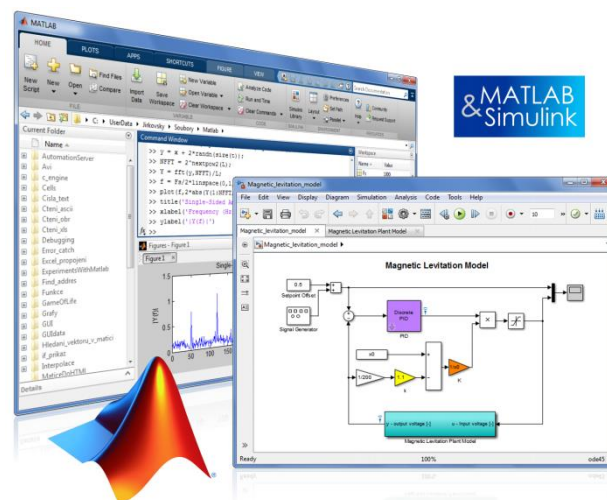


5.9.2018 Brno

## TCC 2019

# Senzorická fúzia ako nástroj pre spoľahlivejšie navigačné systémy



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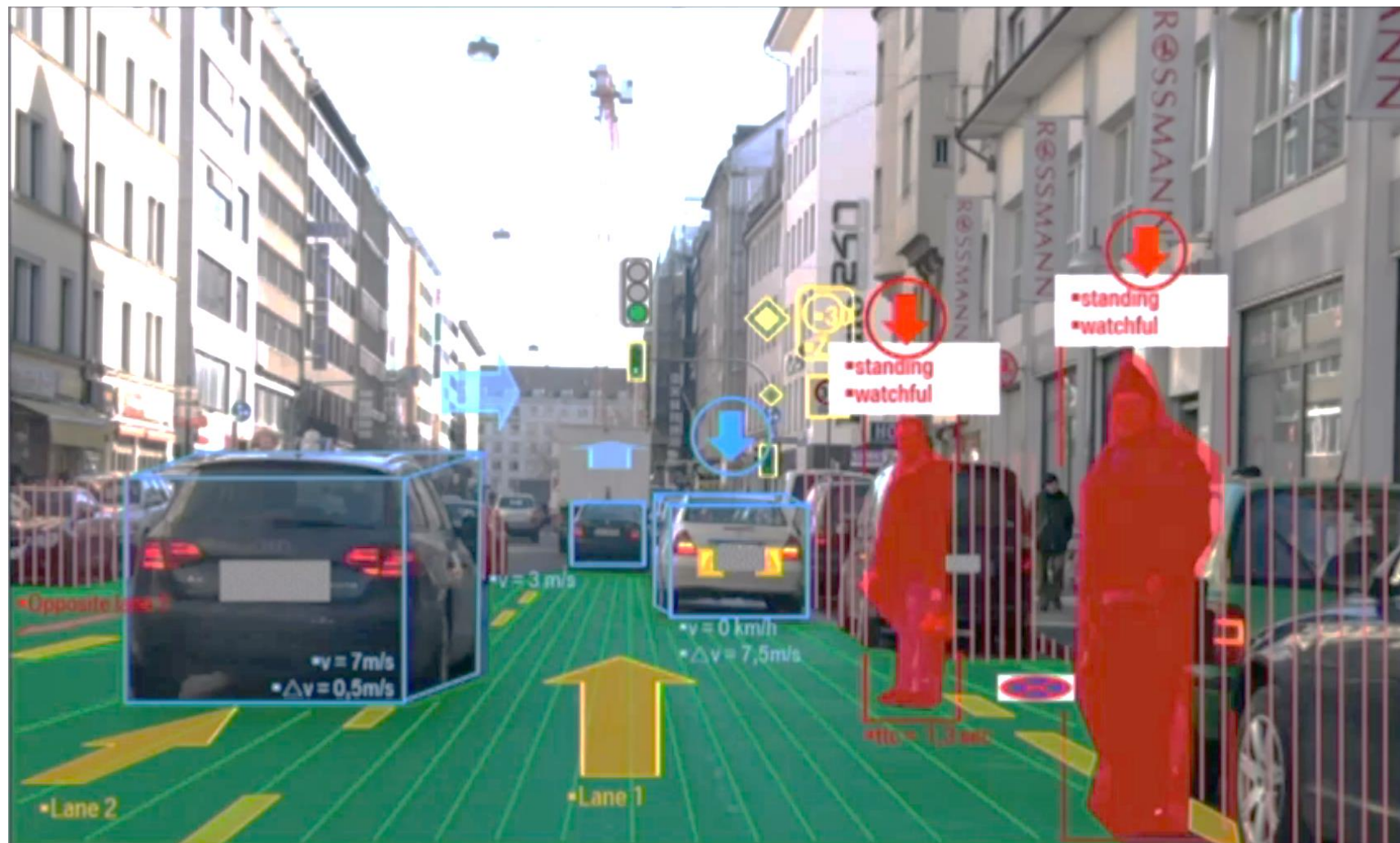
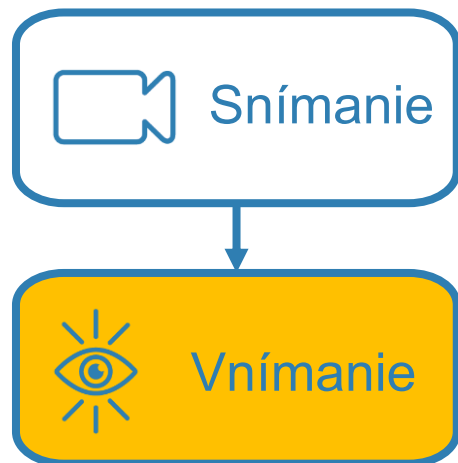
# Autonómne systémy



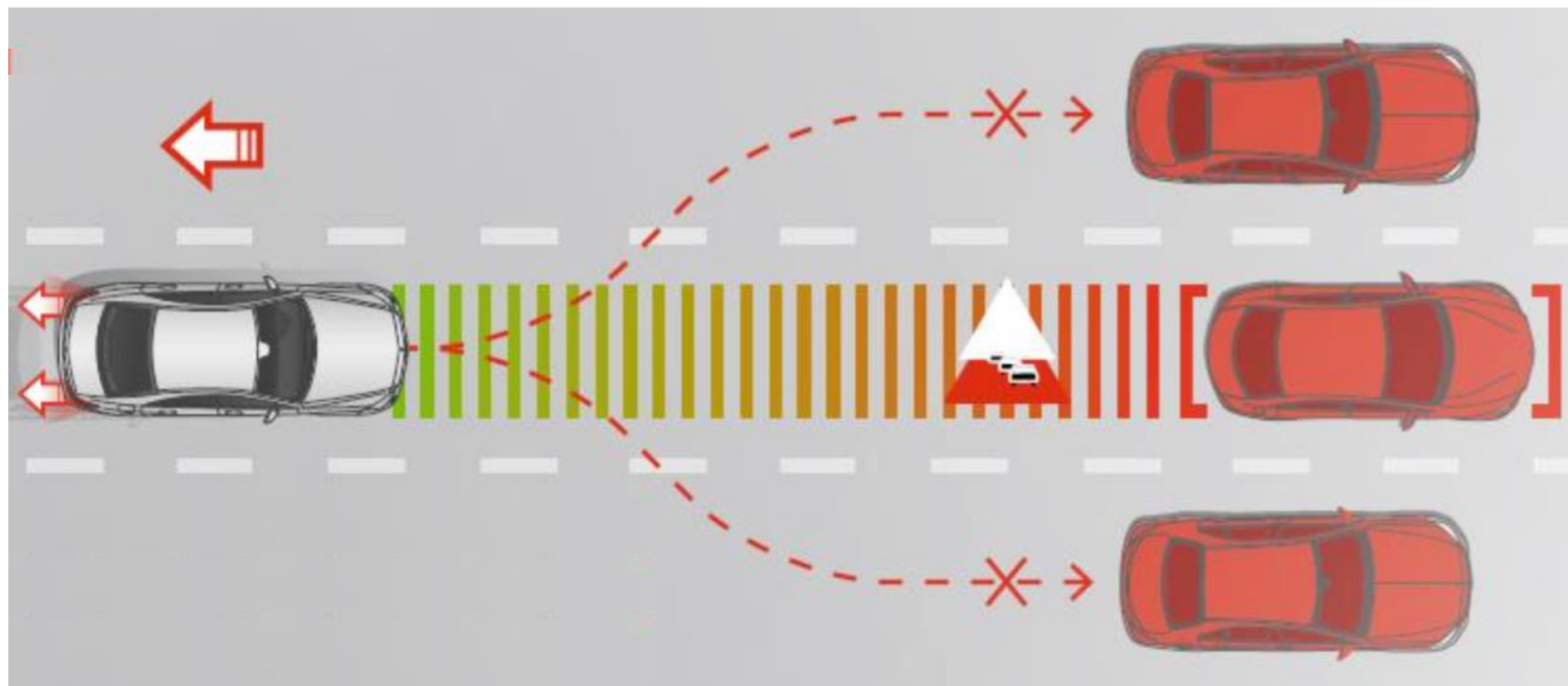
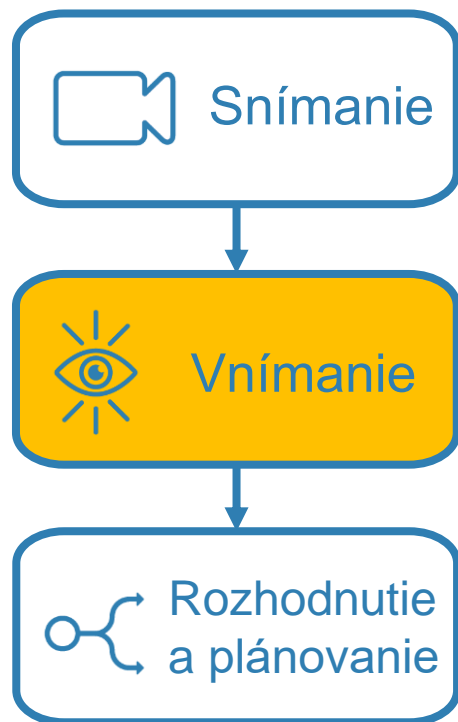
Snímanie



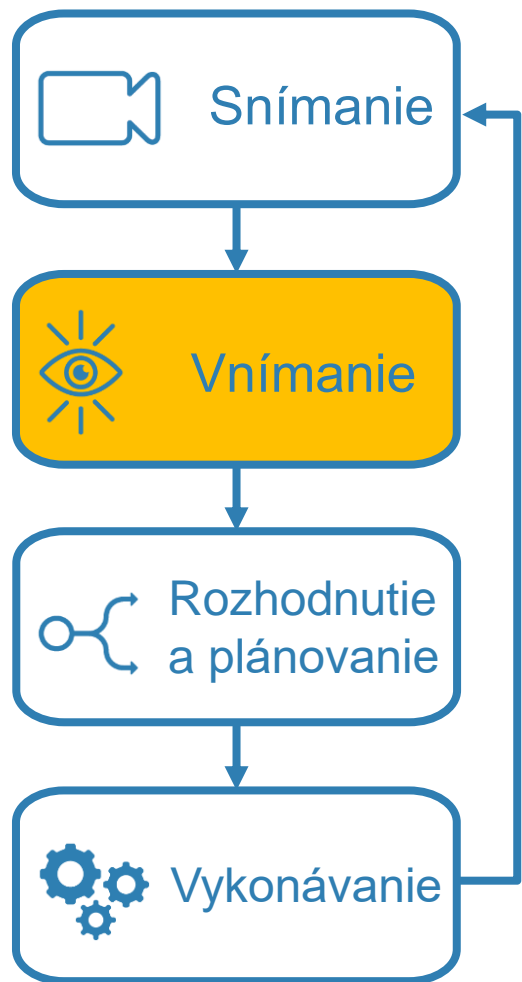
# Autonómne systémy



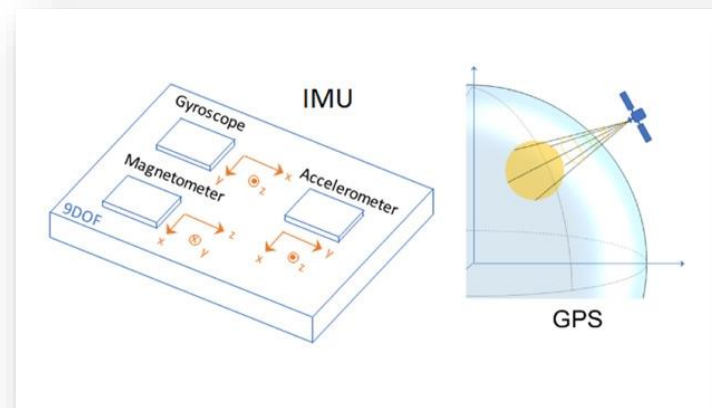
# Autonómne systémy



# Autonómne systémy

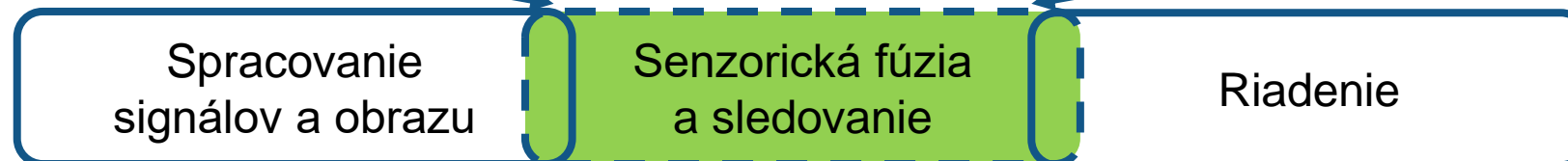


# Senzorická fúzia a sledovanie



Akcelerometer, Magnetometer, Gyroskop, GPS...

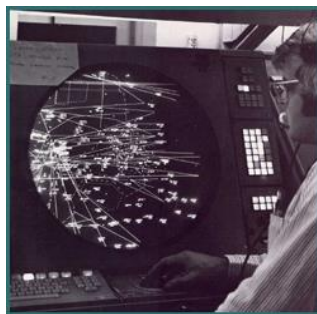
Radar, Kamera, IR, Sonar, Lidar, ...



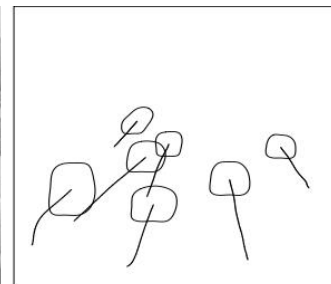
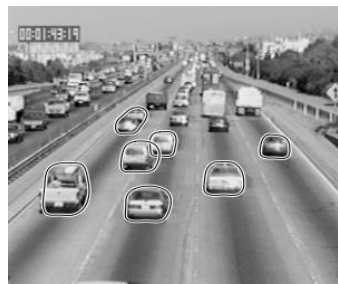
Sensor Fusion and Tracking Toolbox NEW PRODUCT

# Technologický pokrok

## Sledovanie objektov



Letecká prevádzka

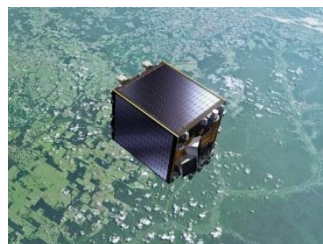


Počítačové videnie v doprave

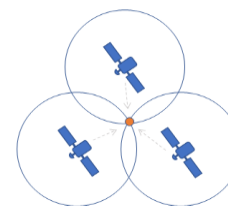


Senzorická fúzia pre autonómne systémy

## Lokalizácia



Armáda



Priemysel

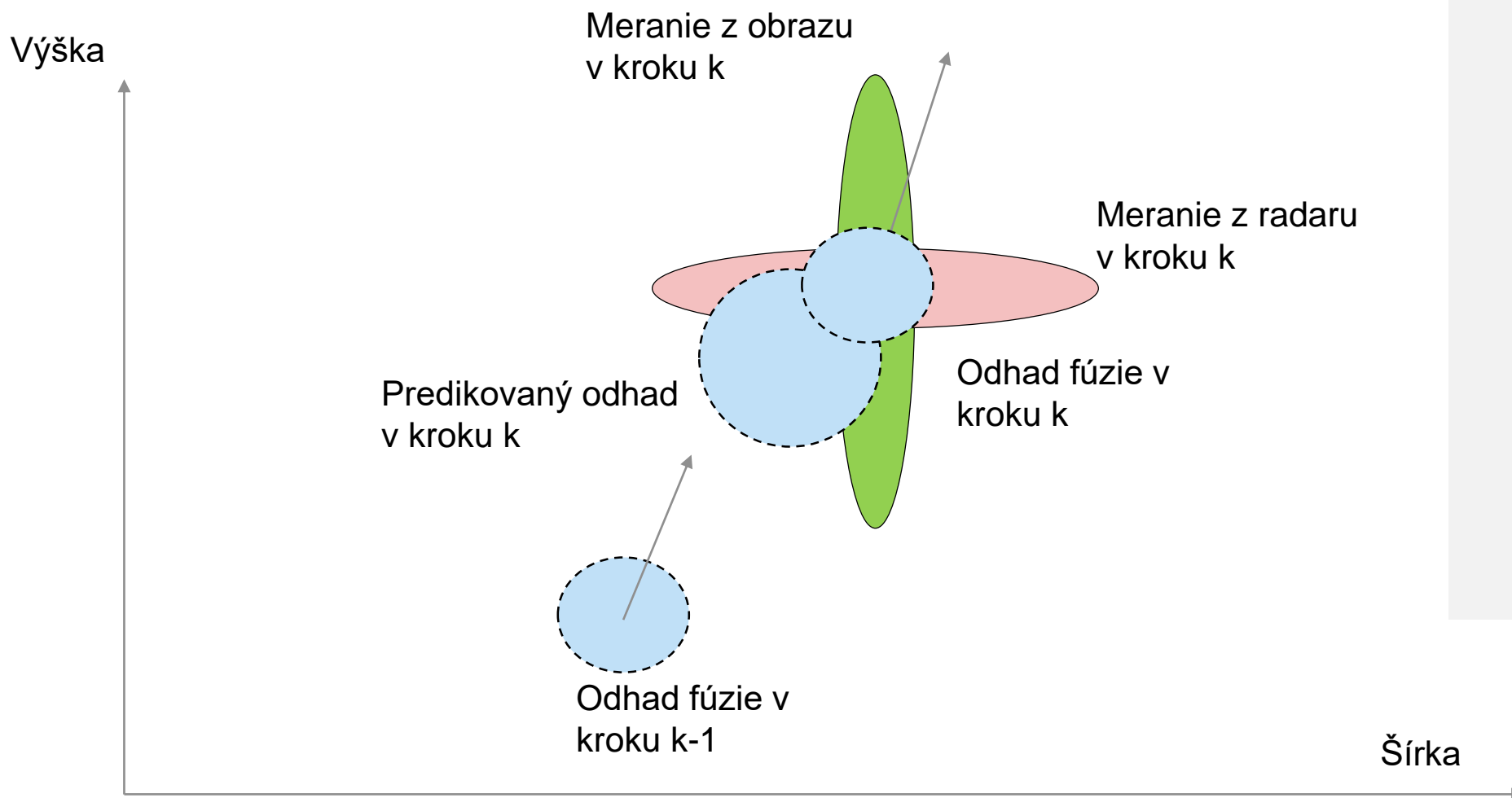


Zariadenia

Dnes

Čas

# Fúzia kombinuje silu každého senzora



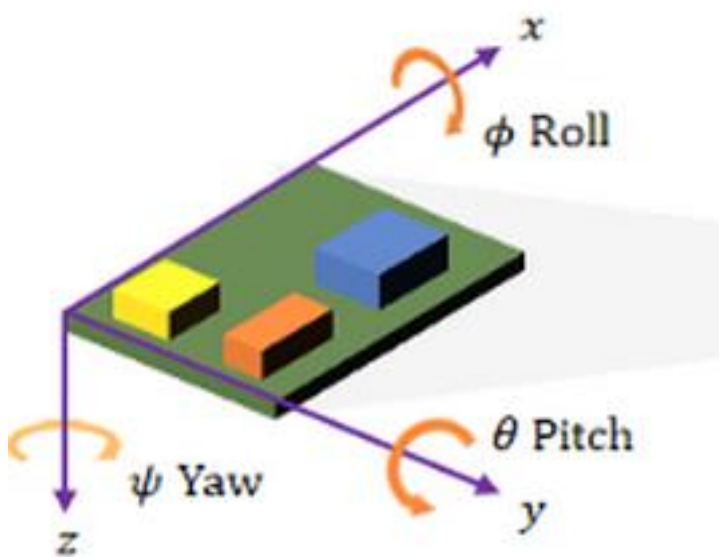
## Popis

-  Meranie z obrazu
-  Meranie z radaru
-  Track (odhad fúzie)

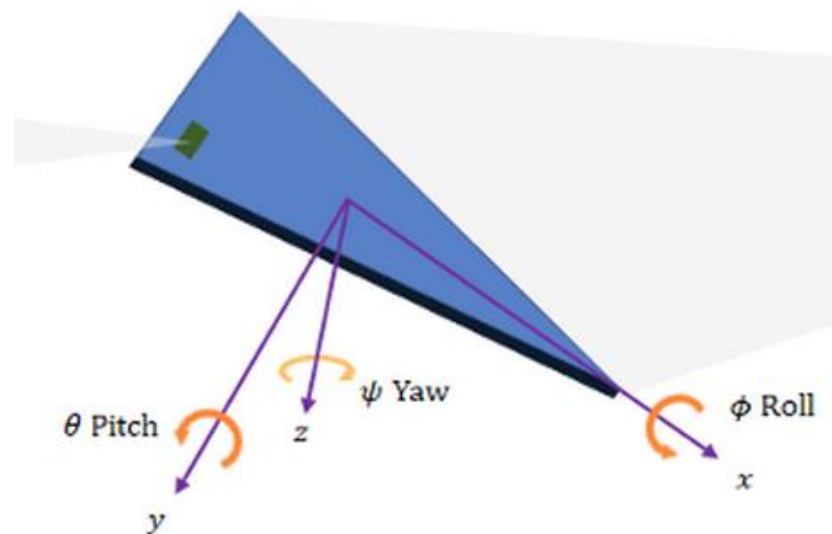
Elipsa reprezentuje neurčitosti



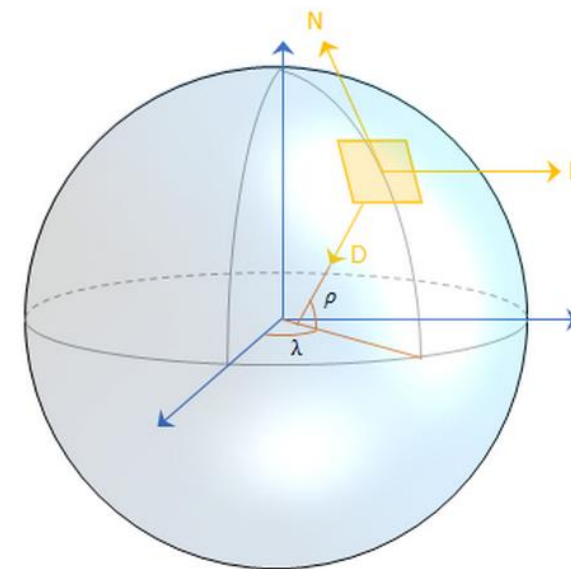
# Lokalizácia autonómnych systémov



Inerciálny senzor



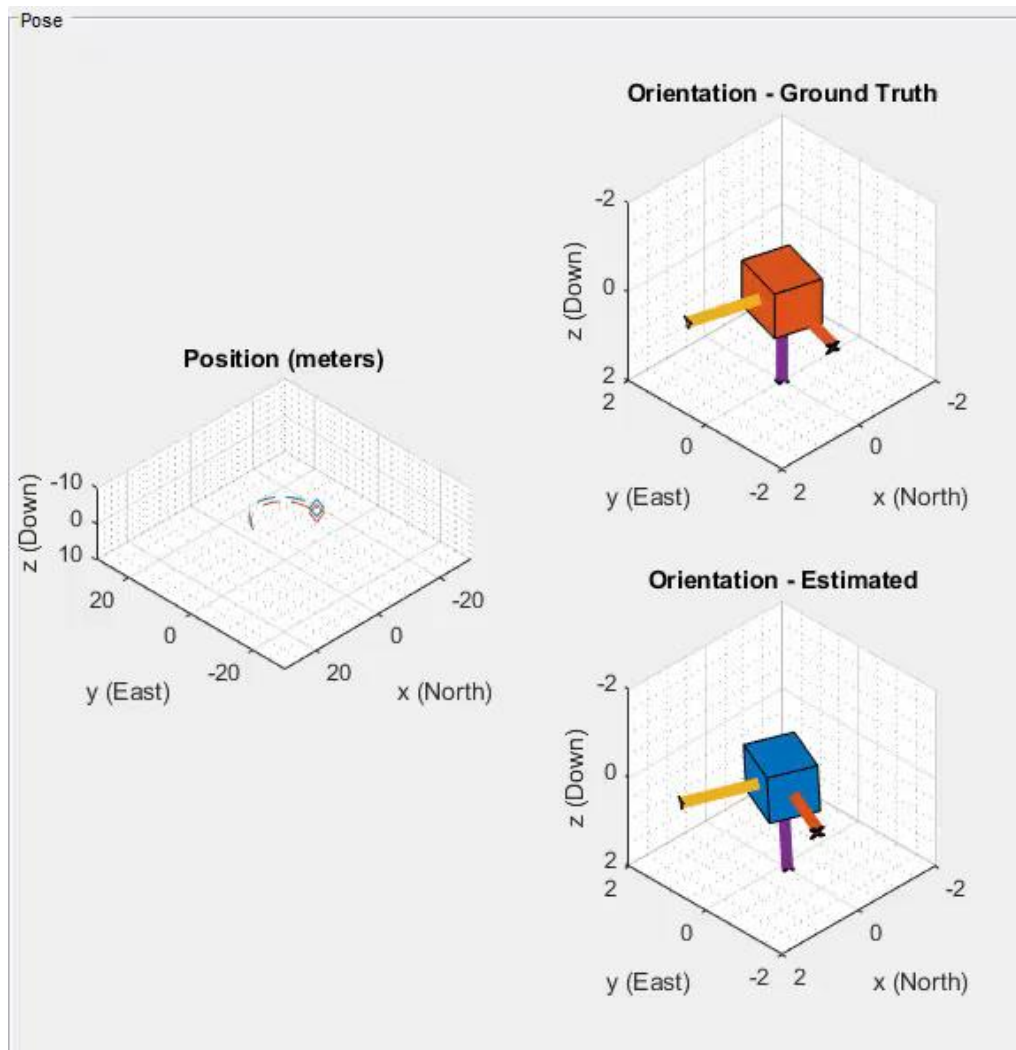
Uchytenie



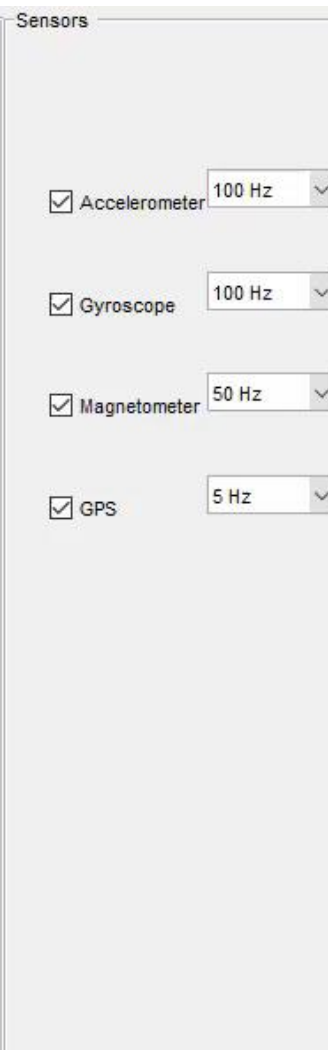
Poloha

# Senzorická fúzia vylepšuje lokalizáciu

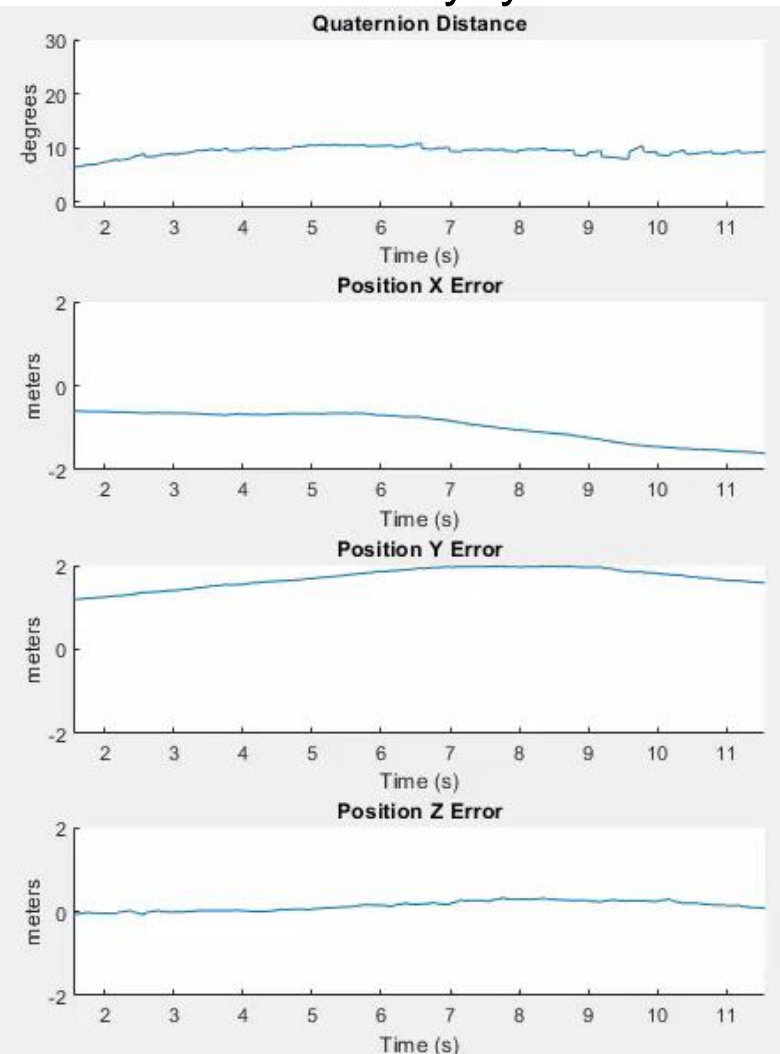
Skutočnosť vs. Odhad



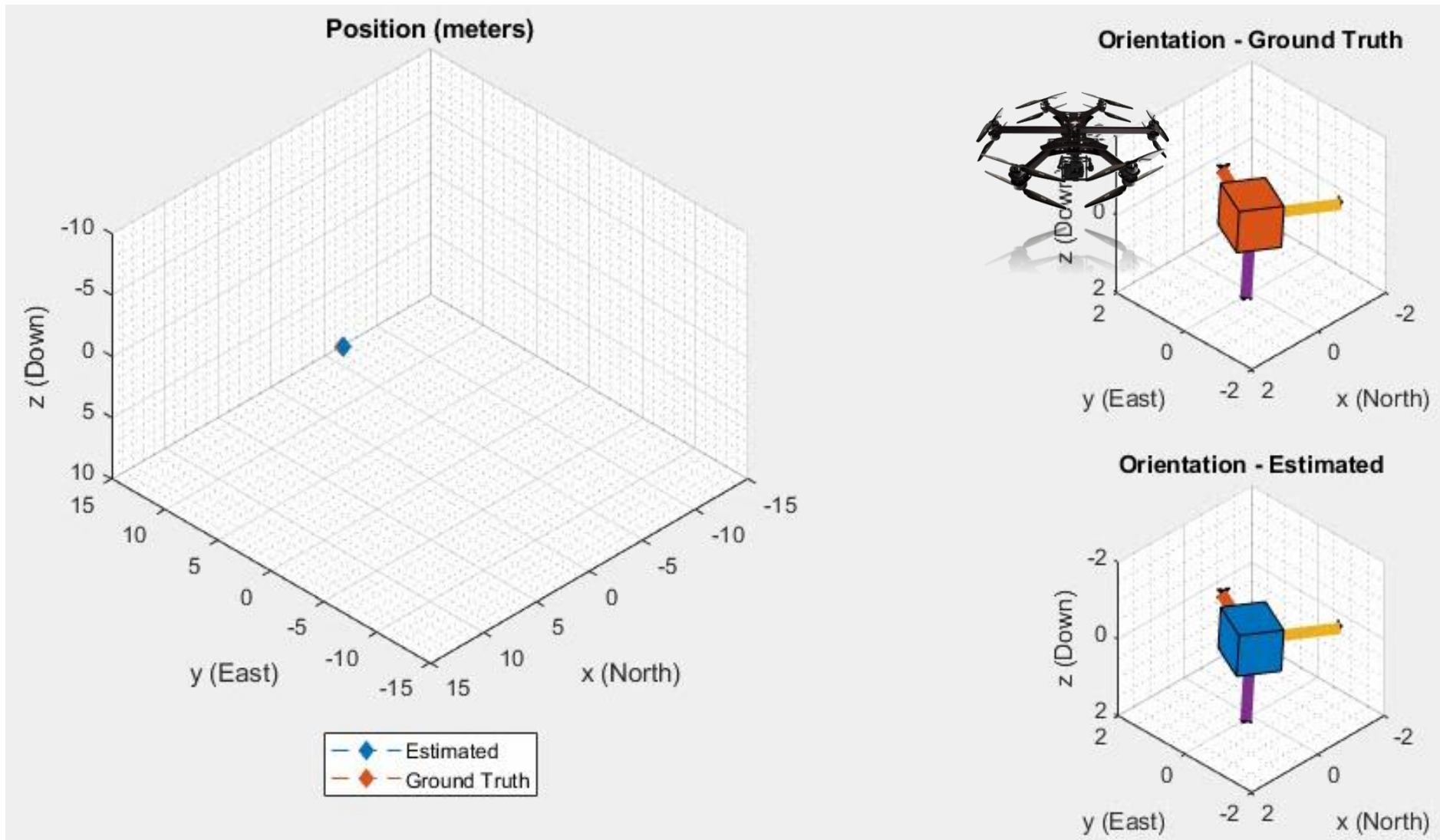
Snímače



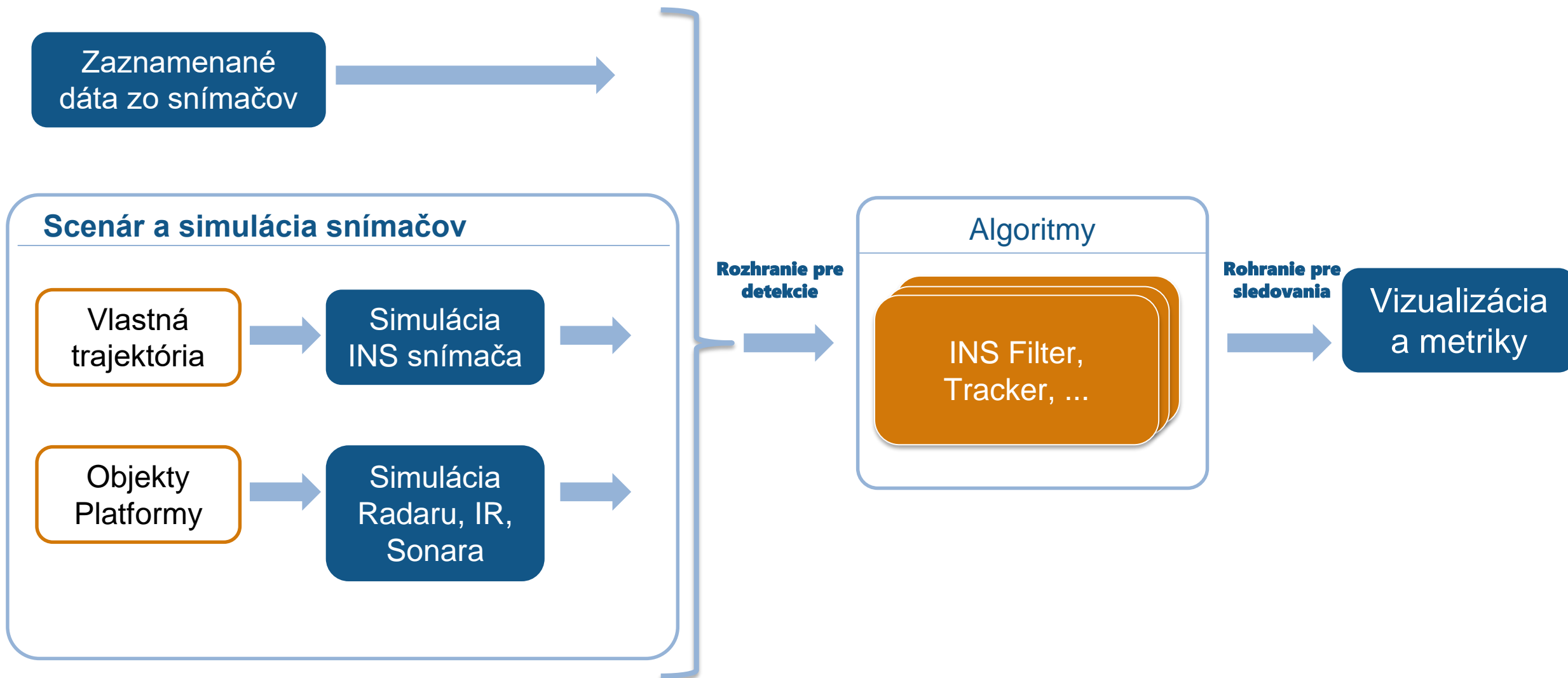
Merania chyby



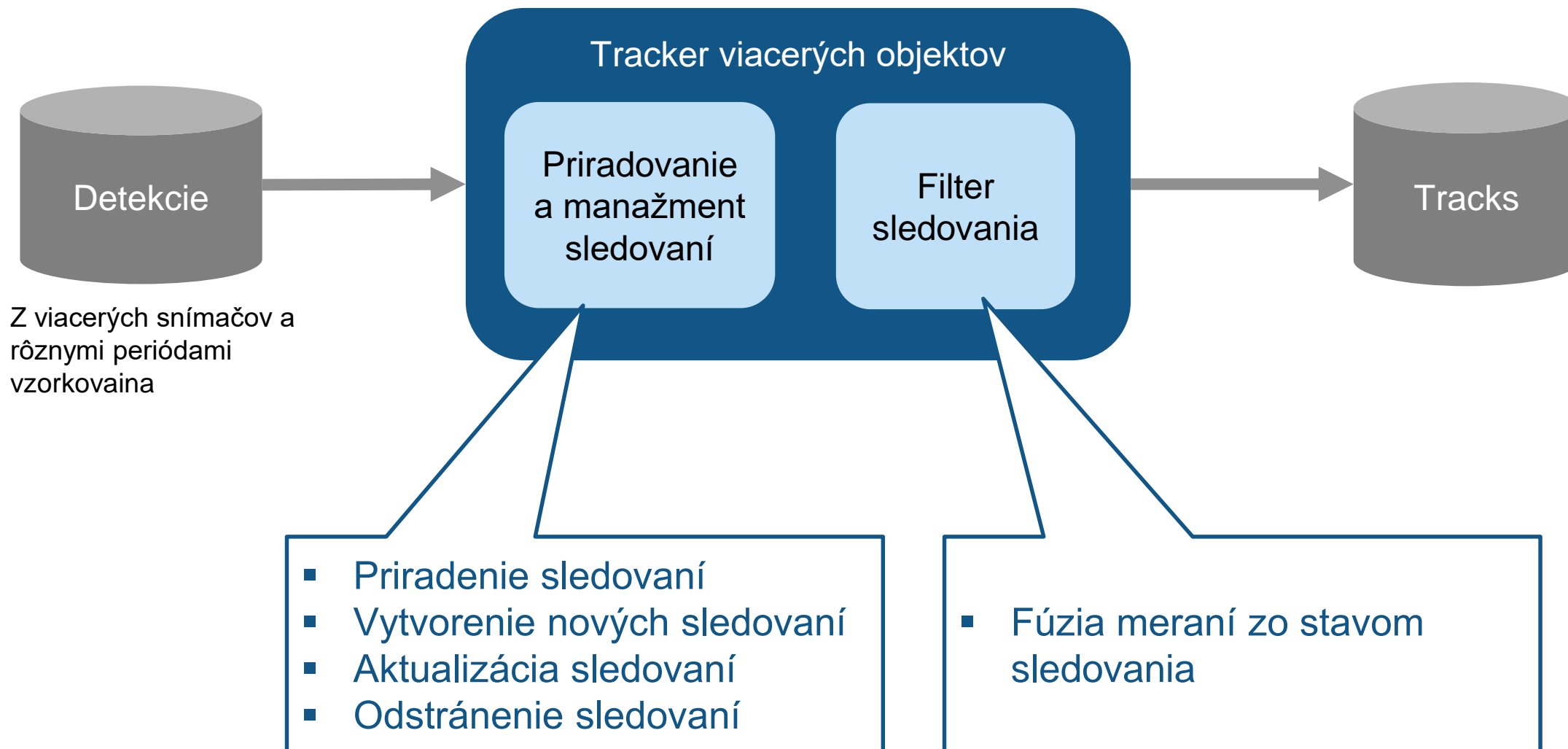
# Fúzia IMU a GPS pre lokalizáciu UAV



# Jednoduché pracovné postupy



# Štruktúra Multi-object Trackera (viac ako Kalmanov filter)

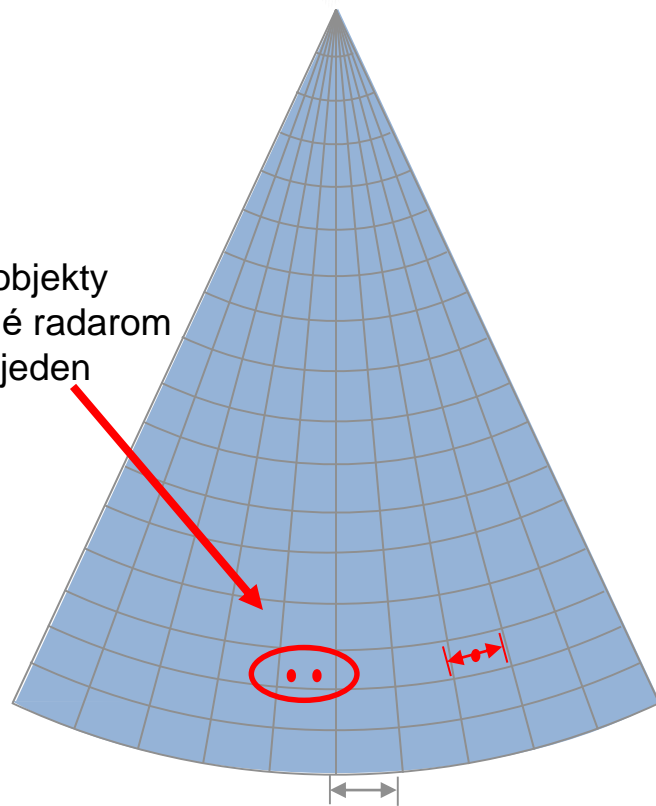


# Analýza (what-if)

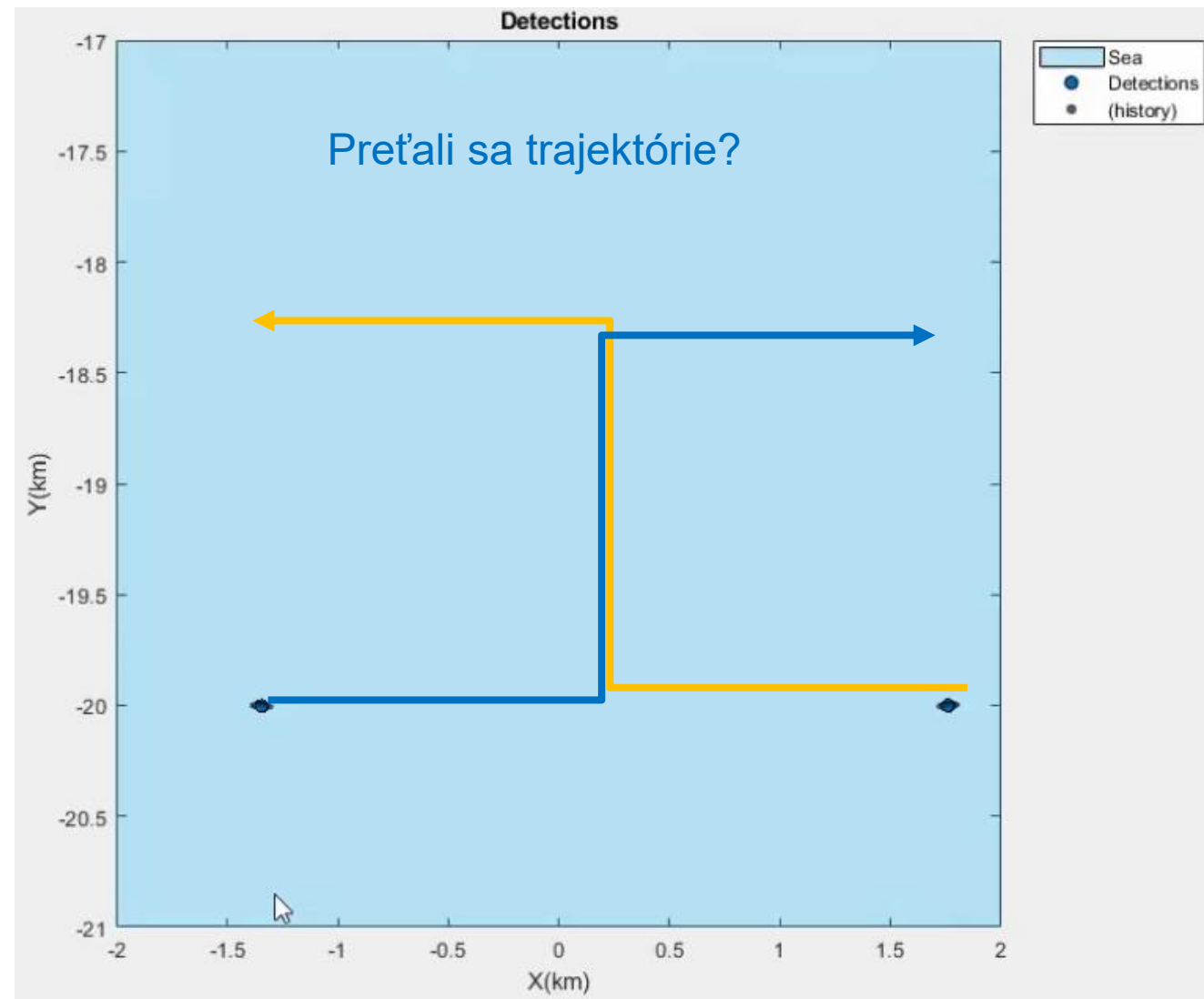


Dva objekty  
rozoznané radarom  
ako jeden

$\pm 270\text{m}$   
pri  $30\text{km}$



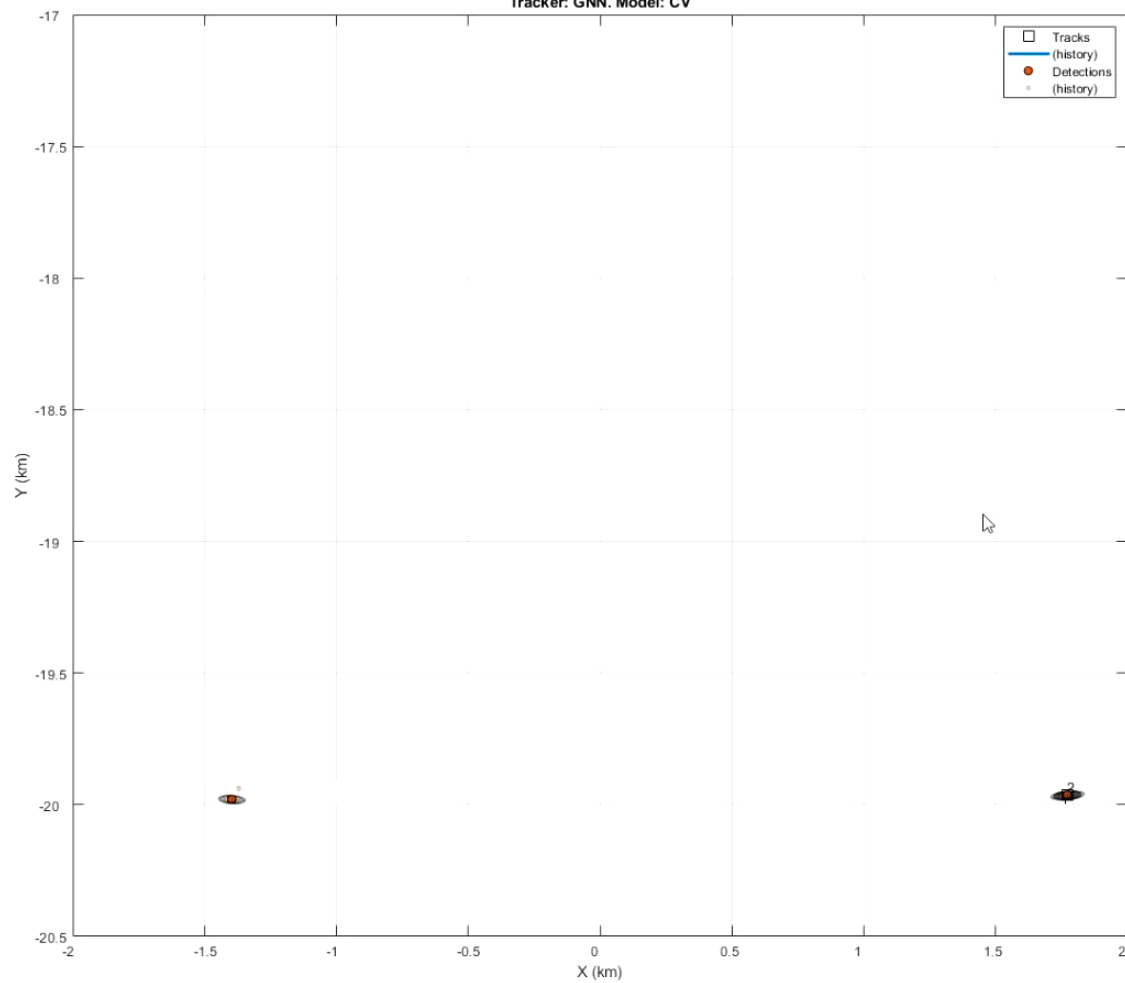
$1^\circ$  Azimuth  
rozlíšenie



# Analýza: rovnaký tracker, rôzny model

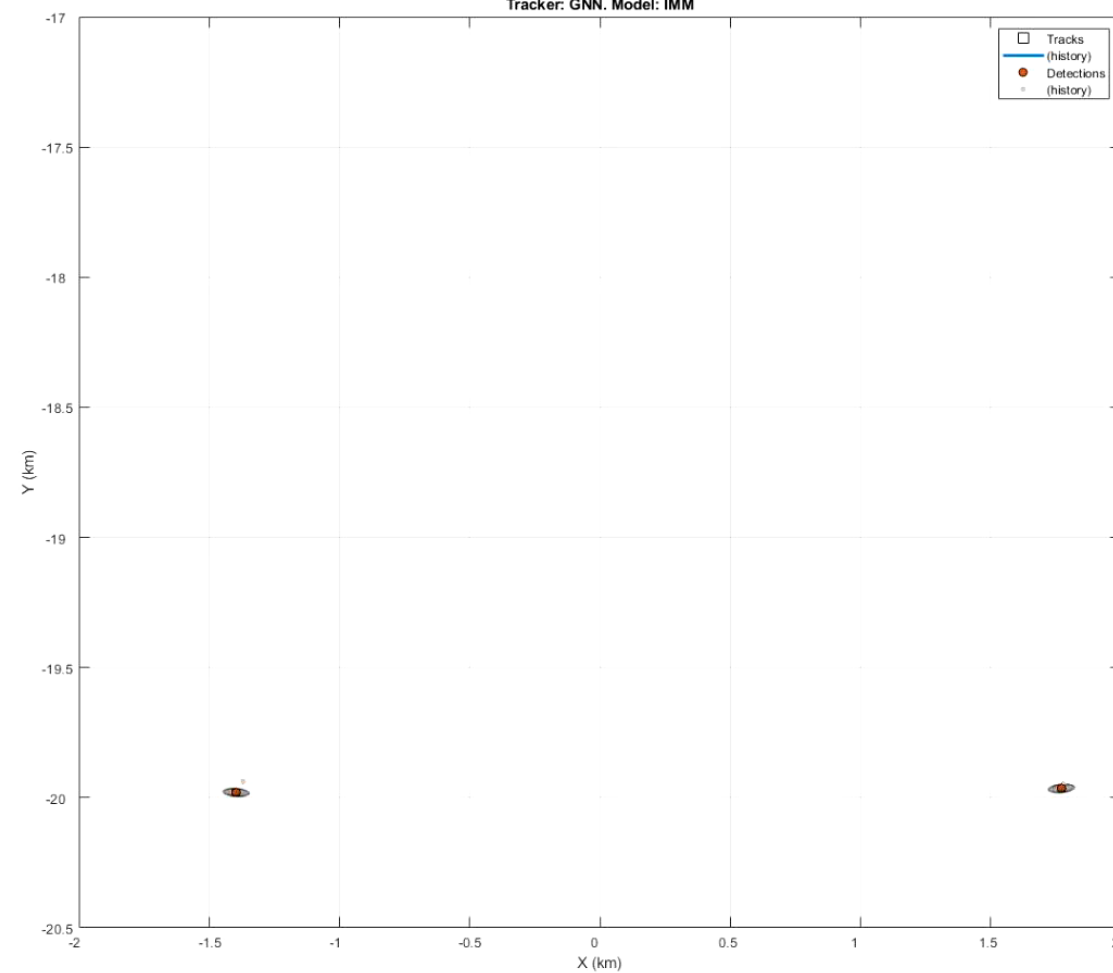
## GNN s CV

Tracker: GNN. Model: CV



## GNN s IMM

Tracker: GNN. Model: IMM



# Analýza: rovnaký tracker, rôzny model

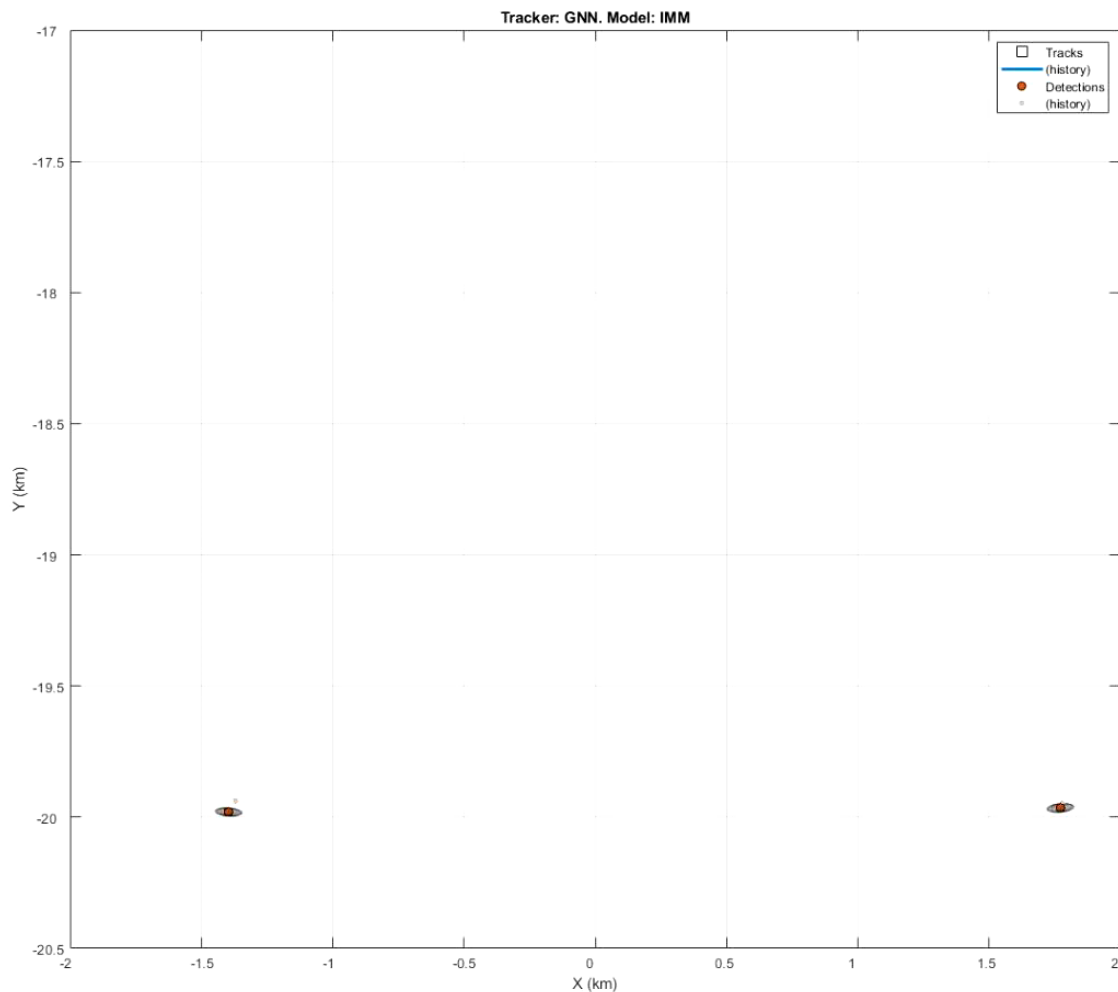
```
tracker = trackerGNN( ...  
  'FilterInitializationFcn',@initCVFilter,...  
  'MaxNumTracks', numTracks, ...  
  'MaxNumSensors', 1, ...  
  'AssignmentThreshold',gate, ...  
  'TrackLogic', 'Score', ...  
  'DetectionProbability', pd, ...  
  'FalseAlarmRate', far, ...  
  'Volume', vol, 'Beta',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

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

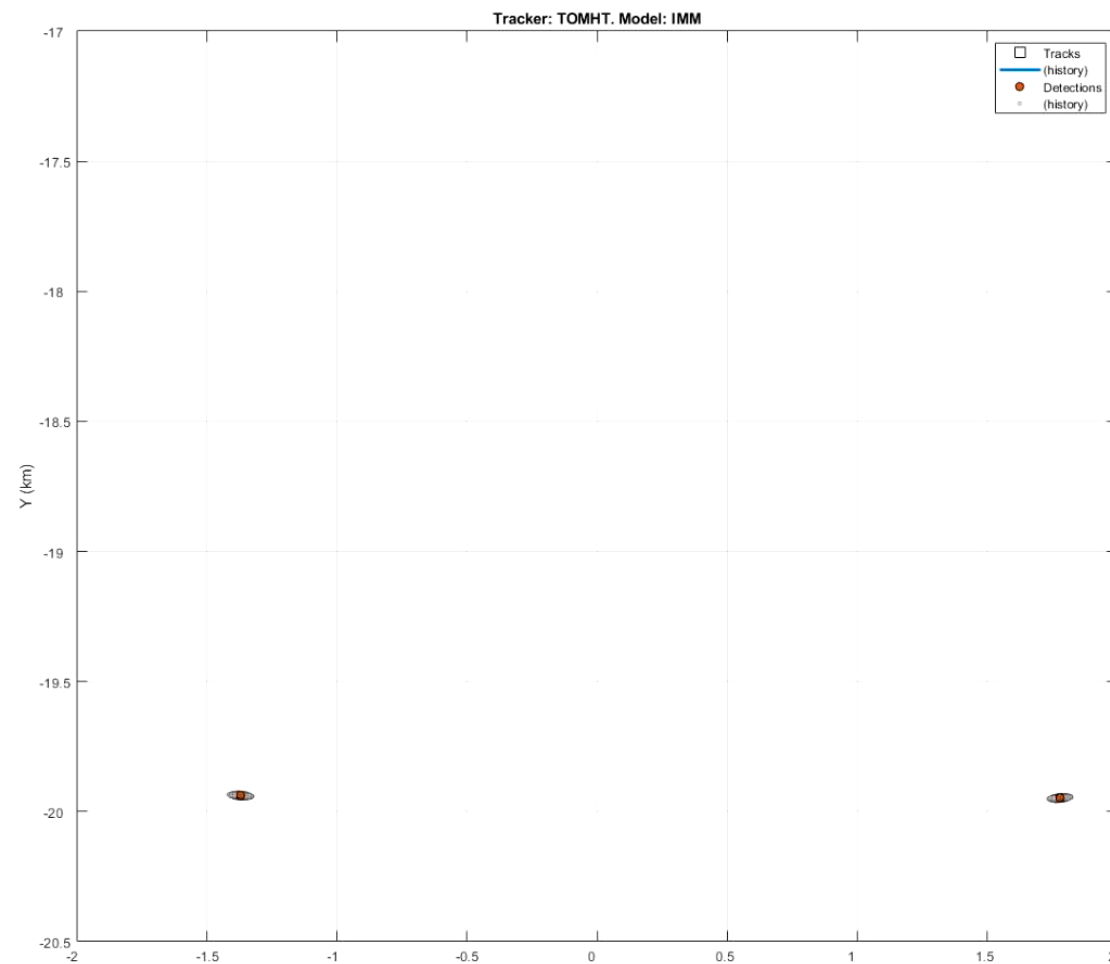


# Analýza: rôzny tracker, rovnaký model

## GNN s IMM



## TOMHT s IMM



# Analýza: rovnaký tracker, rôzny model

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

```
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');
```

# Porovnanie trackerov a filtrov



Zlé a stratené sledovania

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

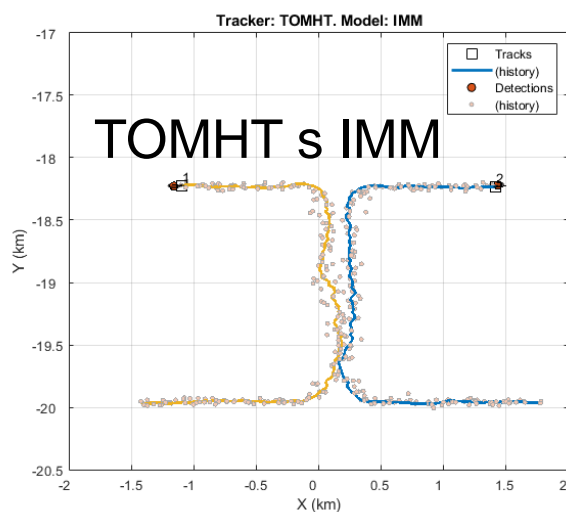
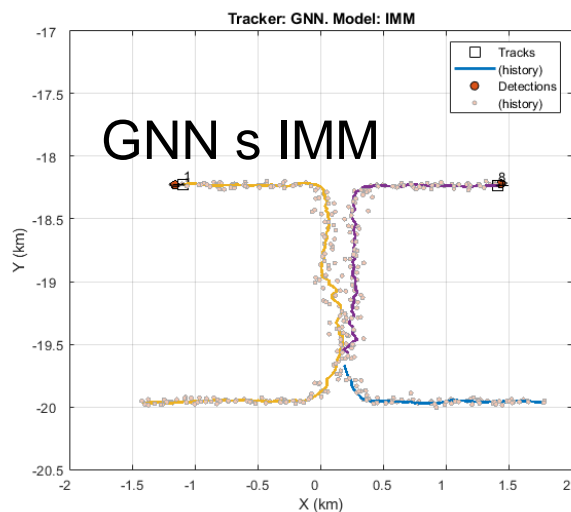
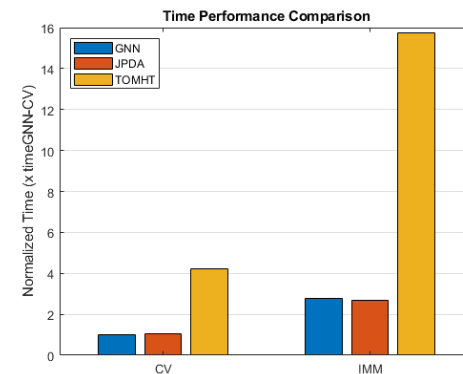
TruthID	AssociatedTrackID	TotalLength	BreakCount	EstablishmentLength
2	1	192	0	2
3	2	192	0	2



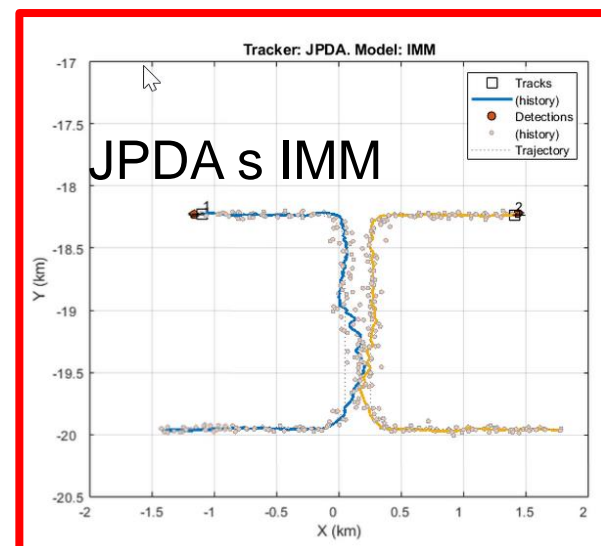
TrackID	AssignedTruthID	Surviving	TotalLength	DivergenceStatus
1	2	true	191	false
2	3	true	191	false

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



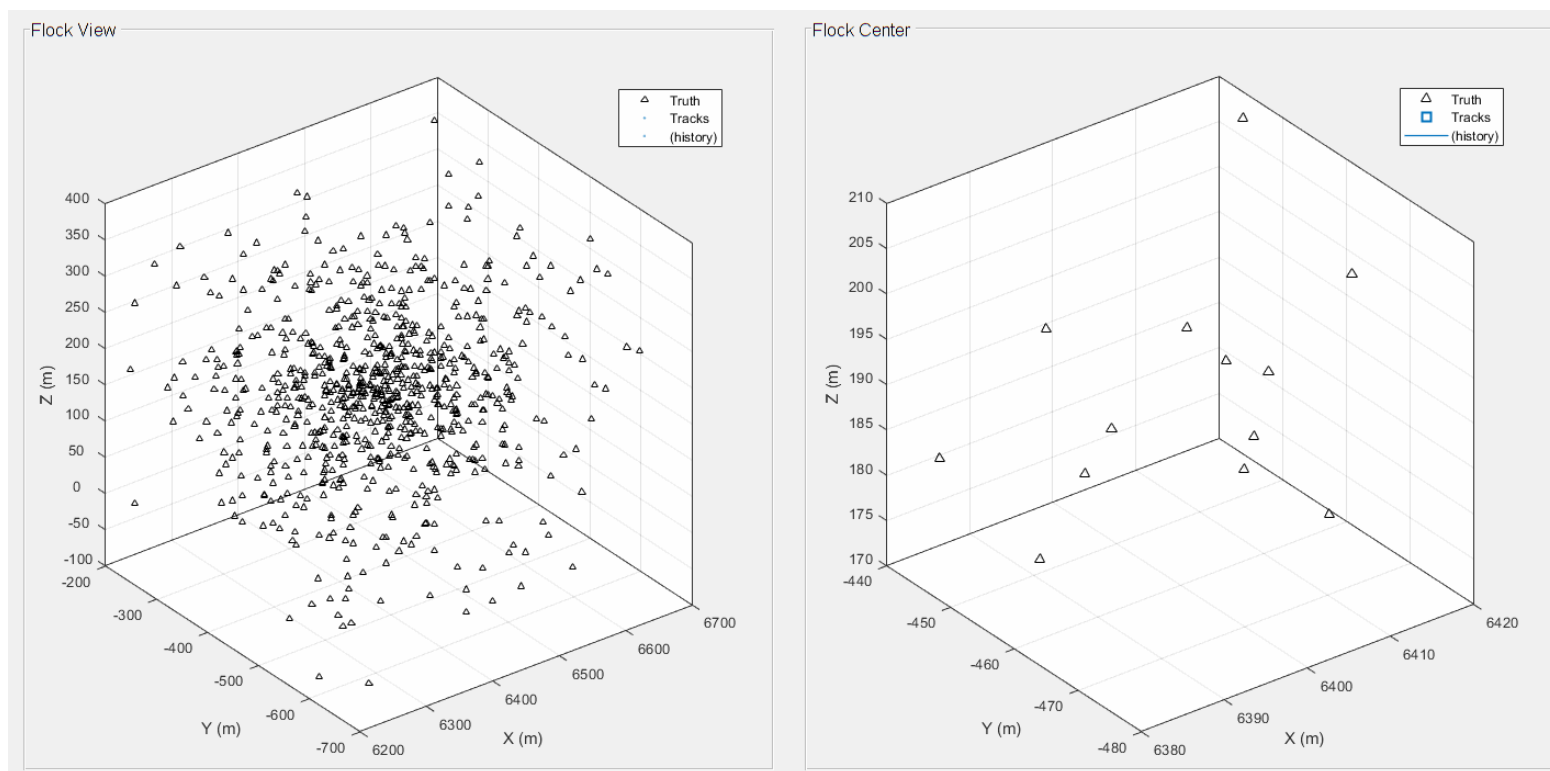
Pomalší







Rýchlejší



# Velký počet objektů



Tracker update time

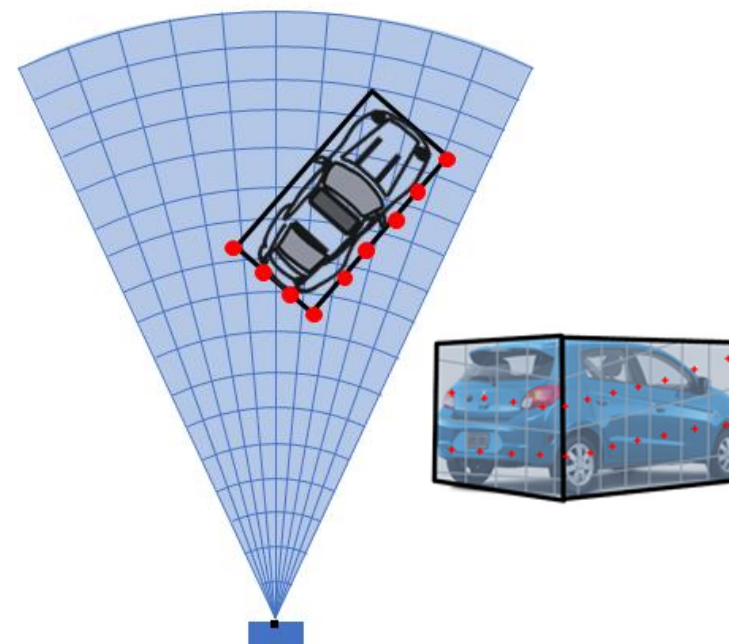
	500 Tracks		2,500 Tracks	
				
18b	7s	0.25s	120s	5.7s*
19a	2s	0.15s	15s	2.6s*
Speedup	3.5x	1.6x	8x	2.2x*

# Počet detekcií na objekt

- **Bodový objekt (Point object)**
  - Objekt reprezentovaný jedným bodom
  - Jedna detekcia na objekt

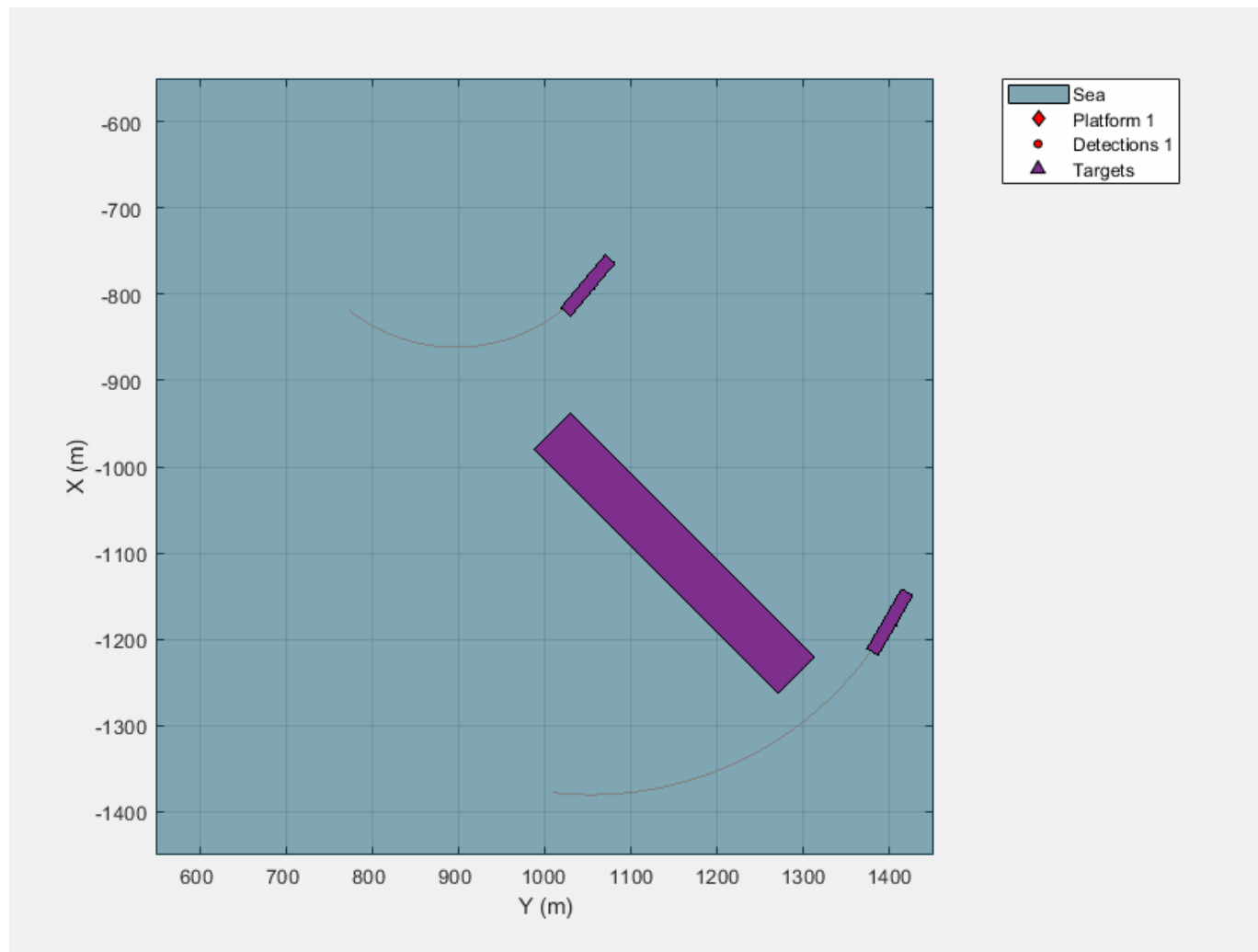


- **Rozšírený objekt (Extended object)**
  - Snímače s vysokým rozlíšením generujú viaceré detekcie na objekt

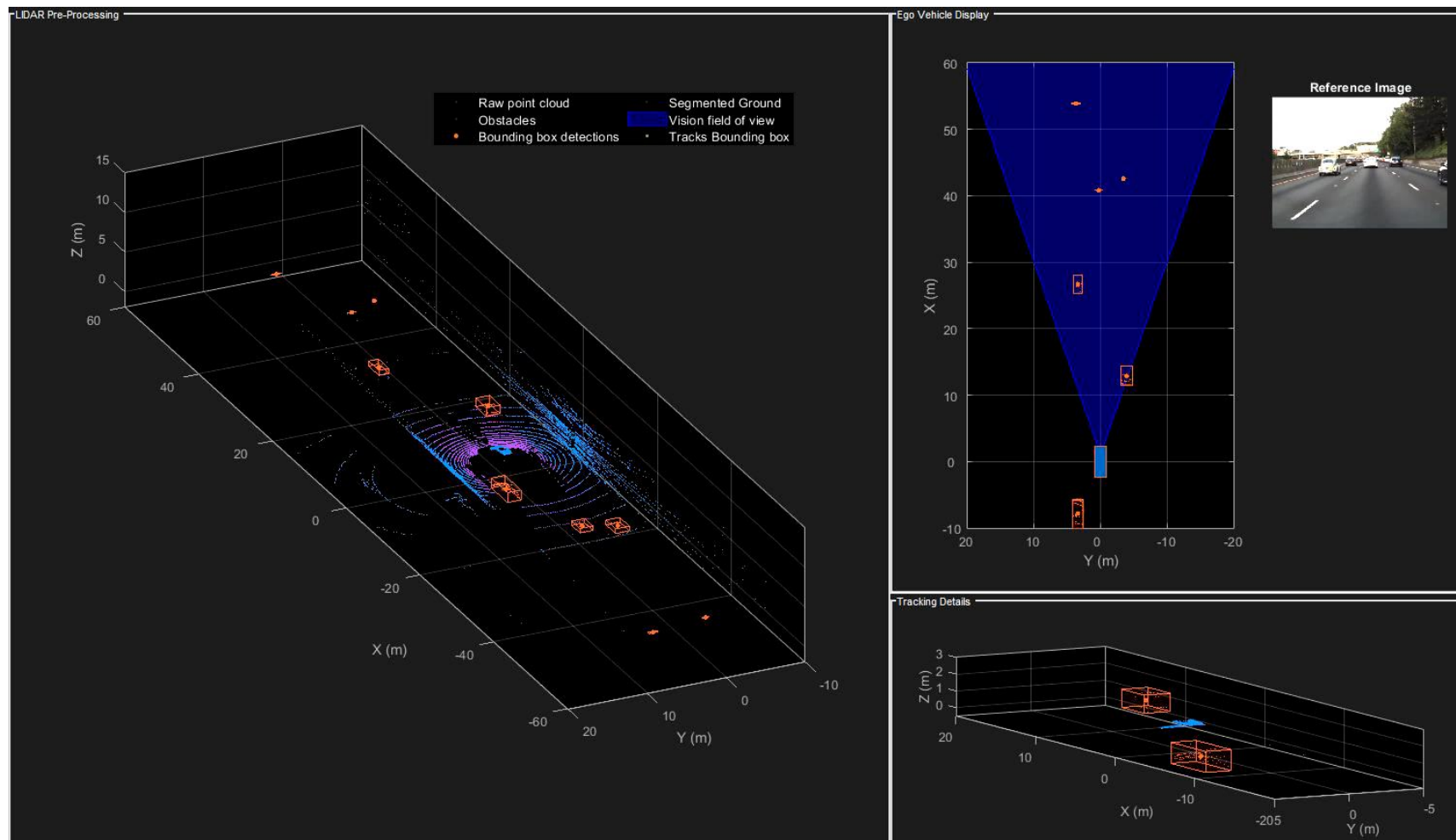


# Sledovanie objektov pomocou radaru

- Odhad polohy, rýchlosti, veľkosti a orientácie
- Zachovanie sledovania aj pri prekrytí



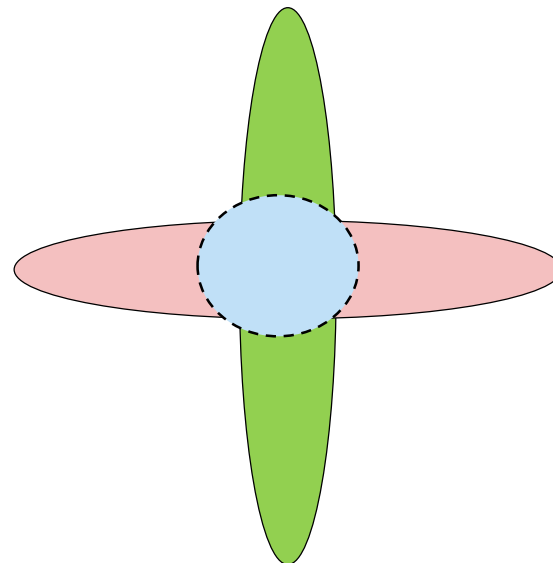
# Sledovanie s lidarom



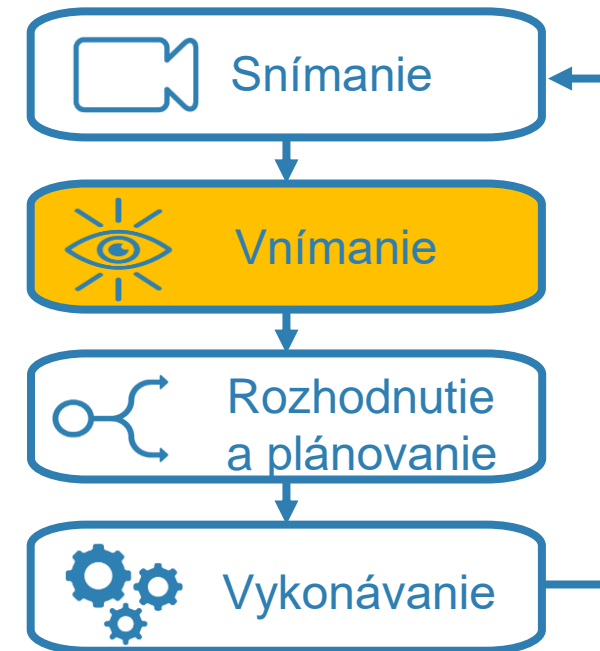
# Senzorická fúzia a sledovanie



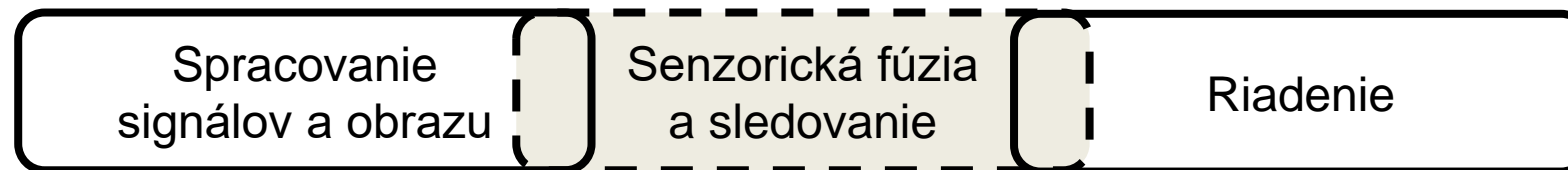
Je prítomná všade



Využíva silu snímačov



Podporuje autonómne systémy



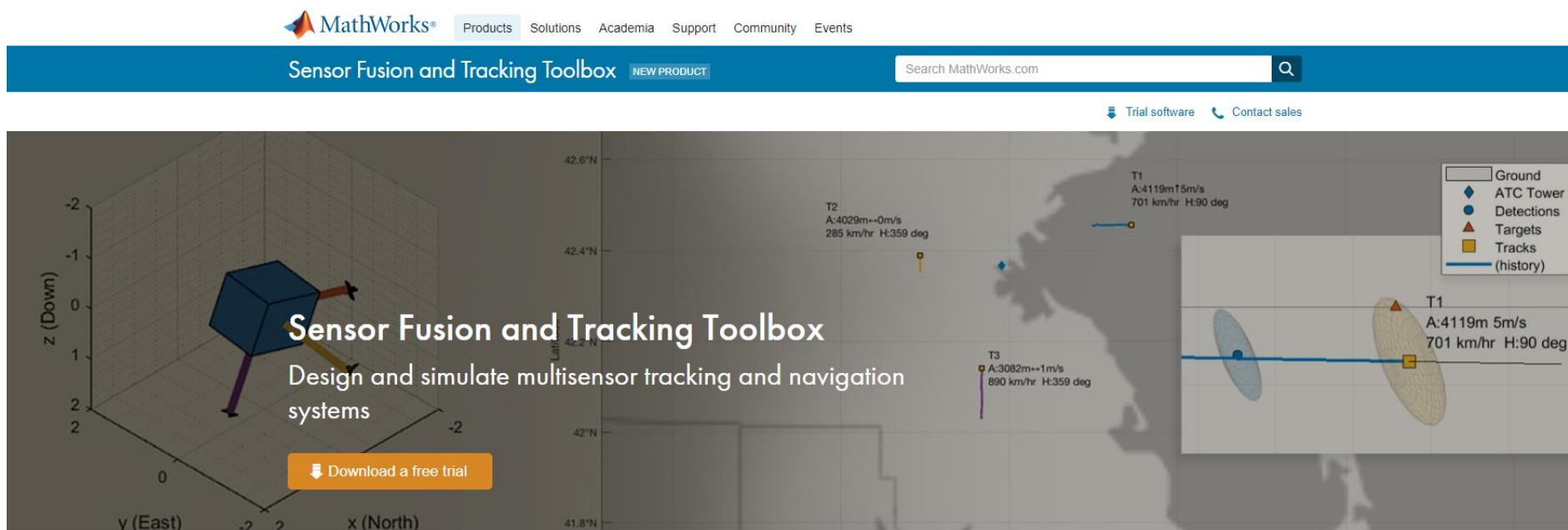


# Viac informácií

Phased Array System Toolbox

Sensor Fusion and Tracking Toolbox **NEW PRODUCT**

Automated Driving Toolbox **MAJOR UPDATE**



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**Sensor Fusion and Tracking Toolbox**  
Design and simulate multisensor tracking and navigation systems

Download a free trial

Legend:  
 □ Ground  
 ◆ ATC Tower  
 ● Detections  
 ▲ Targets  
 ■ Tracks  
 — (history)

Target Data:  
 T2: A:4029m--0m/s, 285 km/hr, H:359 deg  
 T3: A:3082m--1m/s, 890 km/hr, H:359 deg  
 T1: A:4119m 5m/s, 701 km/hr, H:90 deg

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

**Ďakujem za pozornosť**