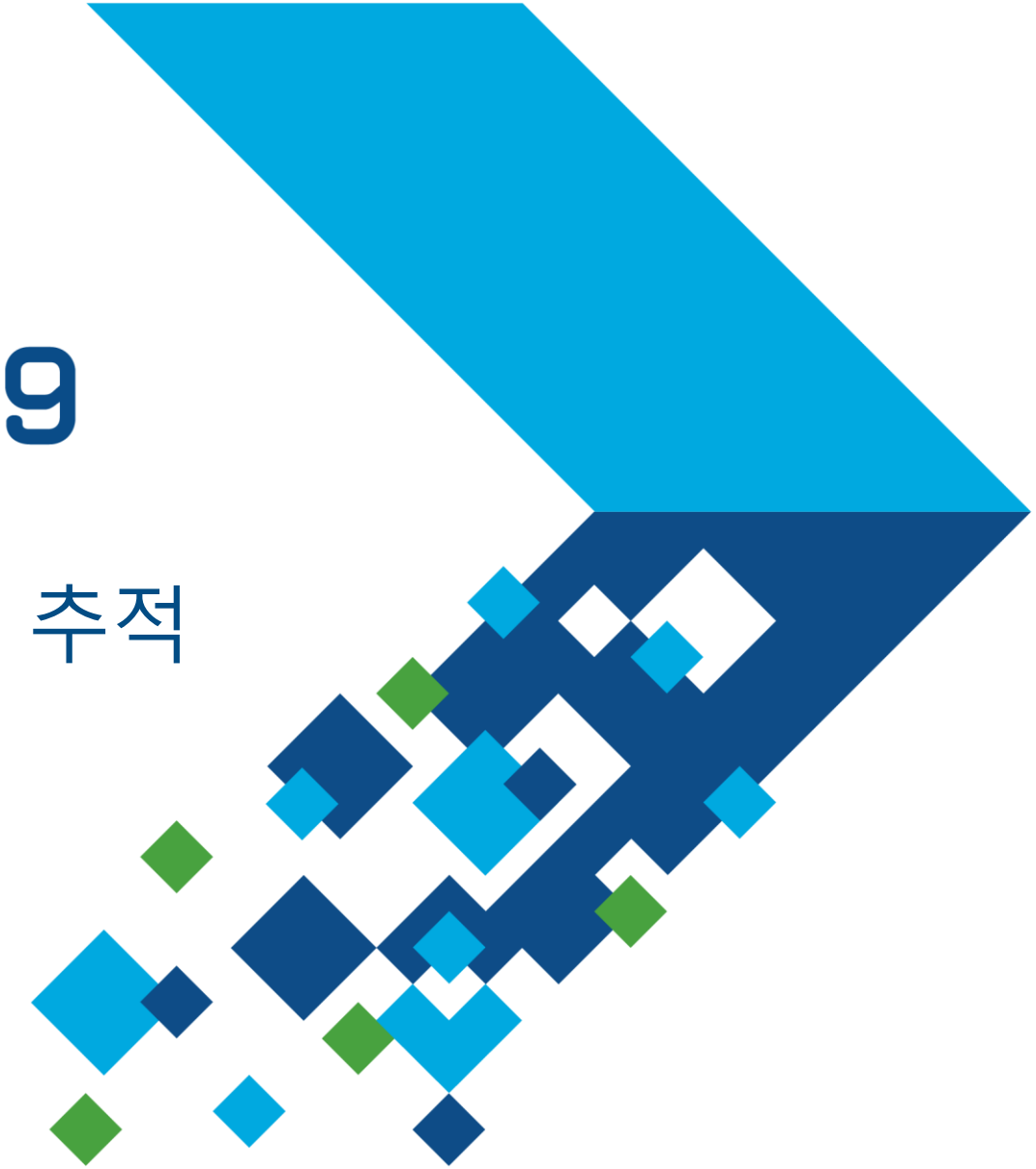
MATLAB EXPO 2019

자율시스템을 위한 센서 융합 및 추적

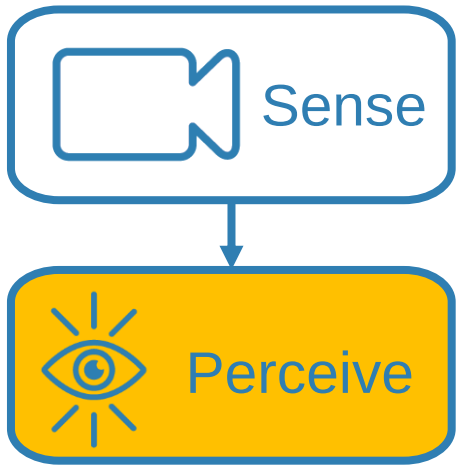
서기환

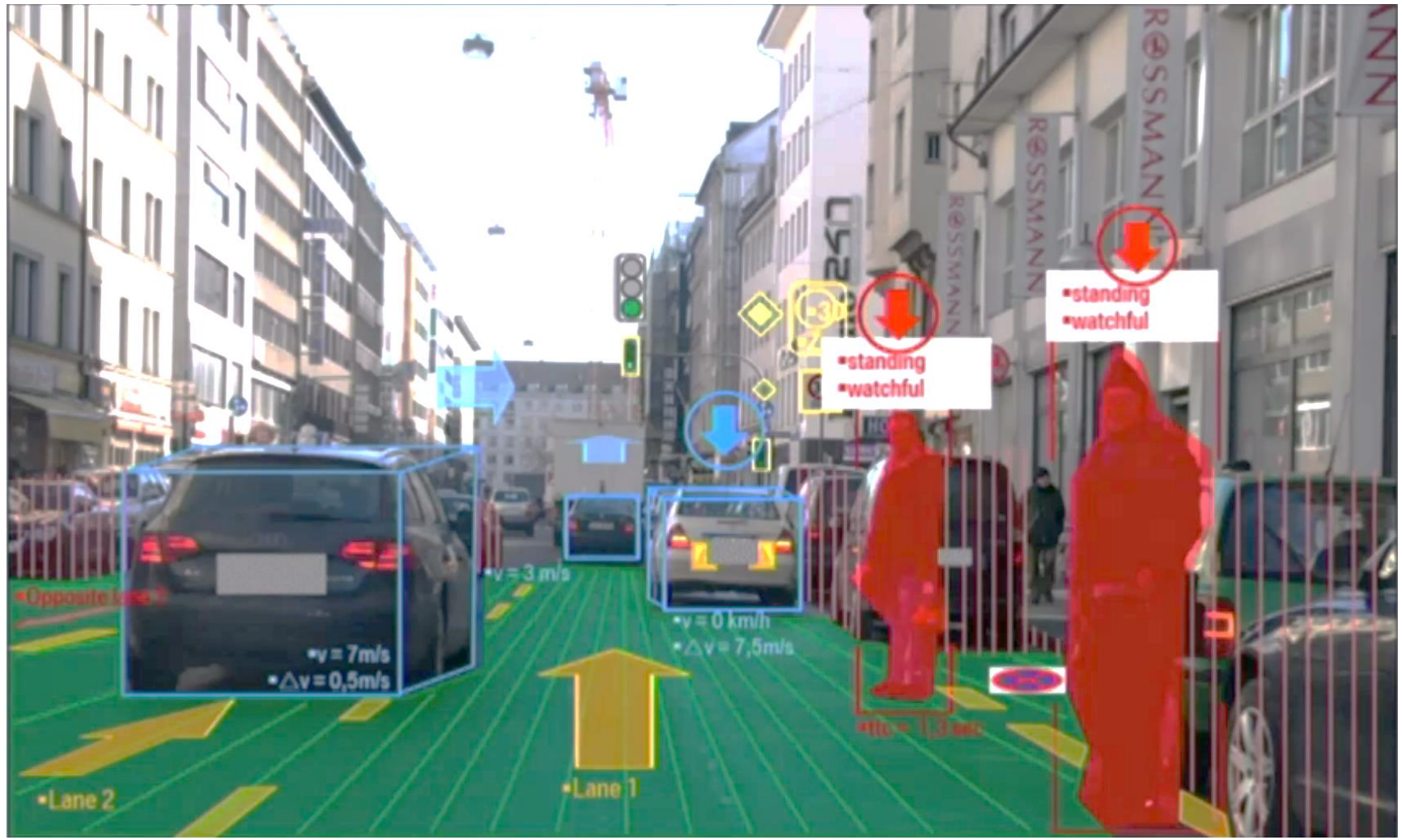


Capabilities of an Autonomous System

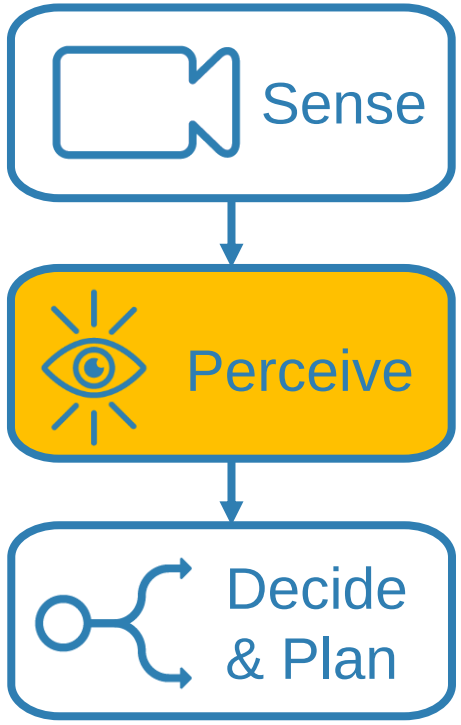
Sense

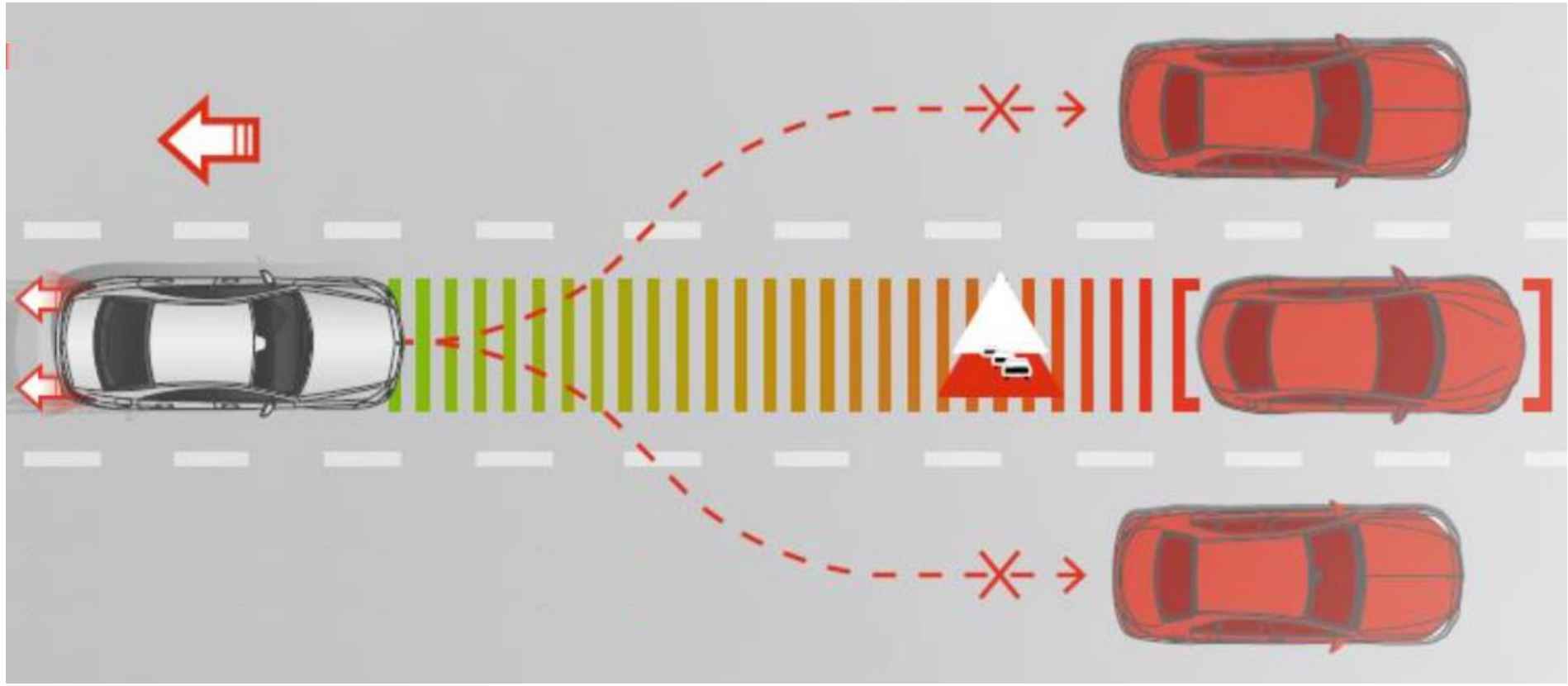
Capabilities of an Autonomous System



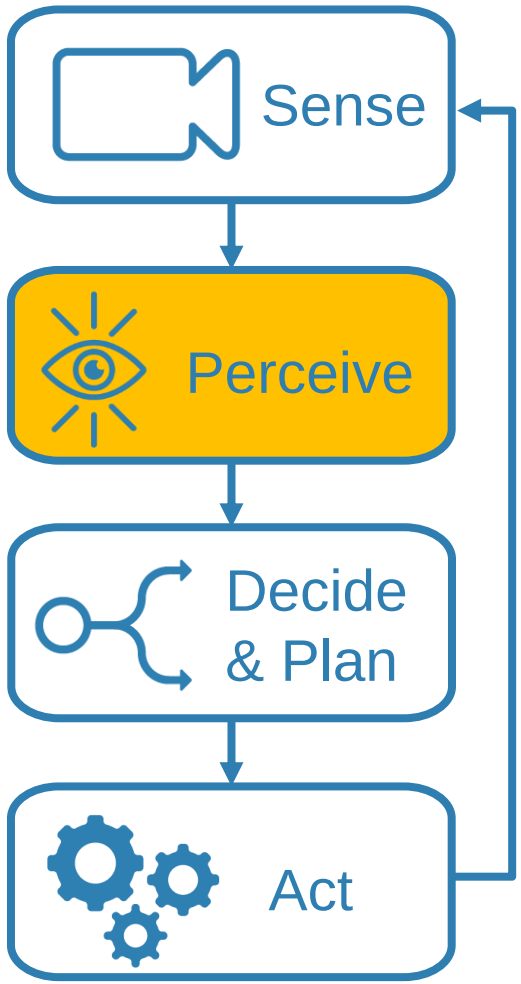


Capabilities of an Autonomous System





Capabilities of an Autonomous System

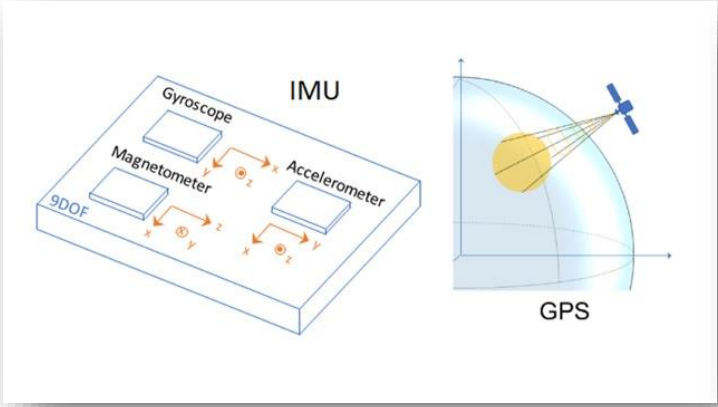


Agenda

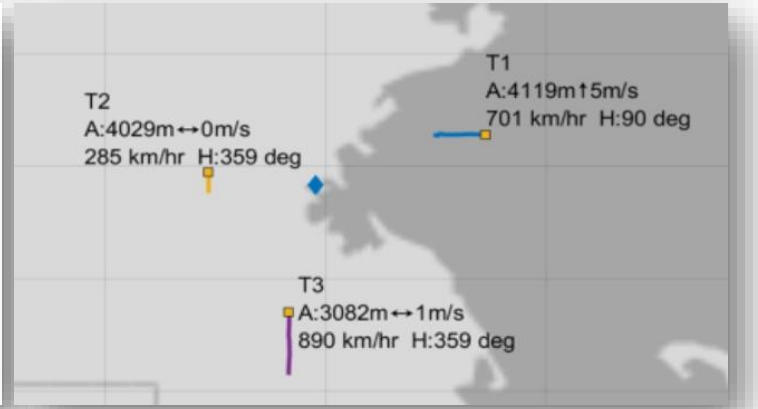
- Introduction
- Technology overview of perception
- Algorithm development for sensor fusion and tracking
- Q&A
- Resources for further exploration

Sensor fusion and tracking is…

Self- awareness



Situational awareness



Accelerometer, Magnetometer, Gyro, GPS…

Radar, Camera, IR, Sonar, Lidar, …

Signal and Image Processing

Sensor Fusion and Tracking

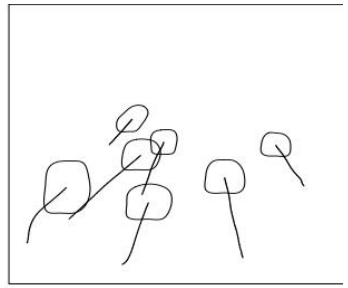
Control

Sensor Fusion and Tracking Toolbox NEW PRODUCT

Timeline of Technology Advances

Multi-object tracking

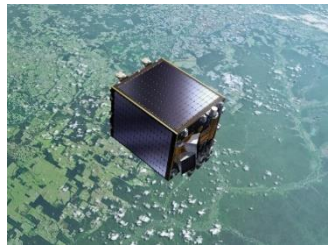
Air Traffic Control



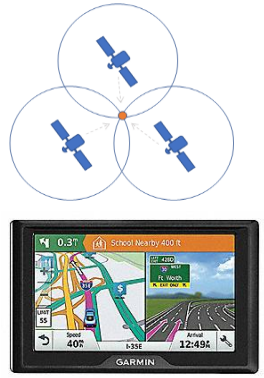
Computer Vision for Transportation

Multi-sensor Fusion for Autonomous Systems

Localization



Military



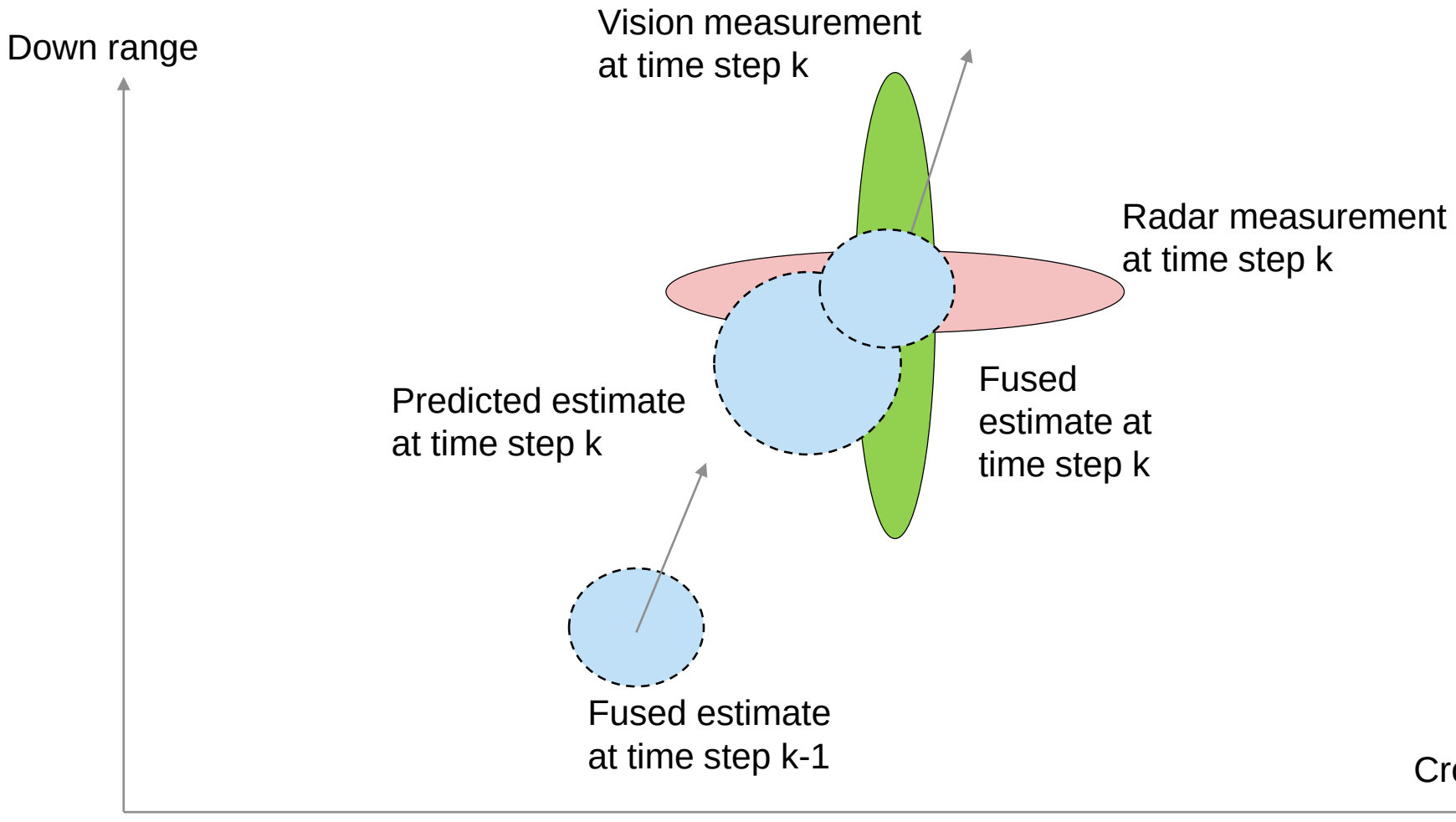
Commercial

Ubiquitous

Today

Timeline

Fusion Combines the Strengths of Each Sensor

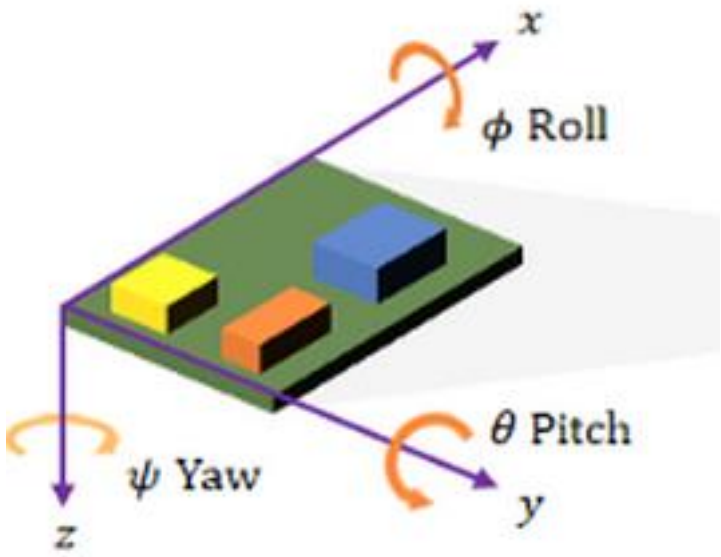


Legend

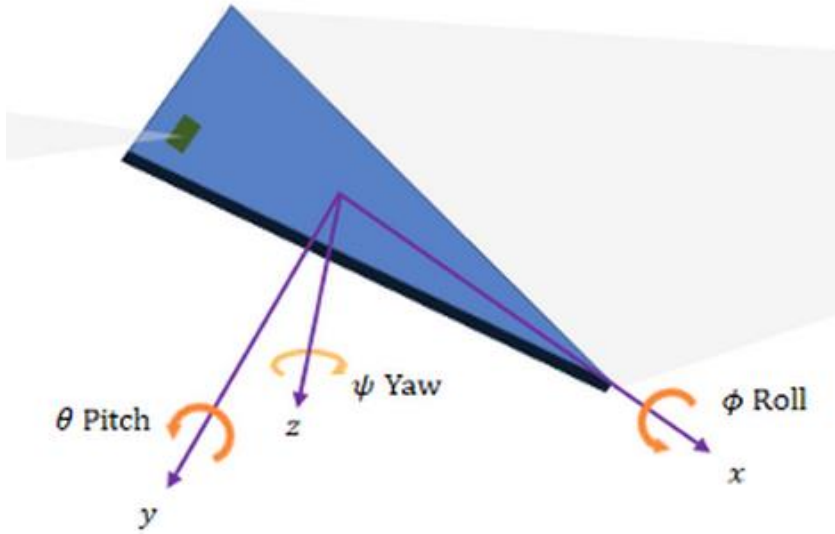
- Vision Measurement
- Radar measurement
- Track (fused estimate)

Ellipse represents uncertainty

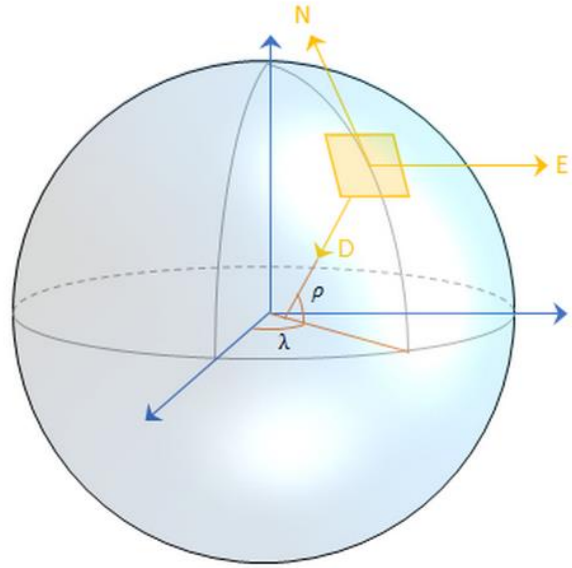
What is Localization?



Inertial Sensor



Attitude



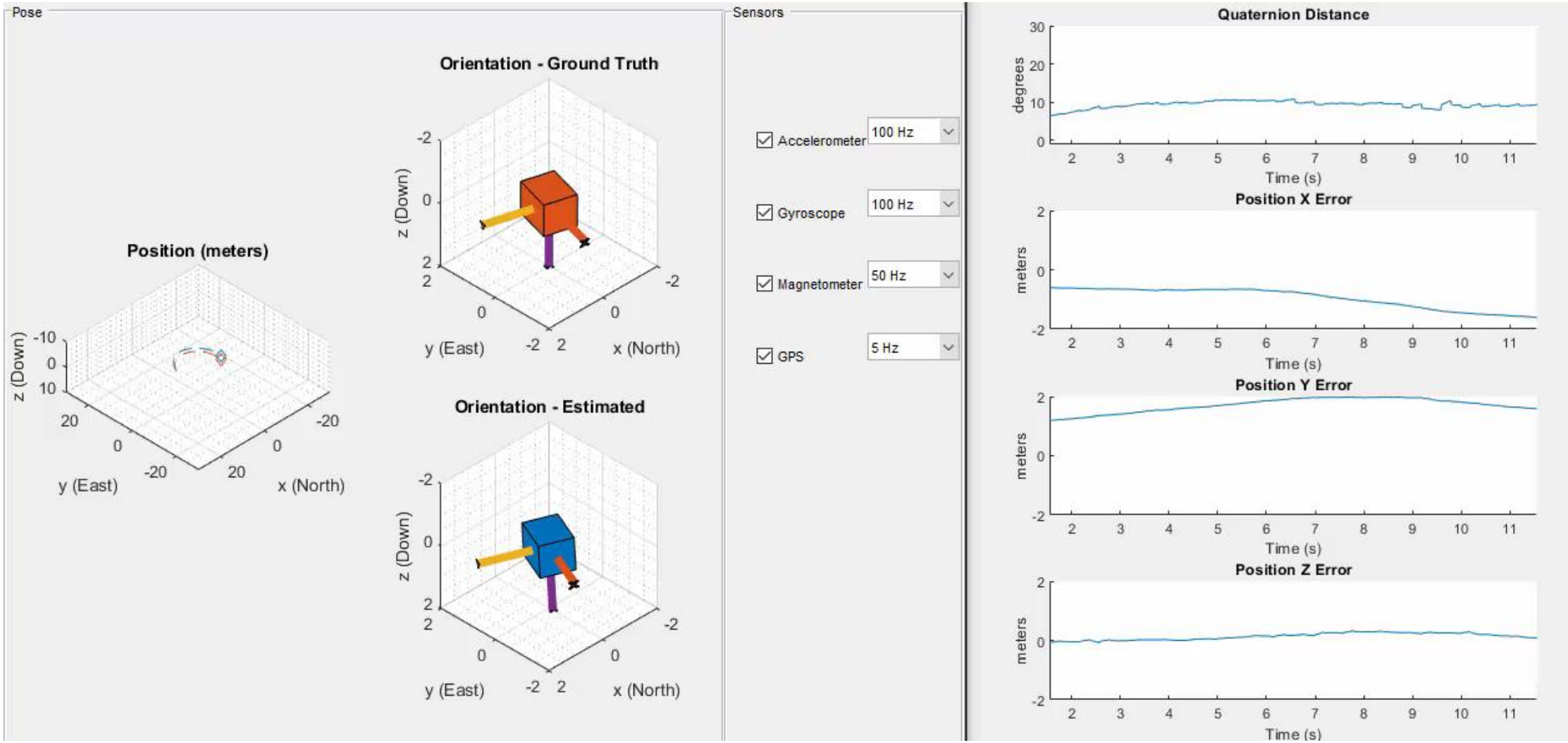
Position

Fusing Sensor Data Improves Localization

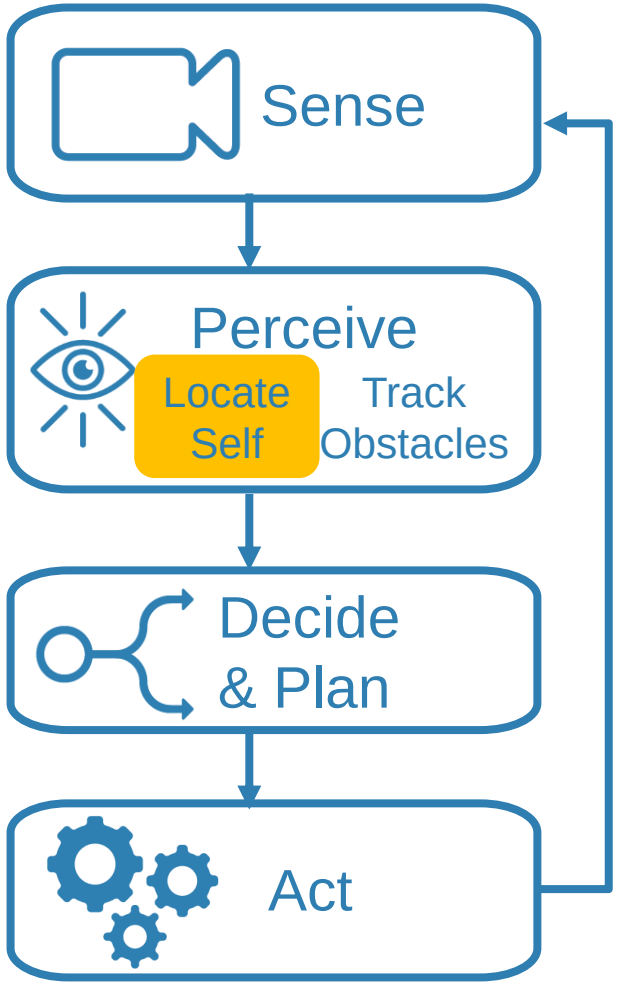
Ground truth vs. Estimate

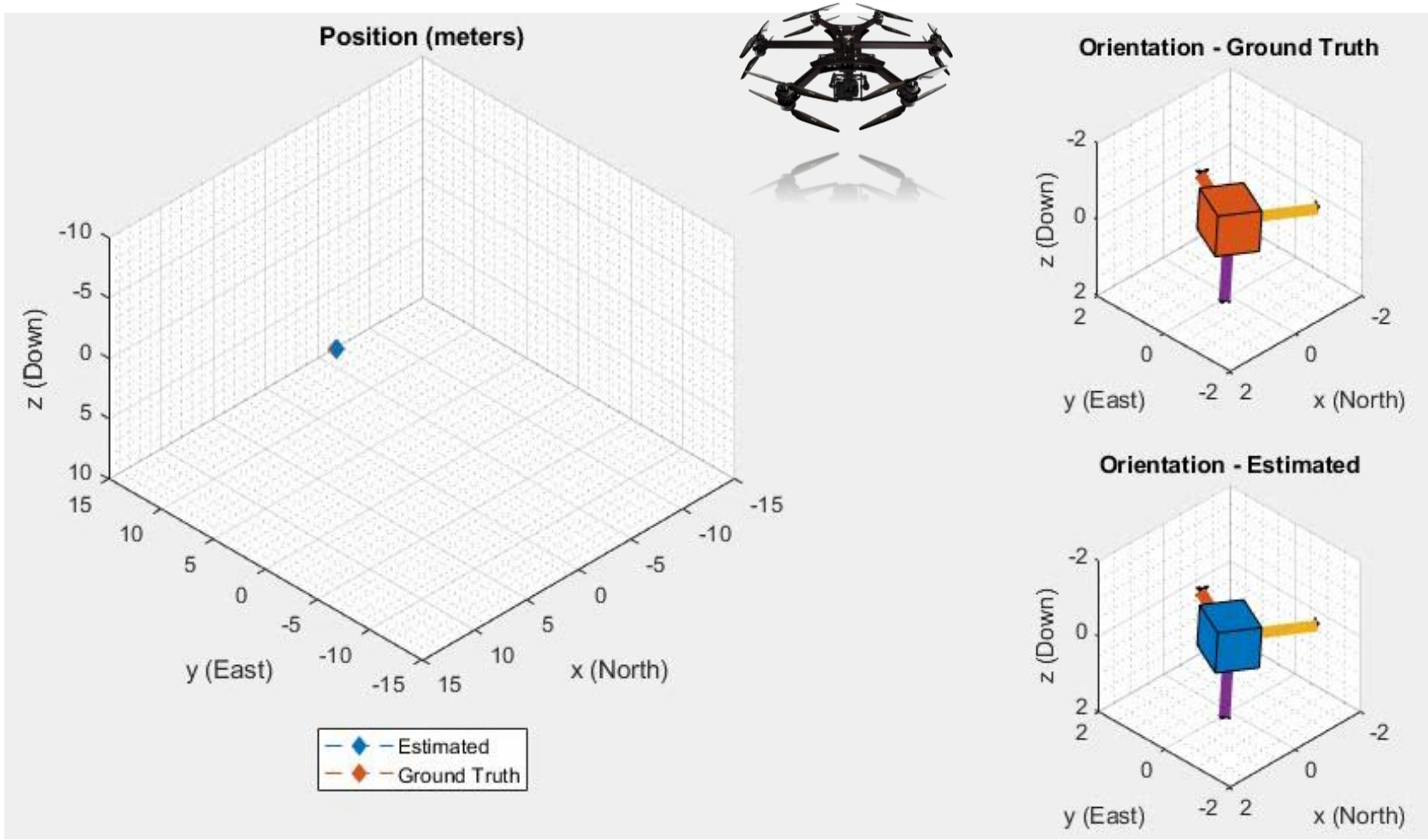
Sensors

Error Measurements

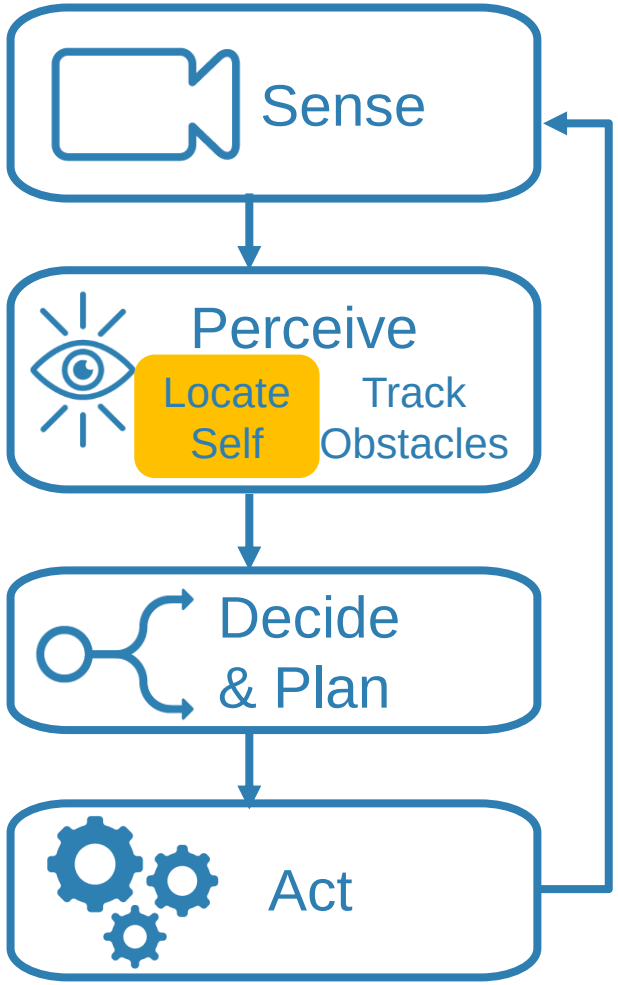


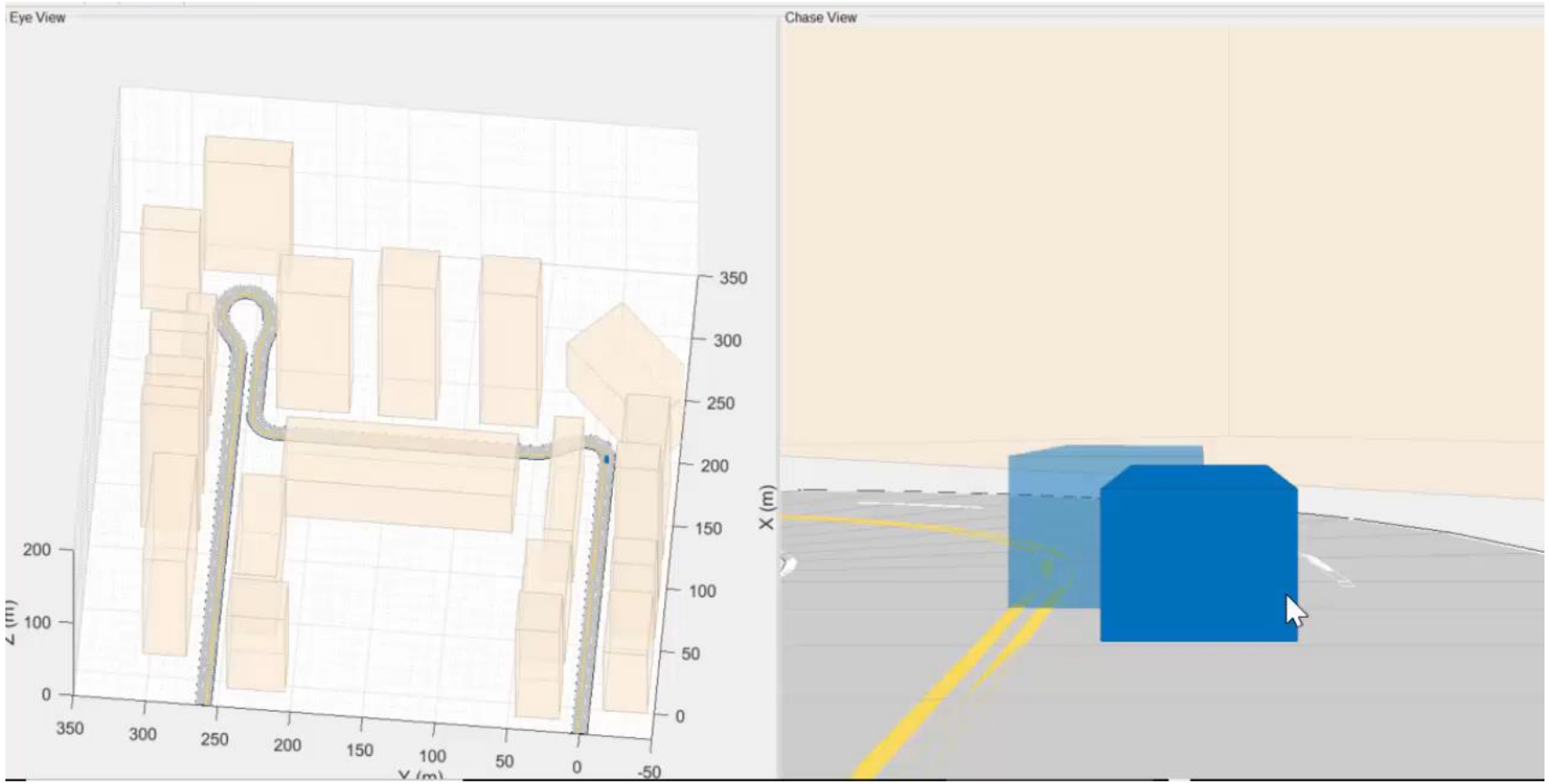
Fuse IMU & GPS for Self-Localization of a UAV



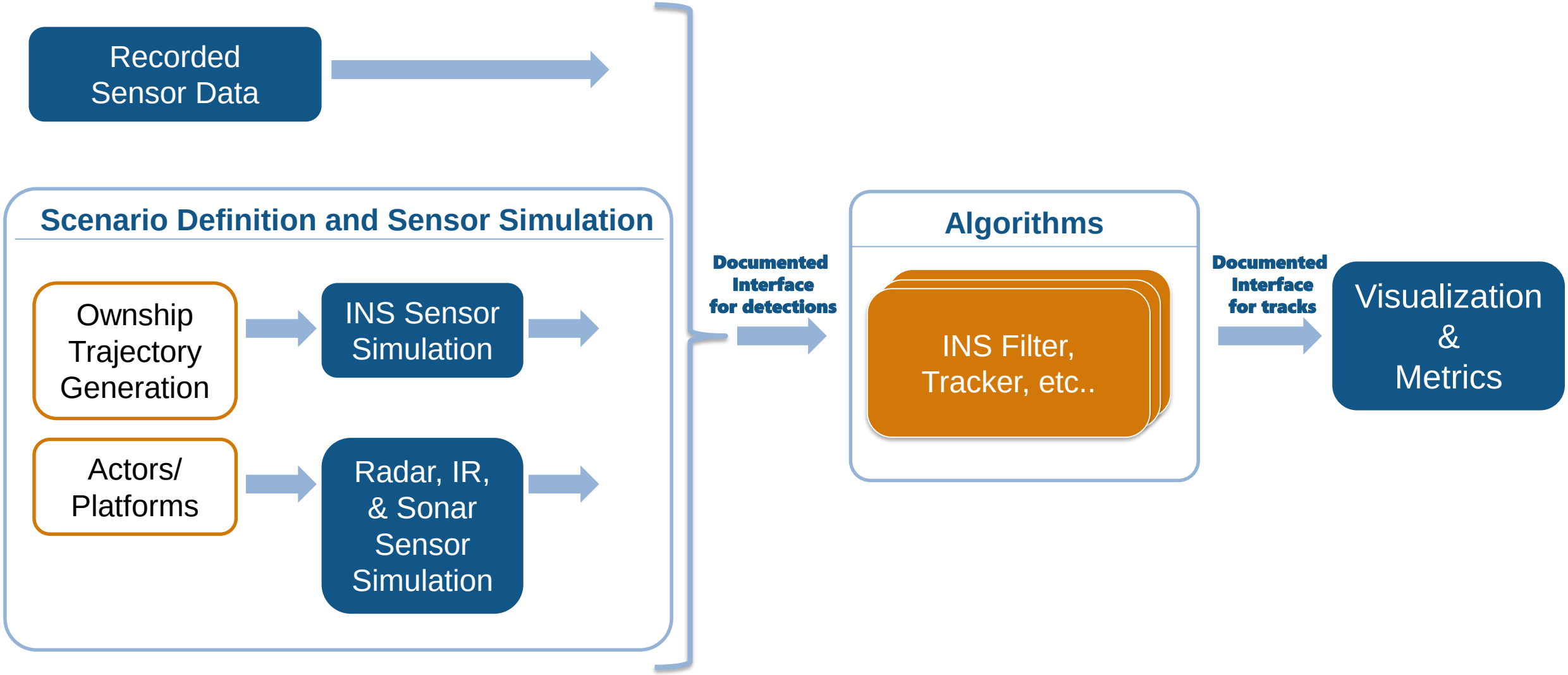


Fuse IMU & Odometry for Self-Localization in GPS-Denied Areas

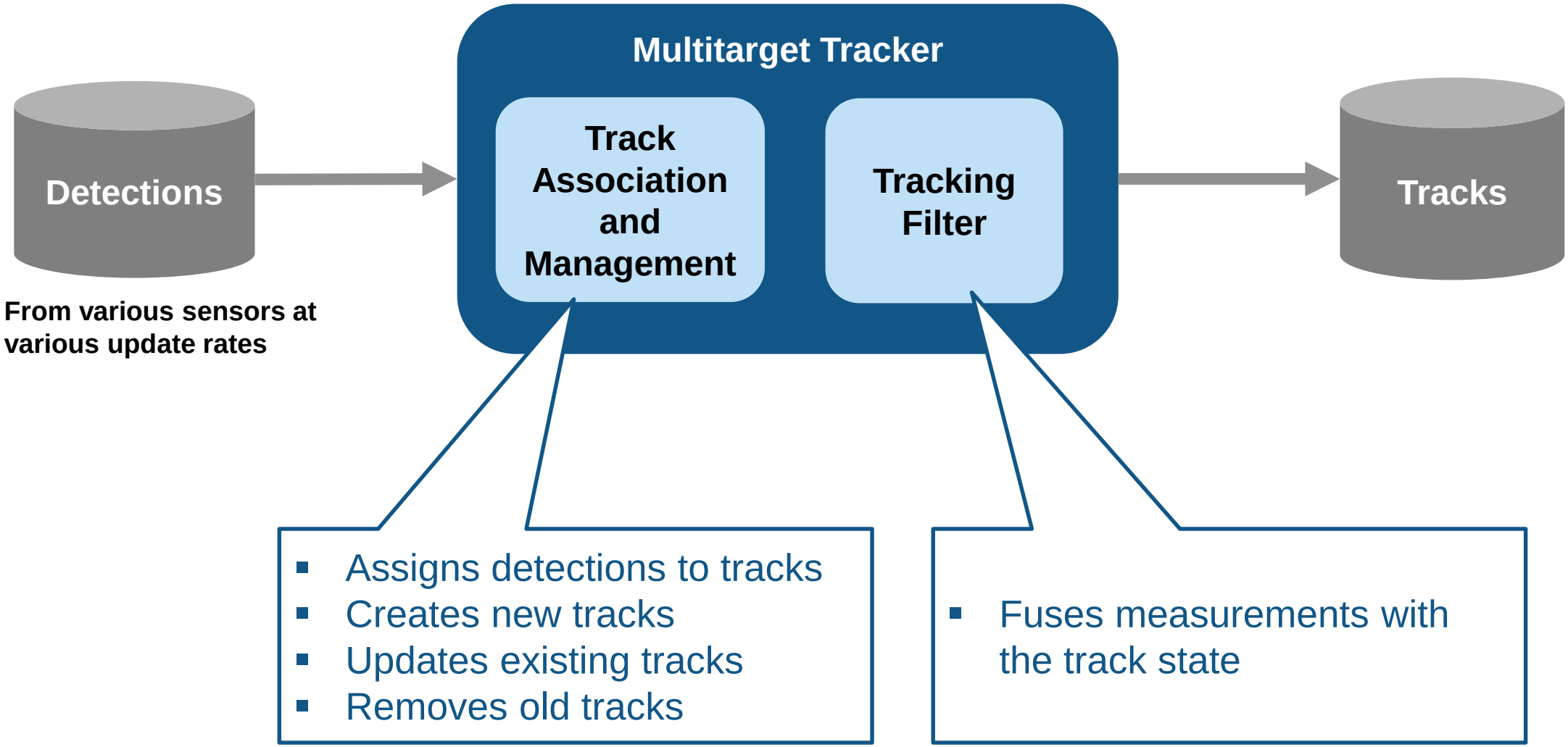




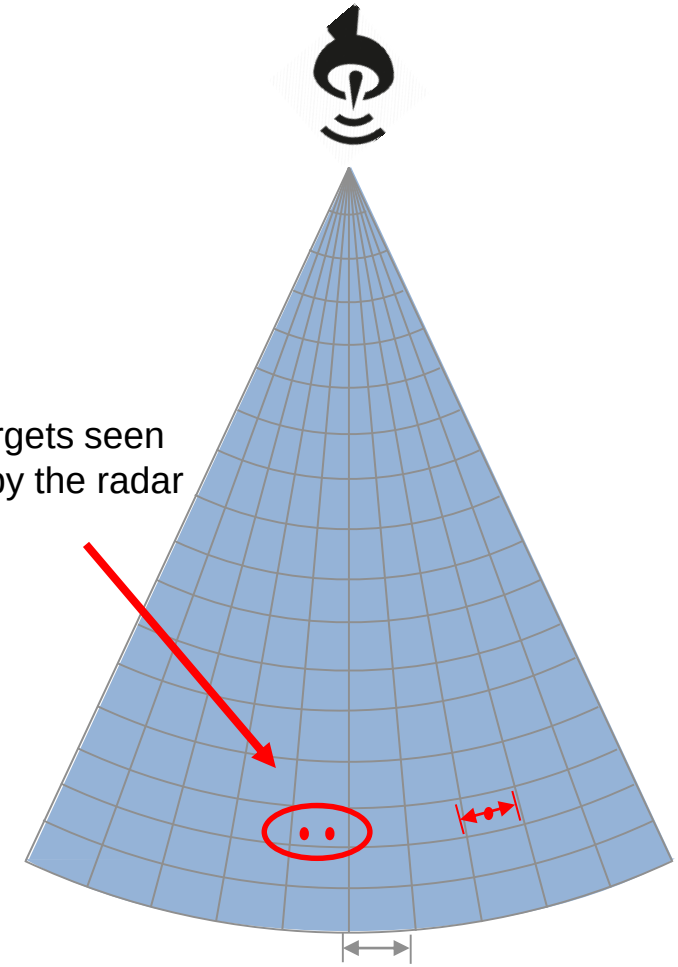
Flexible Workflows Ease Adoption: Wholesale or Piecemeal

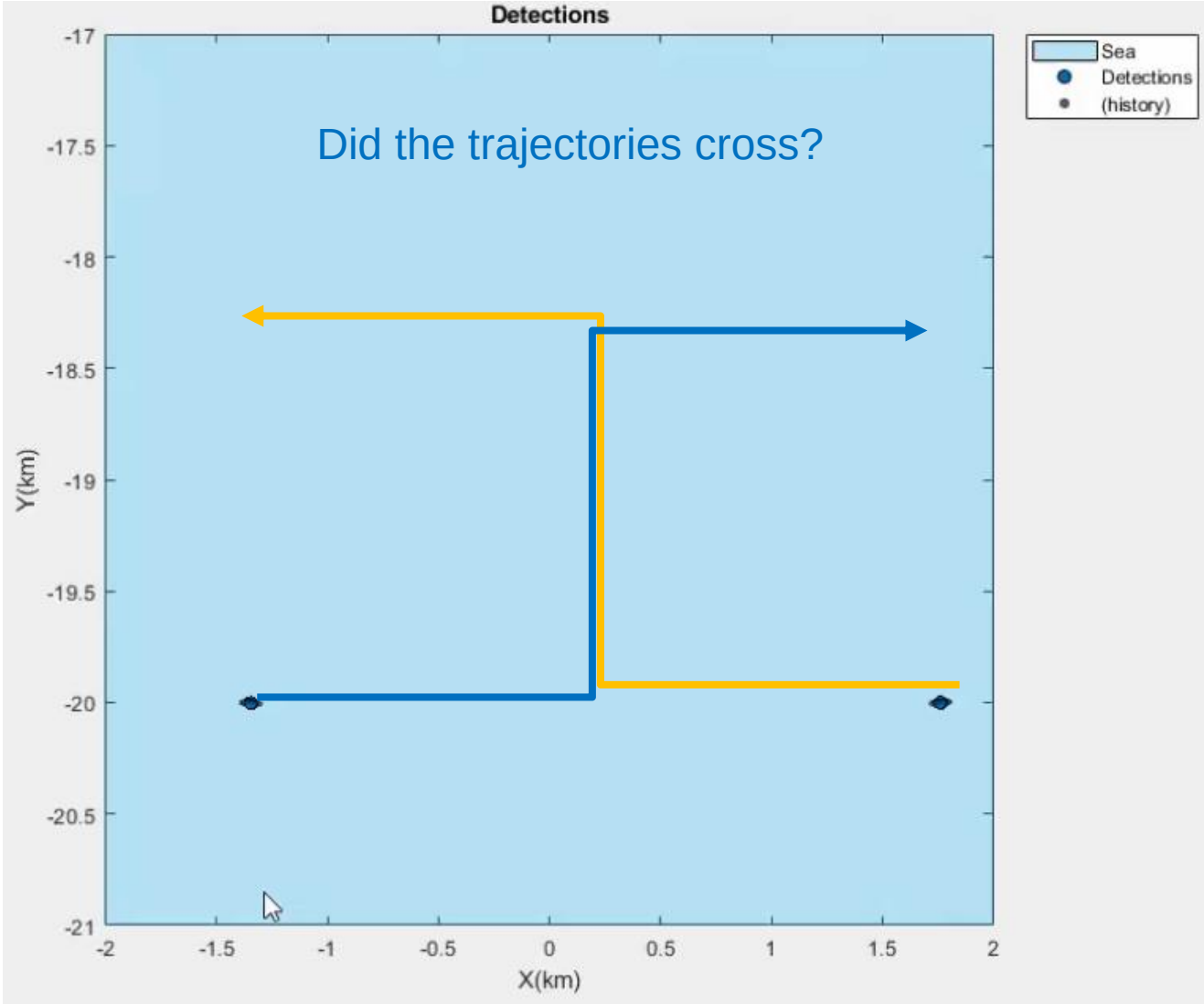


A Multi-object Tracker is More than a Kalman Filter

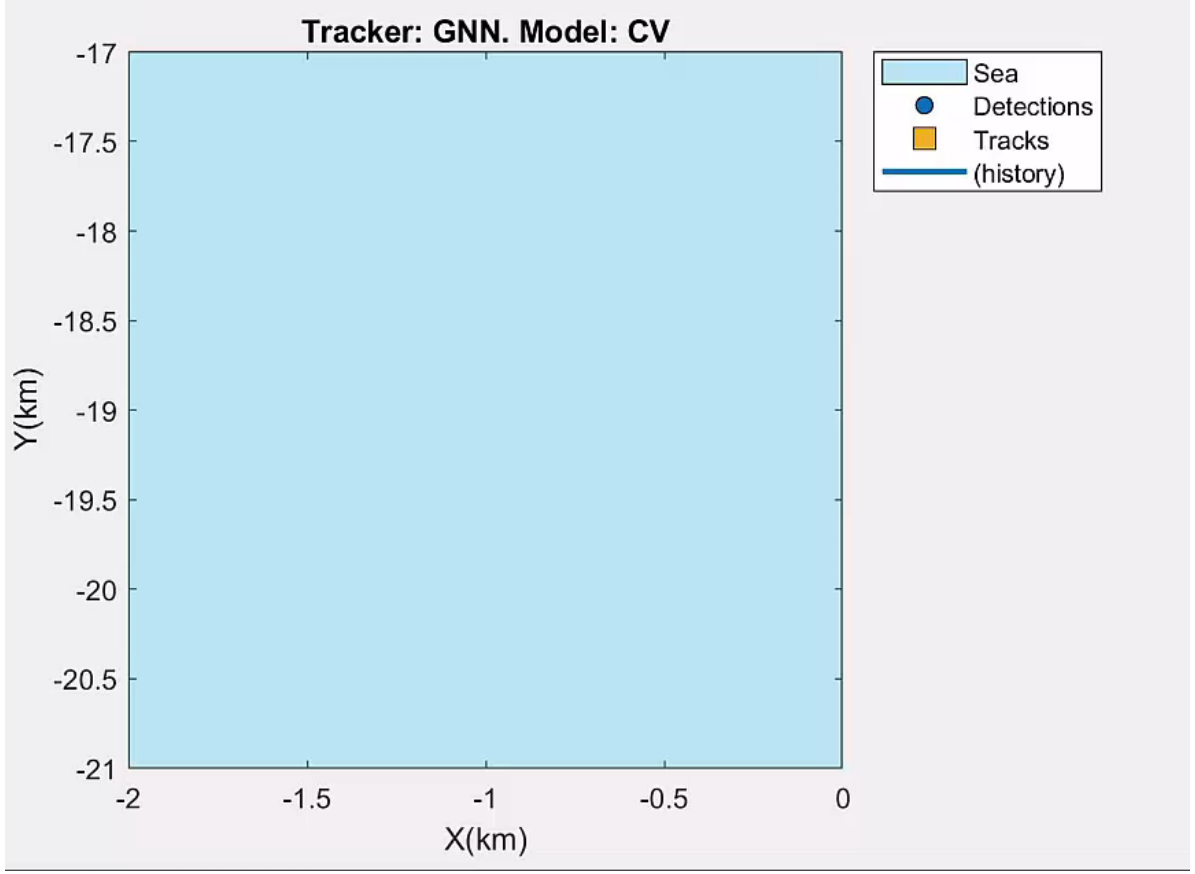


Performing What-If Analysis





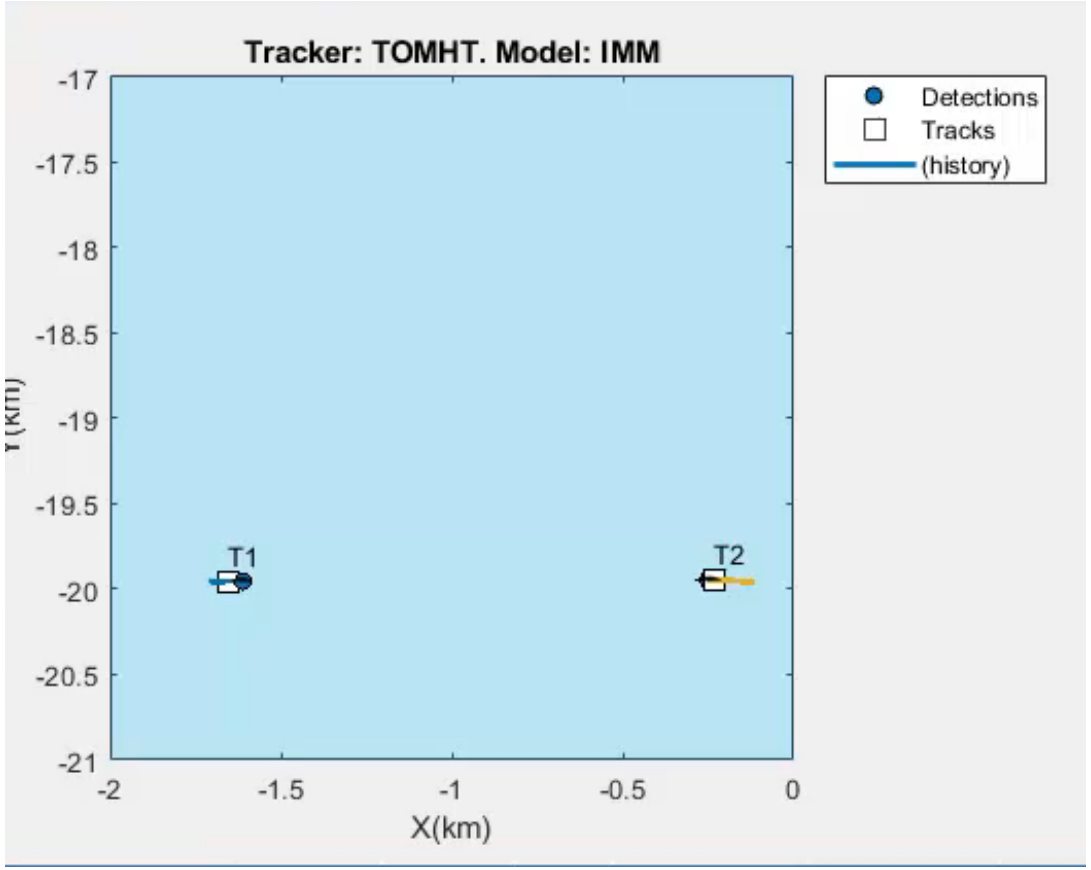
Performing What-If Analysis




```
tracker = trackerGNN( ...
  'FilterInitializationFcn',@initCVFilter,...
  'MaxNumTracks', numTracks, ...
  'MaxNumSensors', 1, ...
  'AssignmentThreshold',gate, ...
  'TrackLogic', 'Score', ...
  'DetectionProbability', pd, ...
  'FalseAlarmRate', far, ...
  'Volume', vol, 'Beta', beta);
```

```
tracker = trackerGNN( ...
  'FilterInitializationFcn',@initIMMFilter,...
  'MaxNumTracks', numTracks, ...
  'MaxNumSensors', 1, ...
  'AssignmentThreshold',gate, ...
  'TrackLogic', 'Score', ...
  'DetectionProbability', pd, ...
  'FalseAlarmRate', far, ...
  'Volume', vol, 'Beta', beta);
```

Performing What-If Analysis



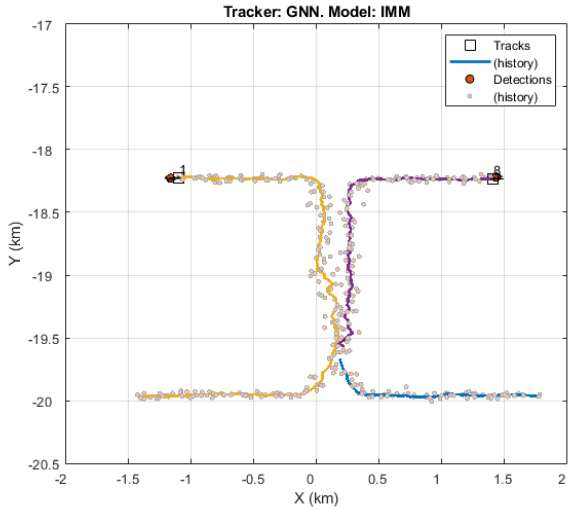

```
tracker = trackerTOMHT( ...
  'FilterInitializationFcn',@initIMMFilter,...
  'MaxNumTracks', numTracks, ...
  'MaxNumSensors', 1, ...
  'AssignmentThreshold',[0.2,1,1]*gate, ...
  'TrackLogic', 'Score', ...
  'DetectionProbability', pd, ...
  'FalseAlarmRate', far, ...
  'Volume', vol, 'Beta', beta, ...
  'MaxNumHistoryScans', 10, ...
  'MaxNumTrackBranches', 5,...
  'NScanPruning', 'Hypothesis', ...
  'OutputRepresentation', 'Tracks');
```

Comparing Trackers and Tracking Filters

False track
Dropped track

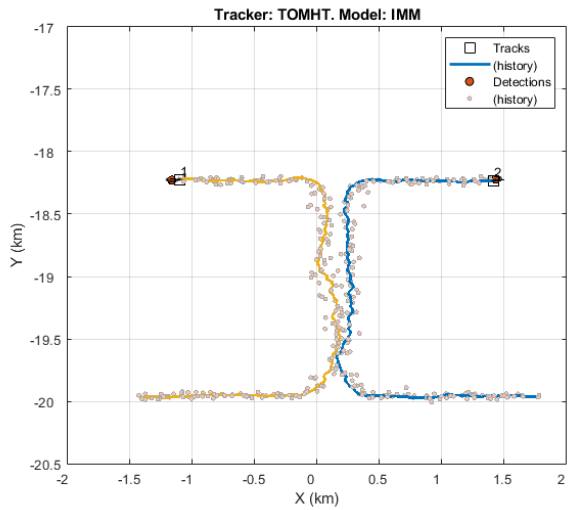
TrackID	AssignedTruthID	Surviving	TotalLength	DivergenceStatus
1	2	true	190	false
2	NaN	false	77	true
8	3	true	111	false

TruthID	AssociatedTrackID	TotalLength	BreakCount	EstablishmentLength
2	1	192	0	4
3	8	192	1	2



TrackID	AssignedTruthID	Surviving	TotalLength	DivergenceStatus
1	2	true	190	false
2	3	true	191	false

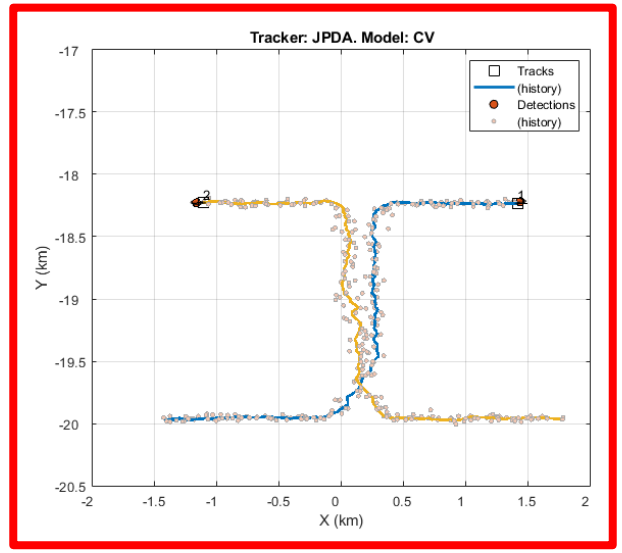
TruthID	AssociatedTrackID	TotalLength	BreakCount	EstablishmentLength
2	1	192	0	2
3	2	192	0	2



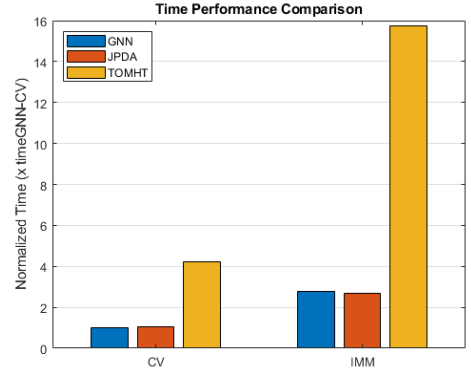
Slower

TrackID	AssignedTruthID	Surviving	TotalLength	DivergenceStatus
1	2	true	191	false
2	3	true	191	false

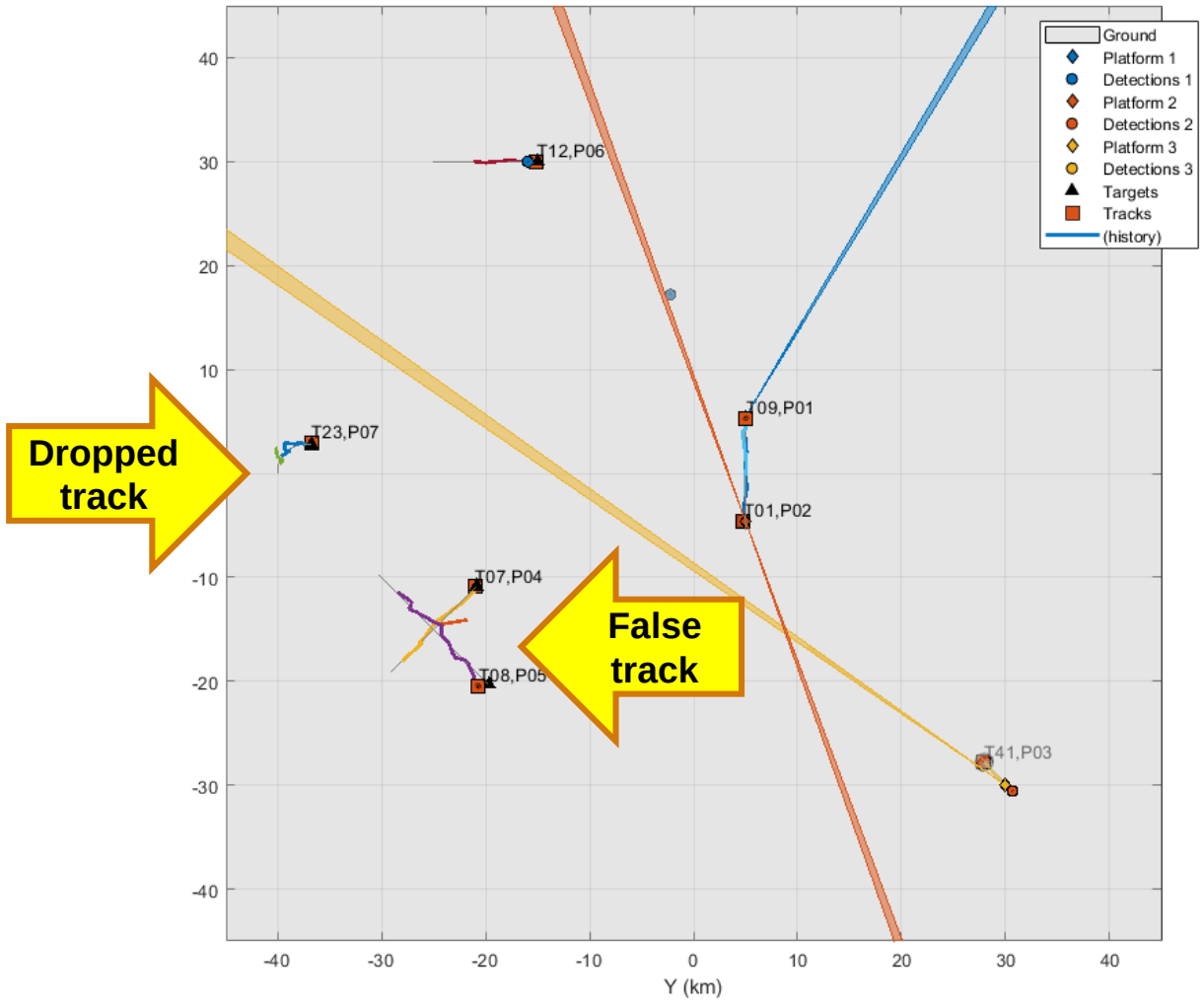
TruthID	AssociatedTrackID	TotalLength	BreakCount	EstablishmentLength
2	1	192	0	1
3	2	192	0	2

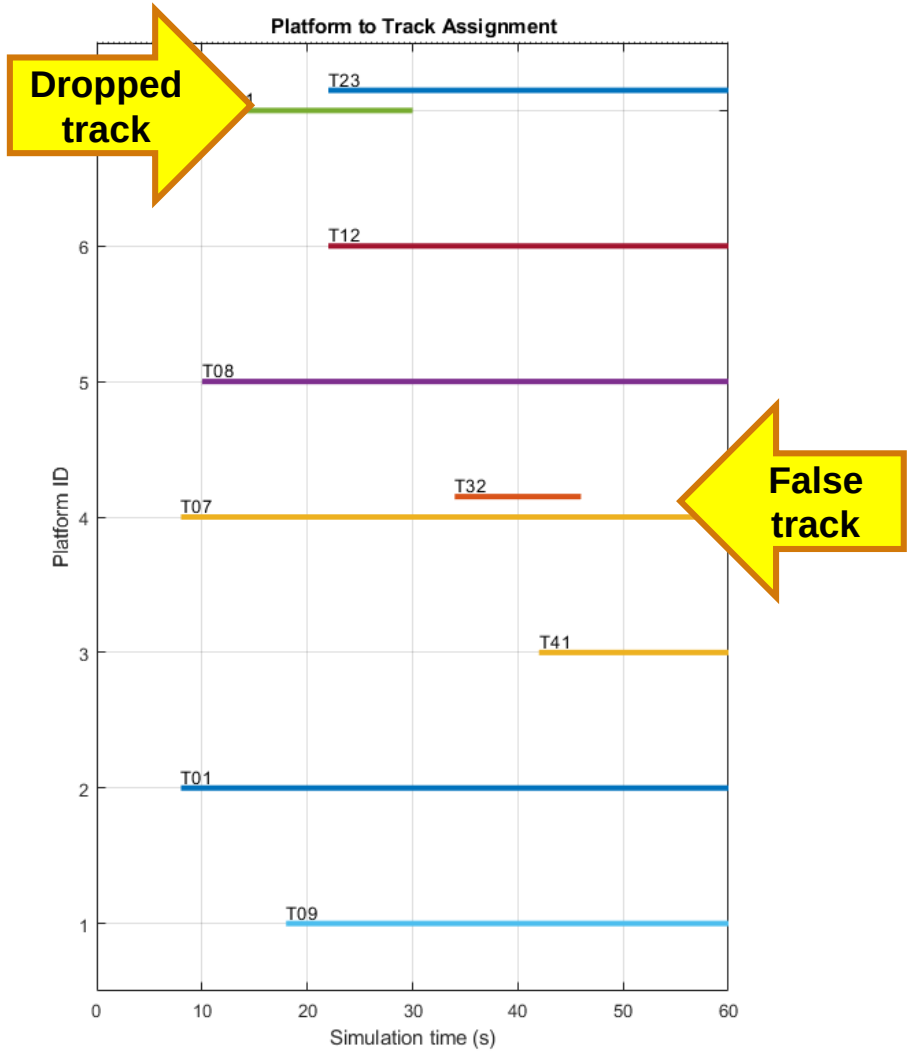


Faster



Tune and Compare Trackers with Assignment Metrics

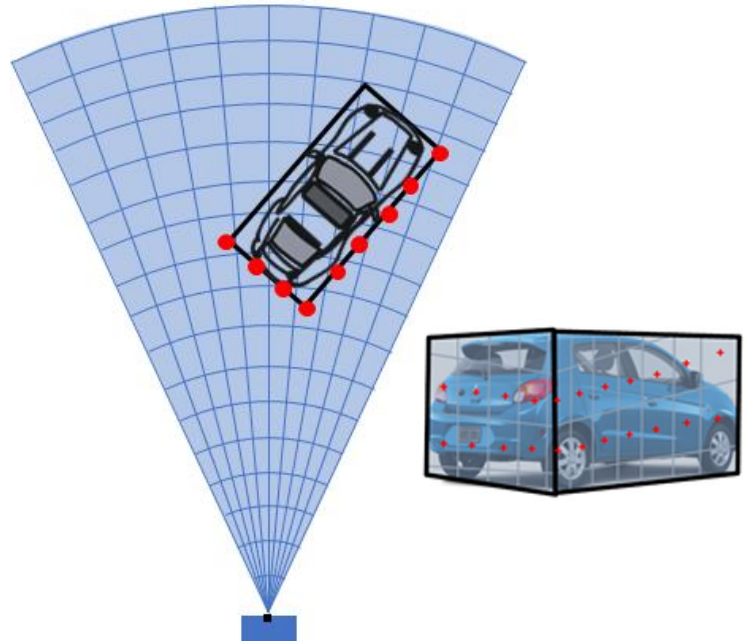




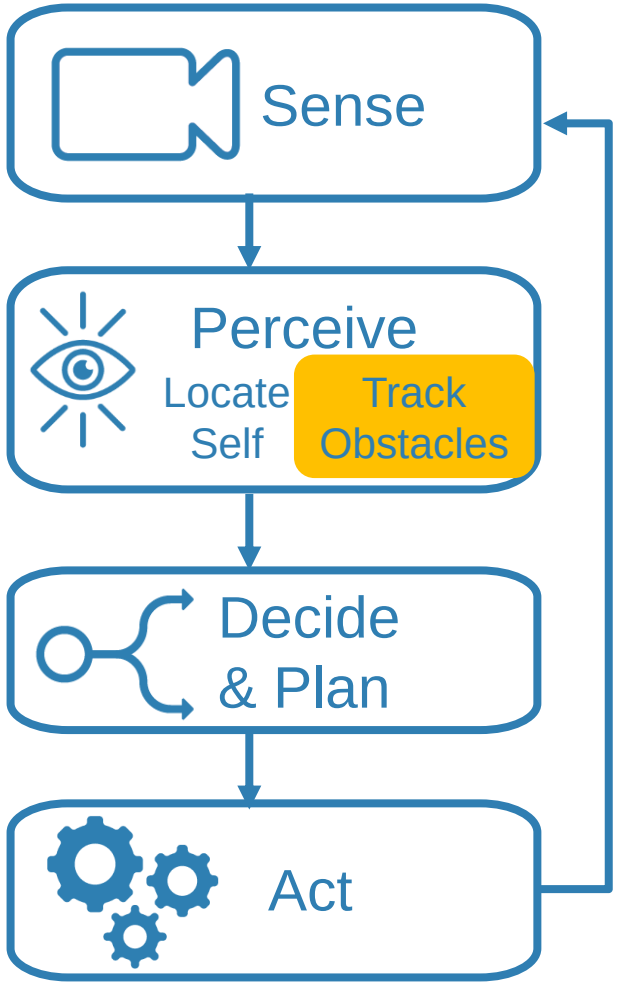
Point object vs. Extended object

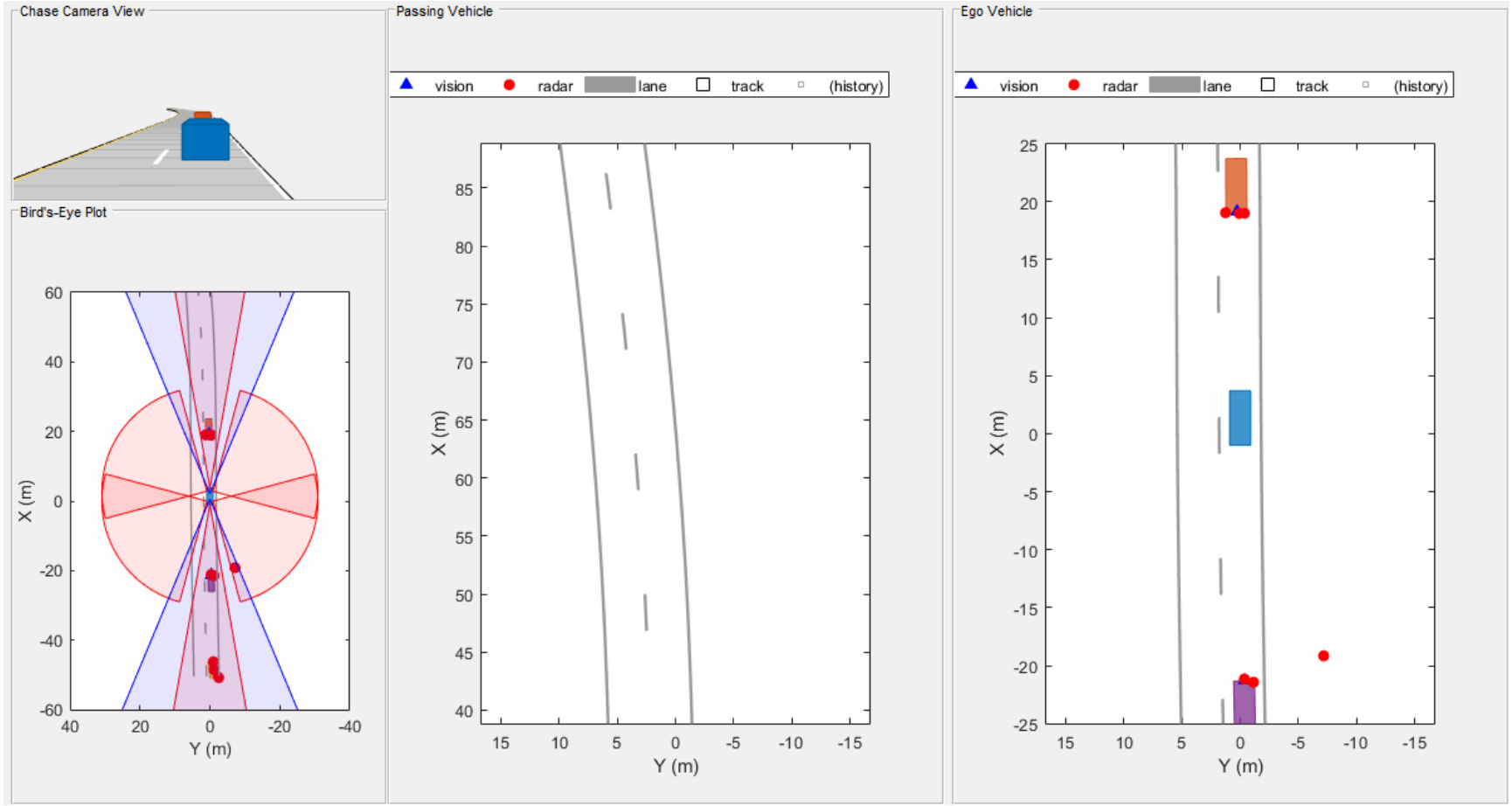
- **Point object**
  - Distant object represented as a single point
  - One detection per object per scan

- **Extended object**
  - High resolution sensors generate multiple detections per object per scan

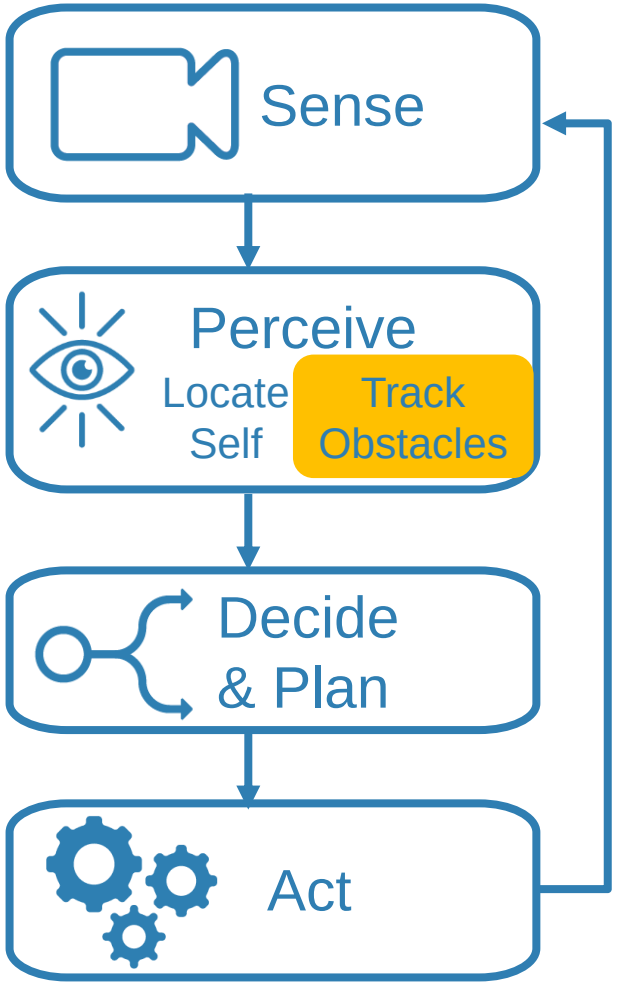


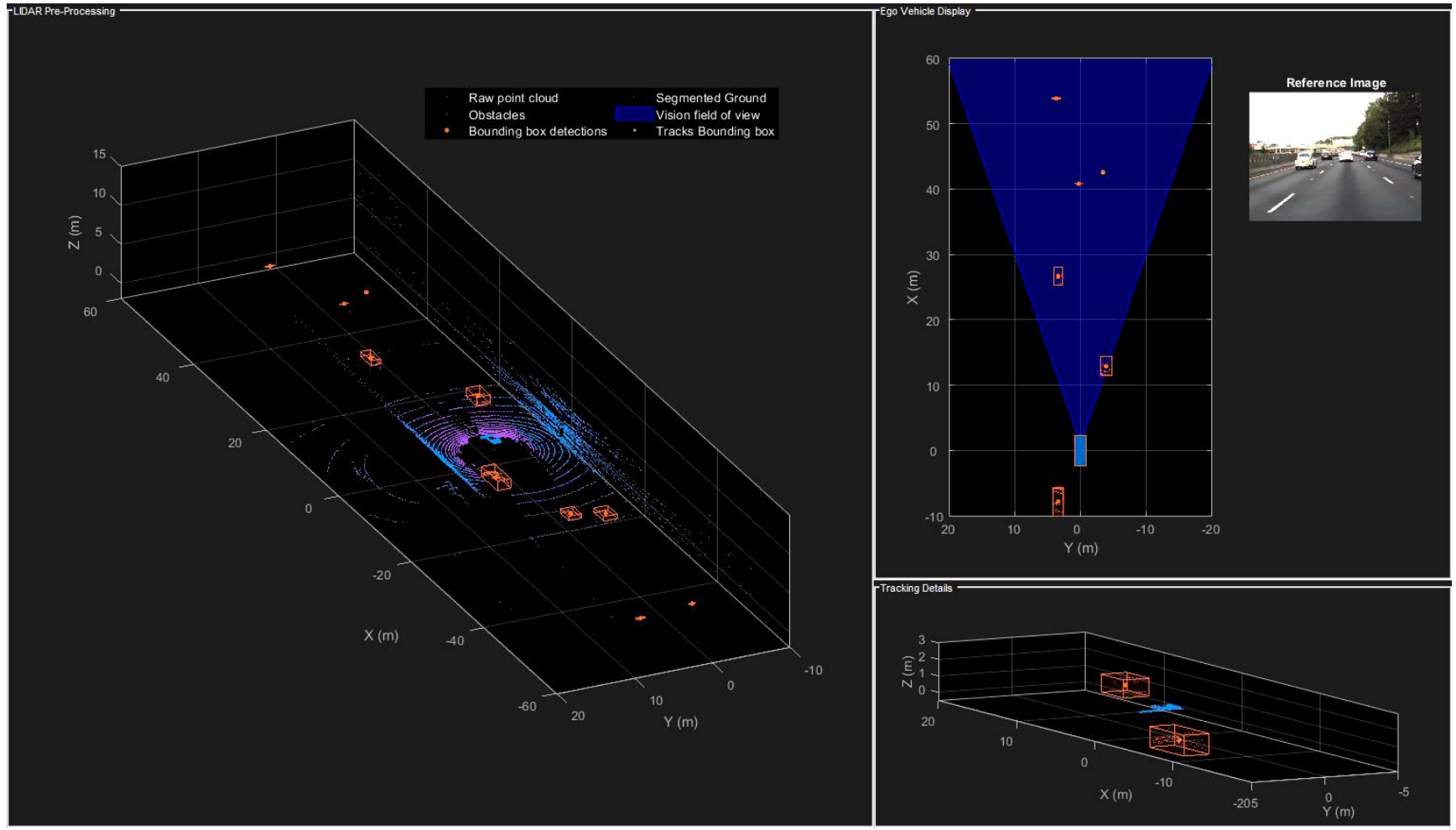
Extended Object Tracking



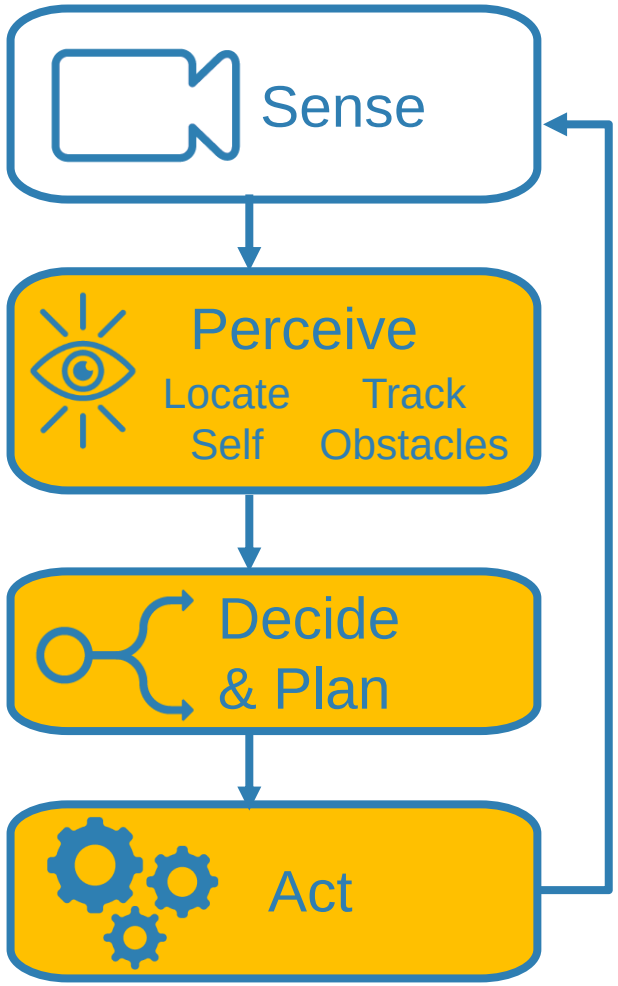


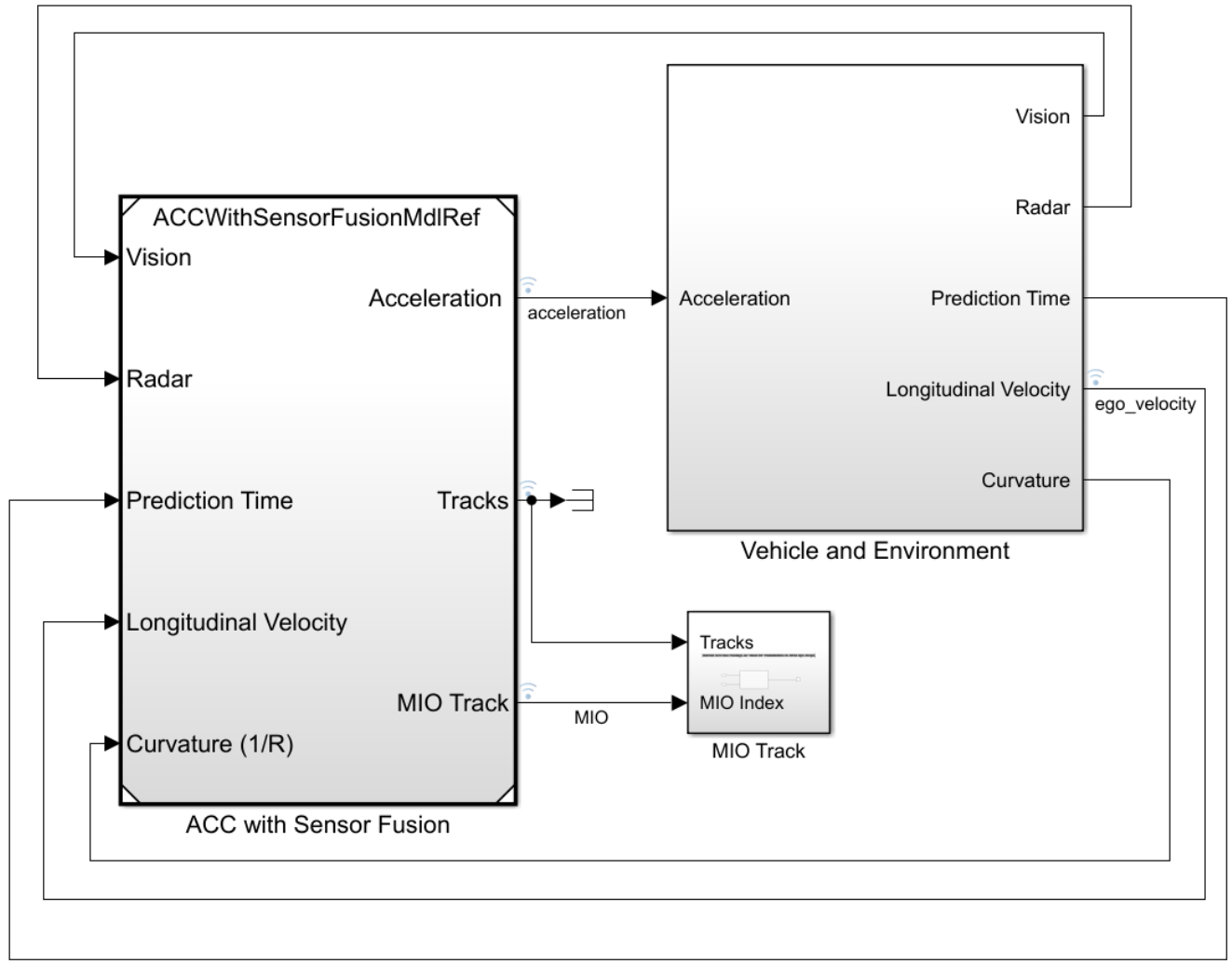
Tracking with Lidar



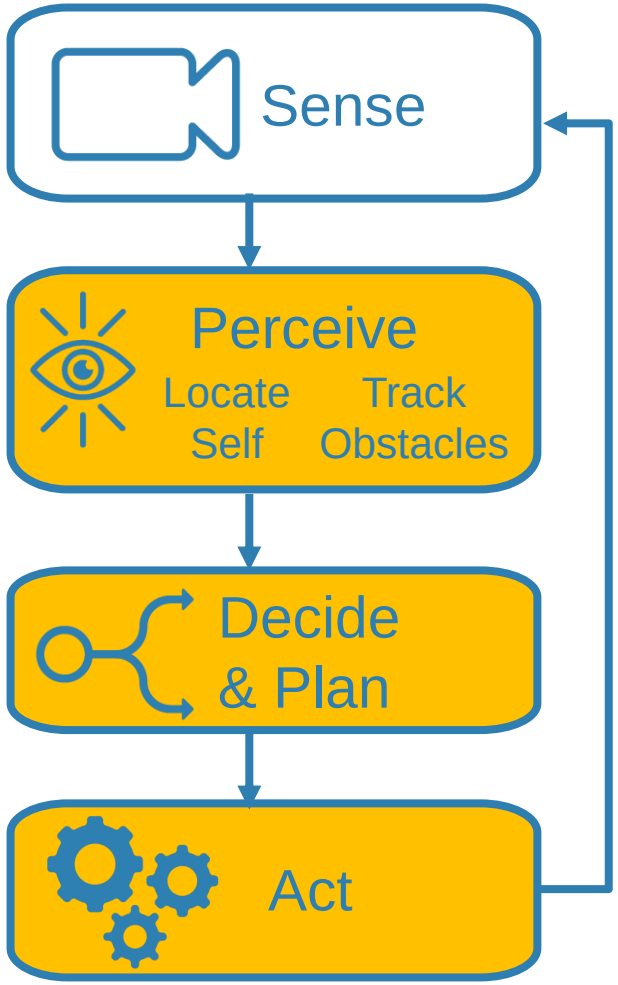


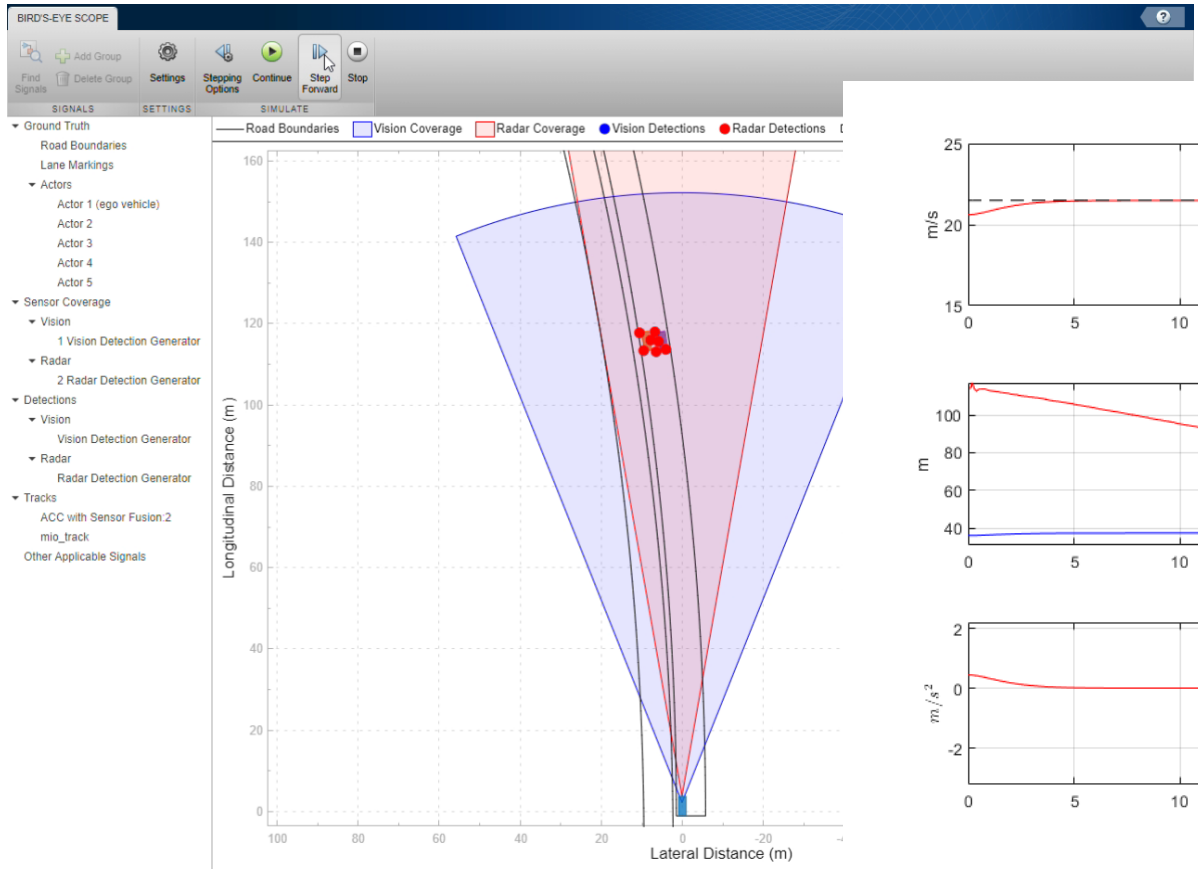
Connect to Decision Making / Control: ACC Demo

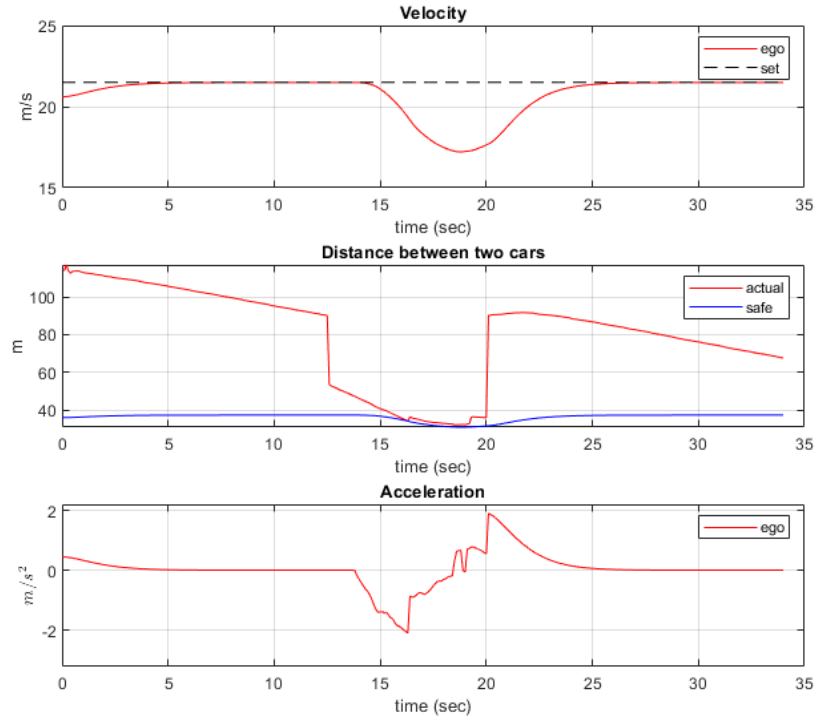




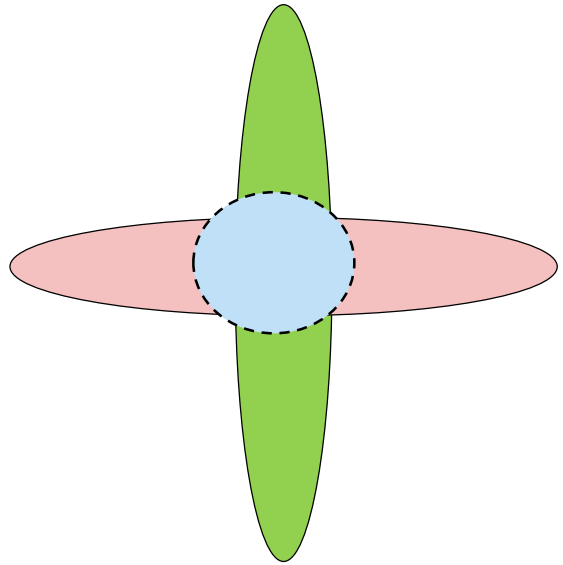
Connect to Decision Making / Control: ACC Demo

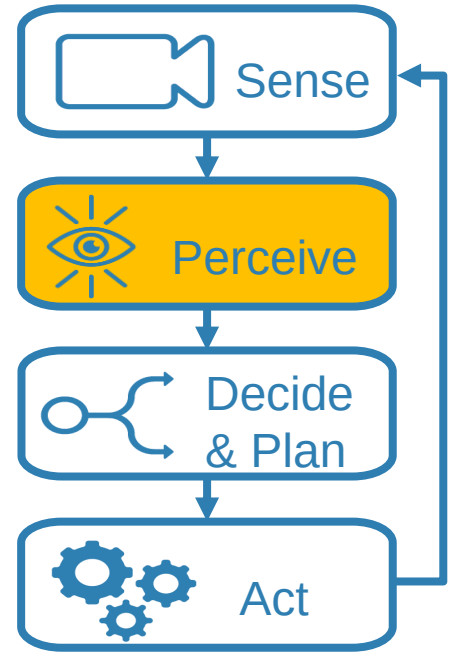






Sensor Fusion and Tracking …





Is Ubiquitous

Leverages Sensor Strengths

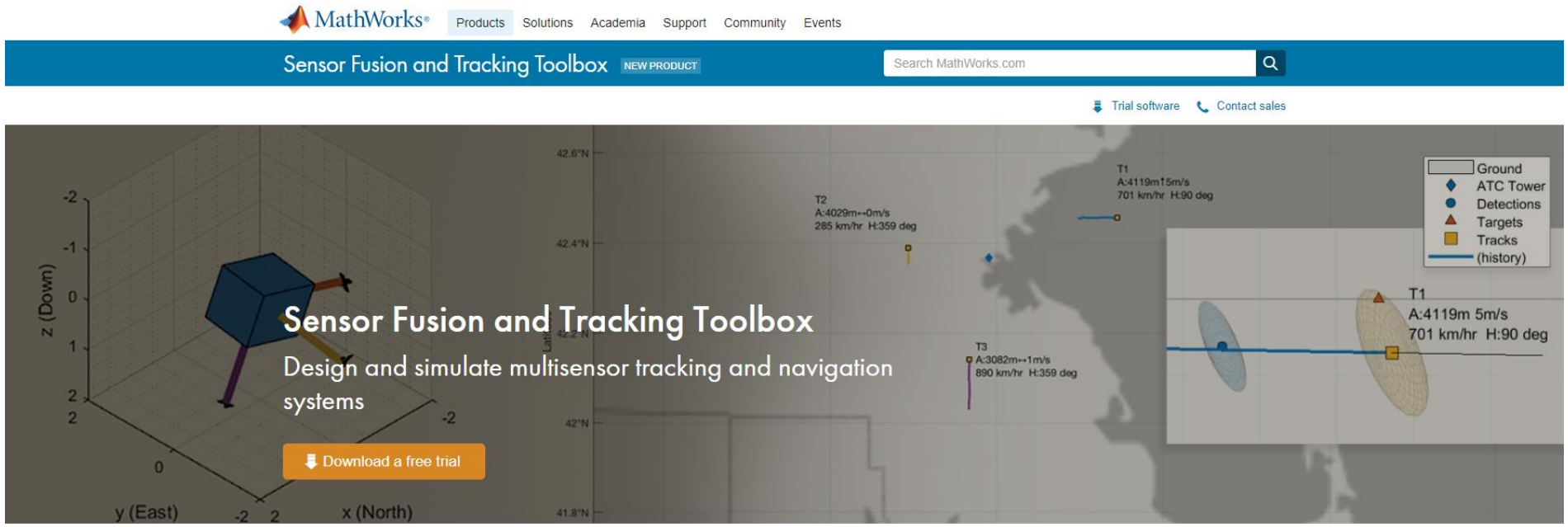
Enables Autonomy

Learn More

Sensor Fusion and Tracking Toolbox NEW PRODUCT

Automated Driving Toolbox MAJOR UPDATE

- Please visit our Technology Showcase for more details on the workflows



https://www.mathworks.com/products/sensor-fusion-and-tracking.html