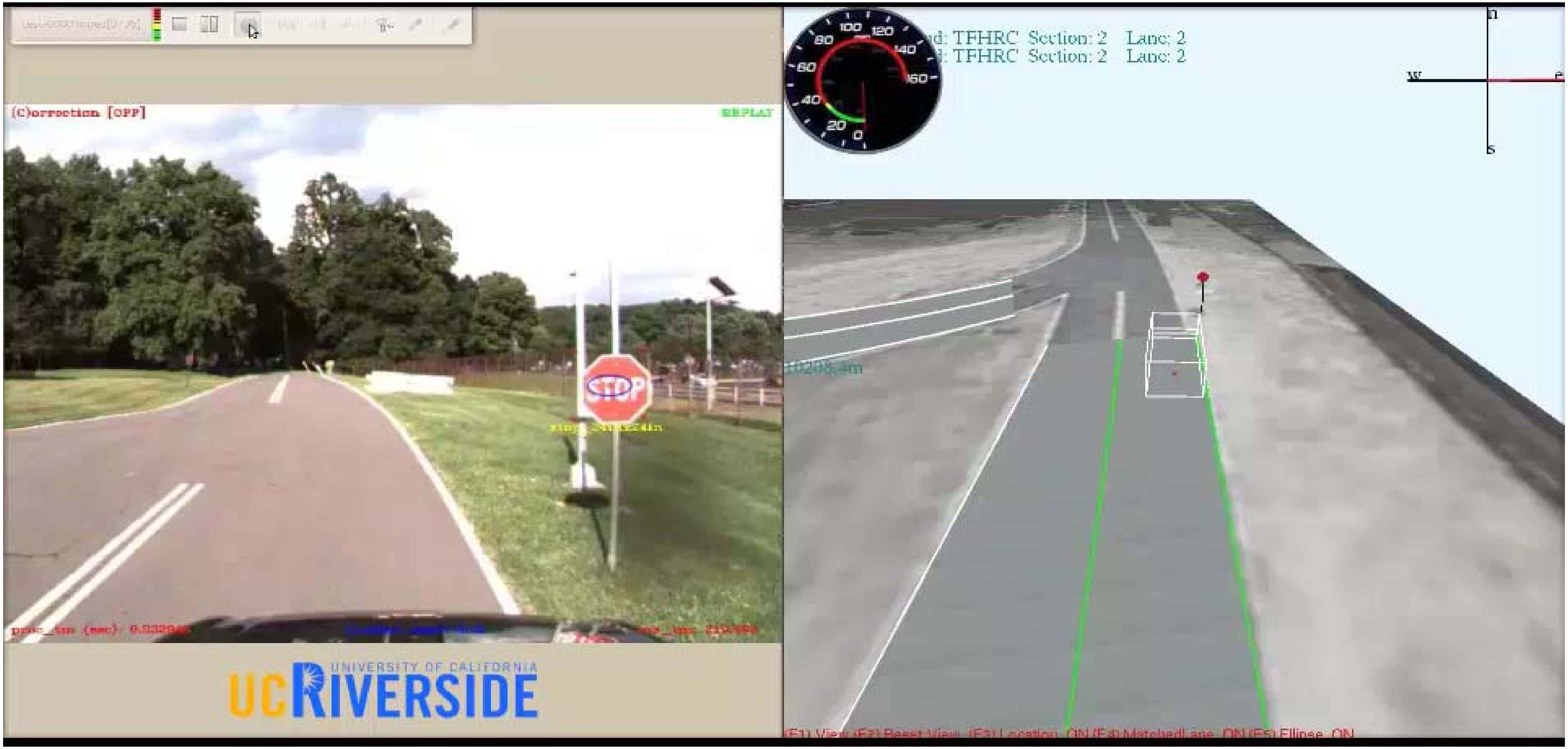
Inexpensive rectilinear camera

No panoramic camera

Application Data Flow



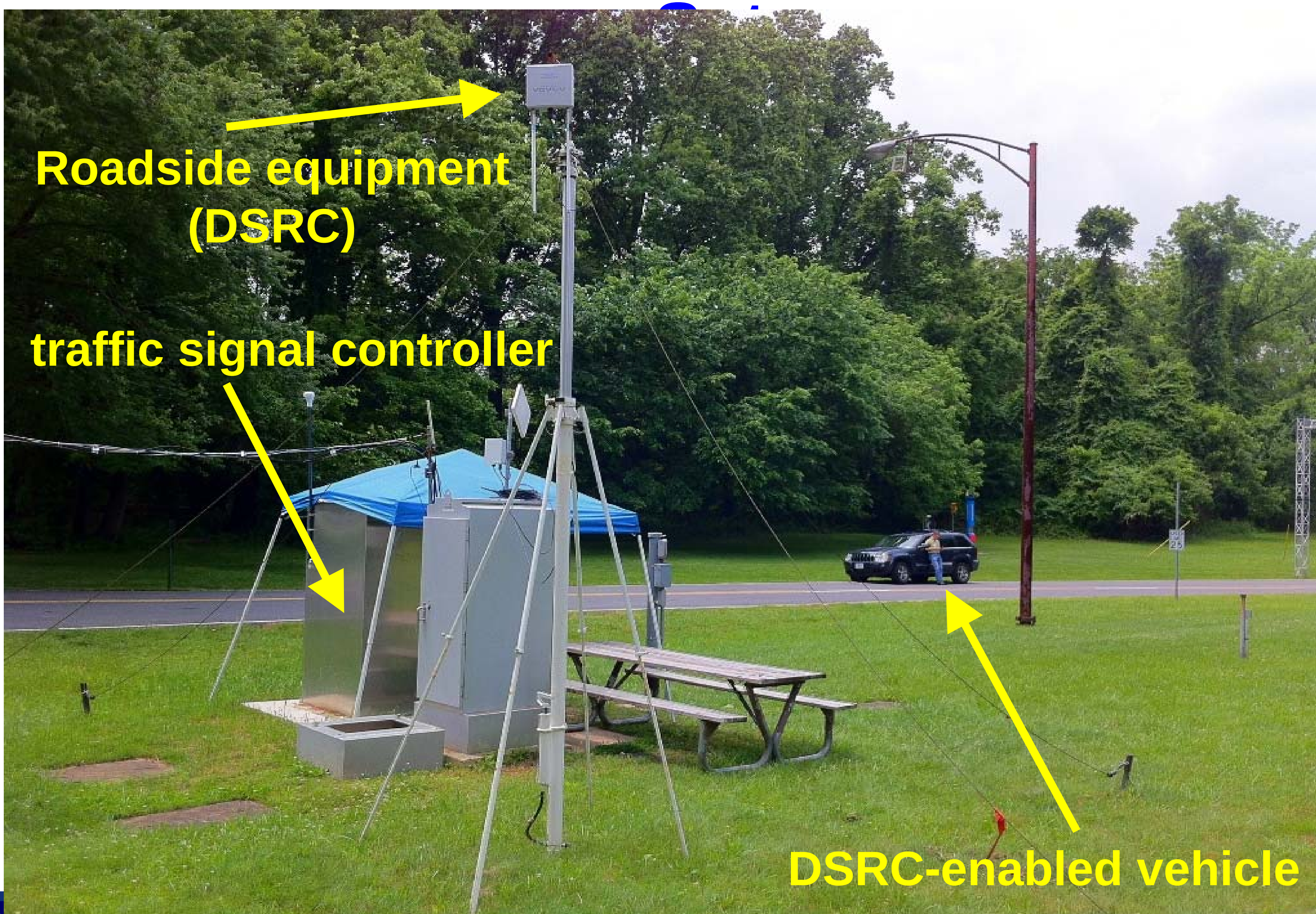
Application Graphical User Interface…



Lane Departure Warning…

Curve Overspeed Warning…

Signal Phase and Timing System



Field Study Summary

- Automated sensor-based mapping is necessary for nationwide lane-level map production
  - This project task developed software and demonstrated that automated sensor-based mapping is feasible with centimeter-level accuracy
- Three lane-level applications built on the foundation of lane-level maps were demonstrated using decimeter-level positioning techniques
  - Lane departure warning
  - Curve overspeed warning
  - Signal Phase and Timing, at lane-level

Potential Areas of Future Research/Development

- Thorough process evaluation in less-structured, more-dynamic environments
- Transition from semi-automated to fully automated mapping process
- Maintenance of the precision map
  - Crowd sourcing
  - Targeted updates
- Large scale computer or cloud implementation for mapping larger environments

Questions ?

Contact info:

James.a.arnold@dot.gov
Rudy.persaud@dot.gov