

# SIPES – Effect of Sensor Data Quality on Target Handoff Accuracy

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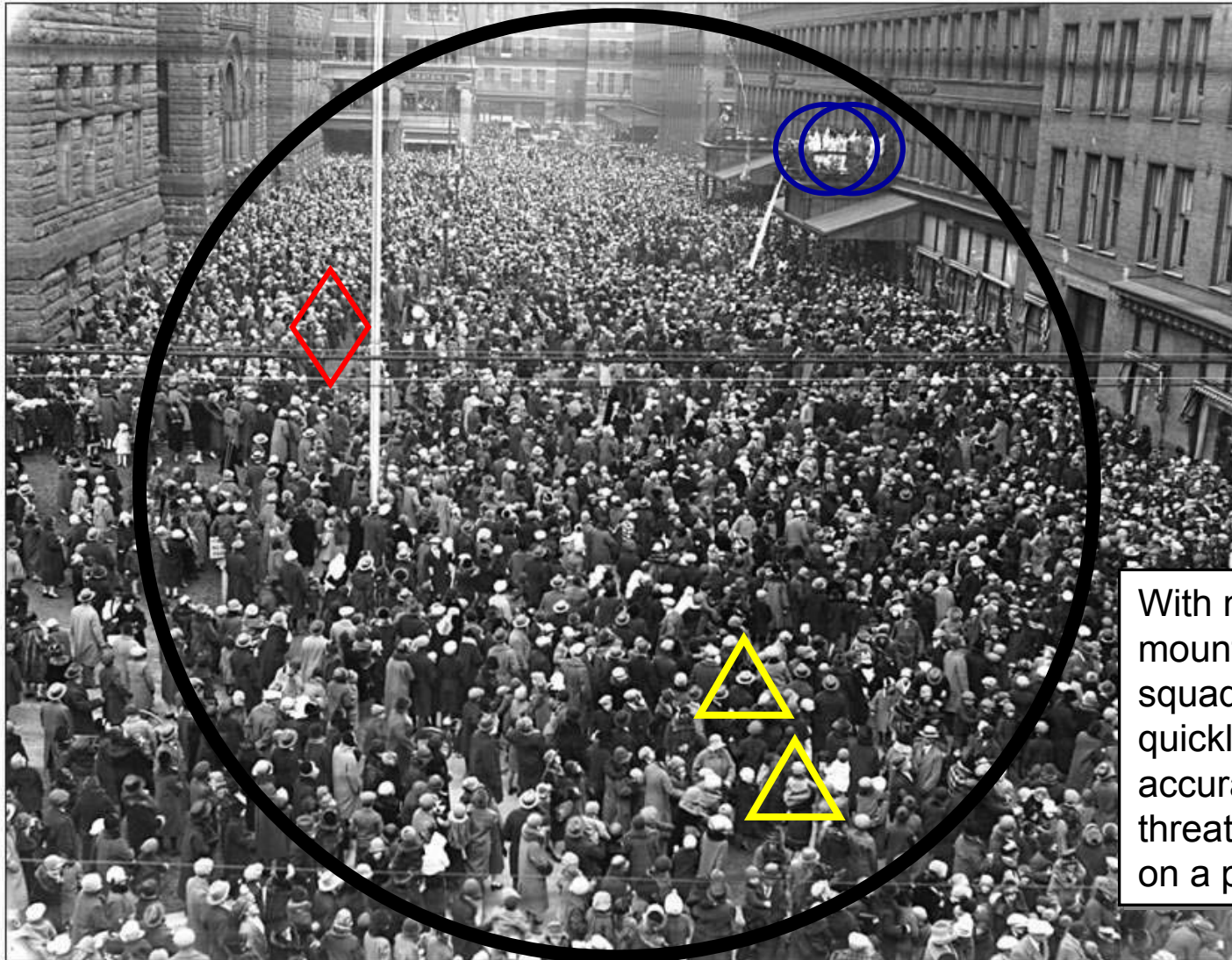
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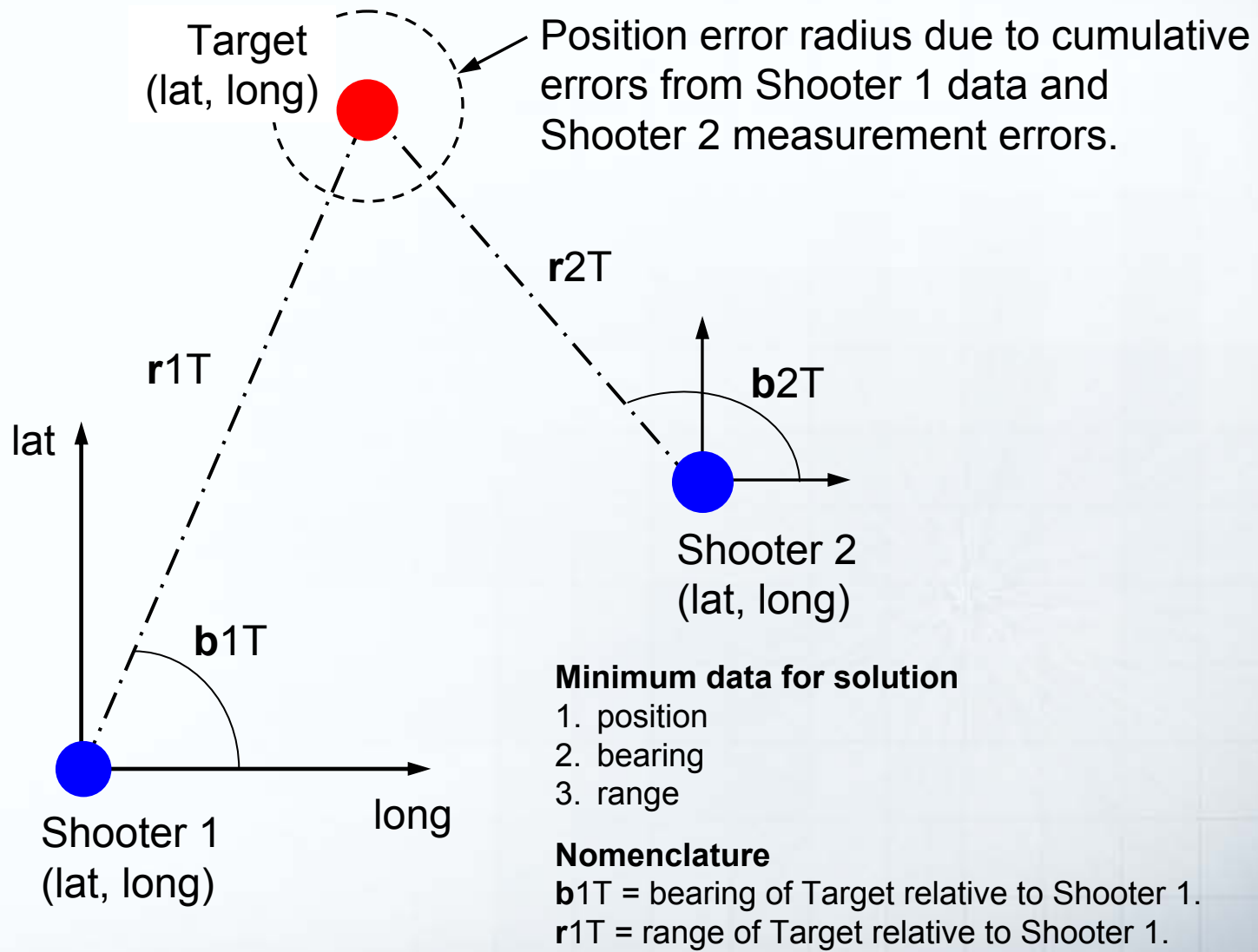
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# Problem Statement



With networked weapon mounted sensors, any squad member can quickly locate and bring accurate fire against a threat or put extra eyes on a potential threat.

## Target Hand-off from Shooter 1 to Shooter 2



# Target Handoff Error Estimates

## Assumptions:

1. Each shooter is equipped with laser range finder (LRF), Attitude and Heading Reference System (AHRS) and GPS.
2. Shooters operating in a non-GPS denied environment.

## Scenario:

1. Shooter 1 identifies the Target range and bearing relative to his GPS coordinates using LRF and AHRS data.
2. Shooter 1 calculates the Target's GPS coordinates and transmit the data to Shooter 2.
3. Shooter 2 calculates the Target distance and bearing relative to his GPS coordinates.
4. Shooter 2 uses his LRF and AHRS to orient himself towards the Target.

# Assumed Sensor System and Accuracies

System	Laser RF (m)	AHRS (deg)	GPS (m)
Typical <sup>a</sup>	0.05	1.0	2.0
DGPS <sup>b</sup>	0.05	1.0	0.50
HQ AHRS + DGPS <sup>c</sup>	0.05	0.1	0.50
Ideal	0.01	0.02	0.04

- <sup>a</sup> Typical sensor system comprised of laser range finder, inertial measurement unit and GPS.
- <sup>b</sup> GPS replaced with a Differential GPS.
- <sup>c</sup> AHRS replaced with an aerospace grade AHRS.
- <sup>d</sup> Ideal system represents potential capabilities of future technology.



# System Comparisons

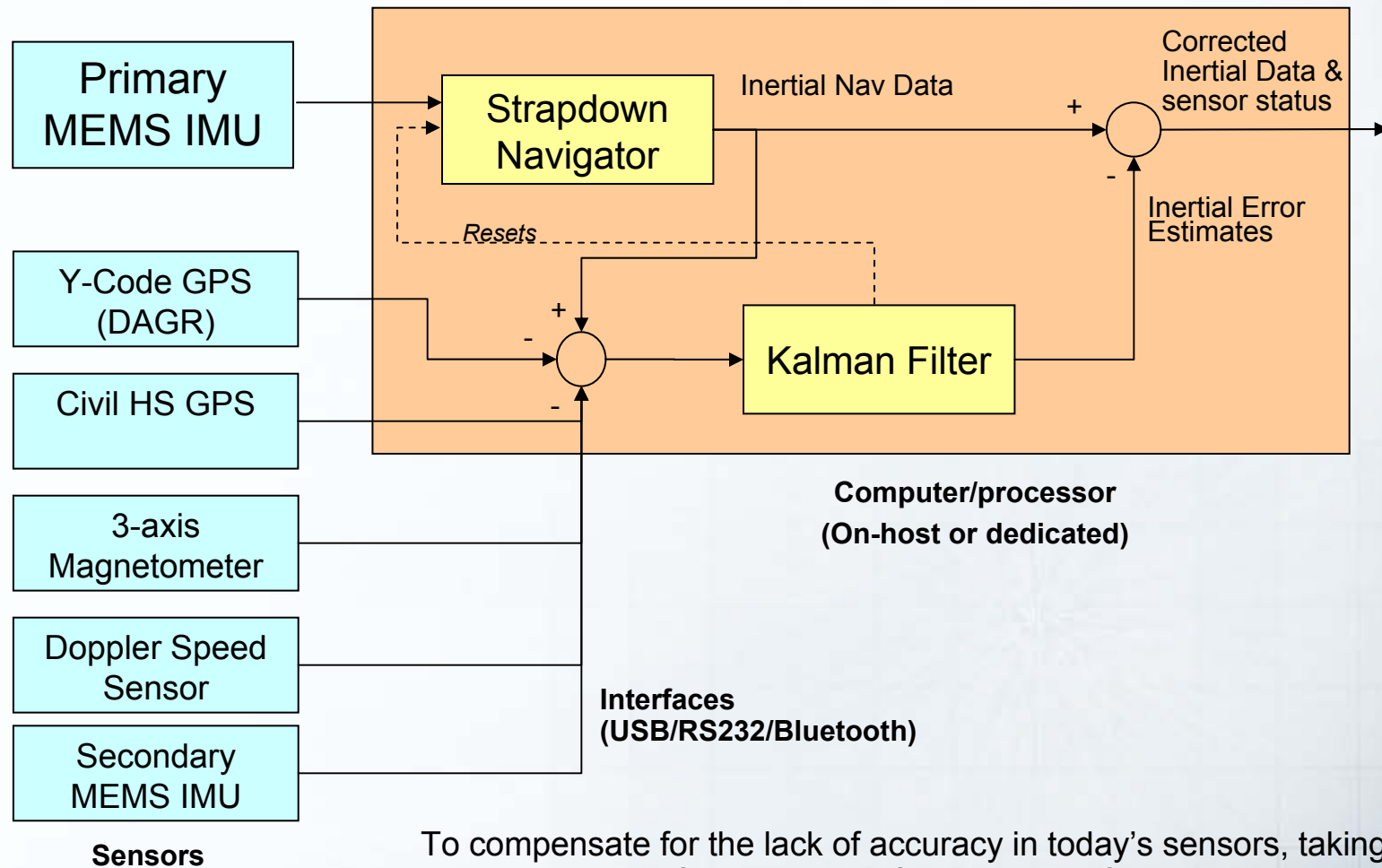
Situation	System	Error radius (m)	FOV min (deg)	% Red. Err. wrt Typical
<b>r1T = 100 m</b>	Typical	± 6.9	12	–
<b>b1T = 60 deg</b>	DGPS	± 3.9	6.8	43
<b>r2T = 66 m</b>	HQ AHRS+DGPS	± 1.3	2.3	81
<b>b2T = 122 deg</b>	Ideal	<b>± 0.14</b>	0.3	98
<b>r1T = 200 m</b>	Typical	± 10	8.0	–
<b>b1T = 60 deg</b>	DGPS	± 7.0	5.6	30
<b>r2T = 143 m</b>	HQ AHRS+DGPS	± 1.6	1.3	84
<b>b2T = 84 deg</b>	Ideal	<b>± 0.20</b>	0.2	97

Note: Assumed hit box corresponds to thorax size 0.290 m (w) x 0.320 m (h).  
 Shooter 2 is located 90 m @ 20 deg from Shooter 1.

Observations:

1. Require extremely accurate sensors to hand-off and fire within hit box for a given range.
2. Requirements on sensor accuracy can be relaxed if gun sight FOV is large enough to allow soldier to bring aim point within hit box.

# System Design Considerations

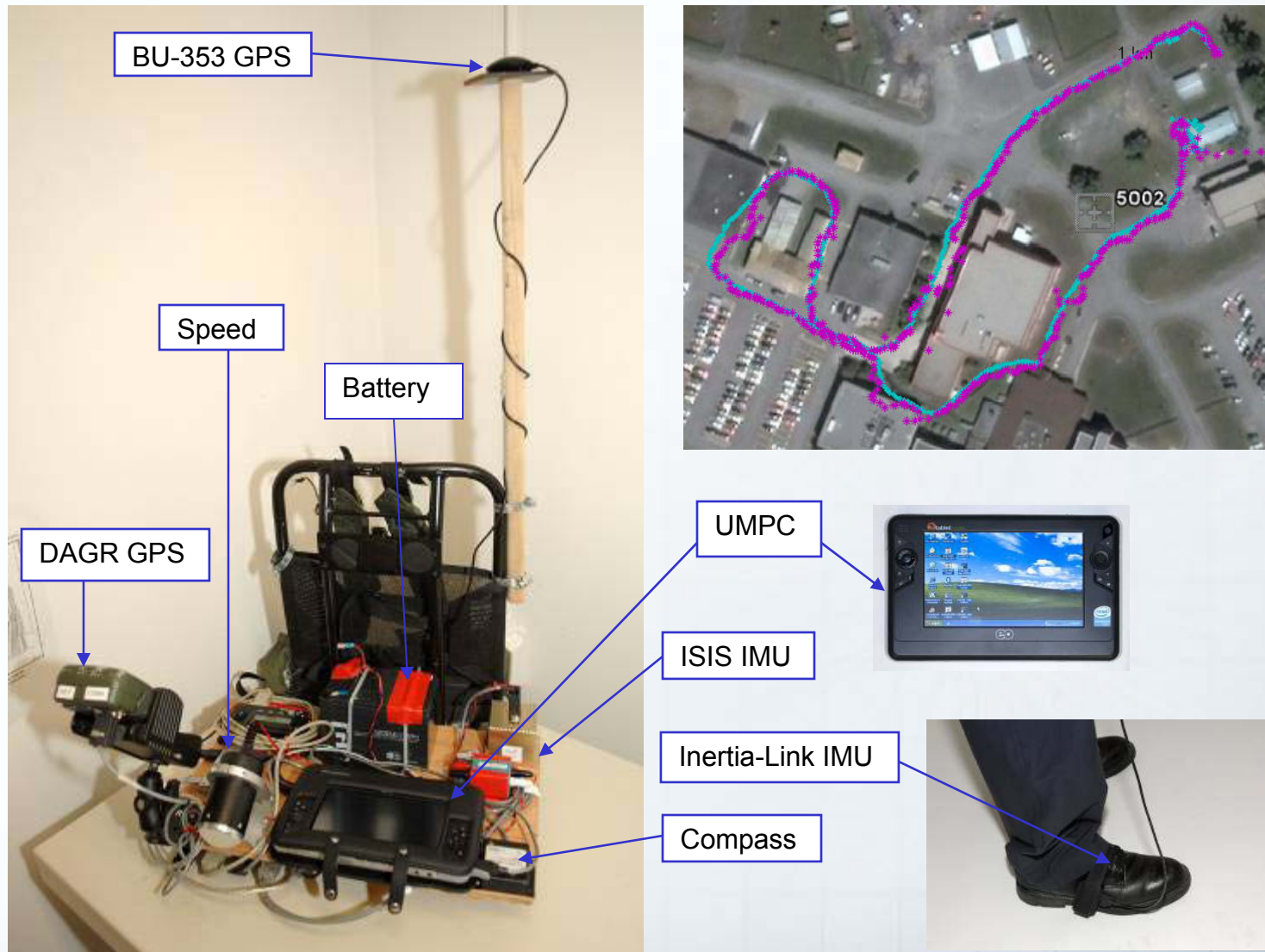


To compensate for the lack of accuracy in today's sensors, taking the measurements from a group of sensors and fusing them through an algorithm in the form of a Kalman Filter may allow better estimates of position, bearing and elevation to be calculated.

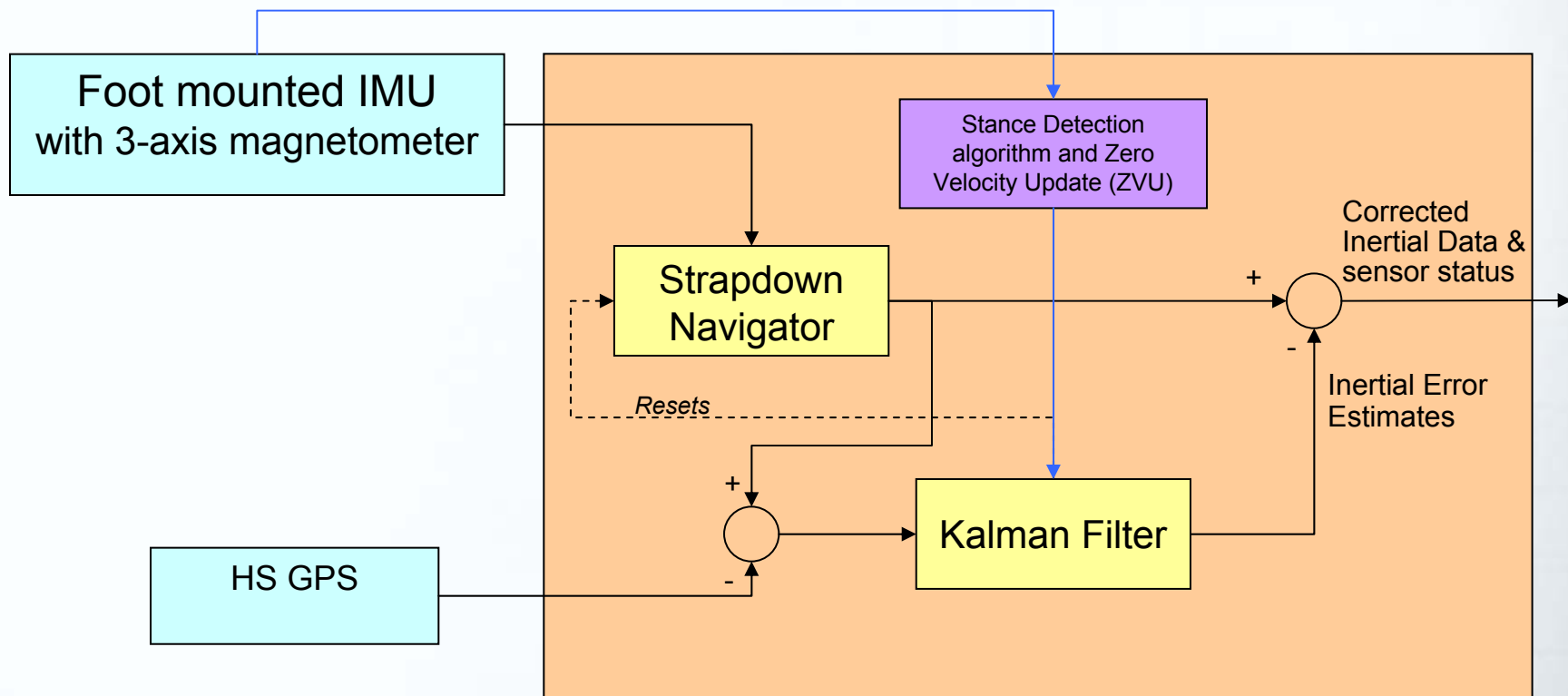


# RPN-P: ROBUST PERSONAL NAVIGATOR

(Dismounted Soldier Navigation in GPS-Denied Environments)



# MiPN Kalman Filter Architecture



“Stance Detection” algorithm enables **Zero Velocity Updates (ZVU)** to be applied at almost every footfall allowing a reduced number of sensors to be used yet still retain good accuracy in the position estimation.

# MiPN Minimal Personal Navigator Sensor Suite (Non-GPS Reliant Indoor/Urban Nav for Dismounted Soldier)



## GlobalSat BU 353 GPS Receiver

- Combined Antenna/Receiver Unit
- Civil L1-CA and WAAS signals only
- 53 mm diameter x 19 mm high, 84 grams
- USB for data and power

## MicroStrain Inertia-Link IMU

- 3 MEMS gyros/accels
- Delta- $\theta$ , Delta-V at 100Hz
- 3-axis magnetometer
- 41 x 63 x 24 mm, 39 grams
- USB for data and power



- △ GPS only
- ★ MiPN

graphic from DRDC Ottawa

## Way Ahead – AHRS and KF Study

- Catalog typical shooter movements and C7 positions where target hand-off may be employed.
- Set up a vision-based tracking arena to measure the orientation of a representative C7 in earth-based coordinates.
- Mount AHRS at three different positions along representative C7 to evaluate local bearing and elevation accuracies and signal noise using vision-based data.
- Evaluate possibility of acquiring reference pose or zero velocity updates for typical shooter movements or C7 positions.
- Develop Kalman Filter algorithm to make use of reference data to improve local bearing and elevation estimates.
- Explore alternative strategies that eliminate need for GPS location data.