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SIPES – Effect of Sensor Data Quality on Target Handoff Accuracy

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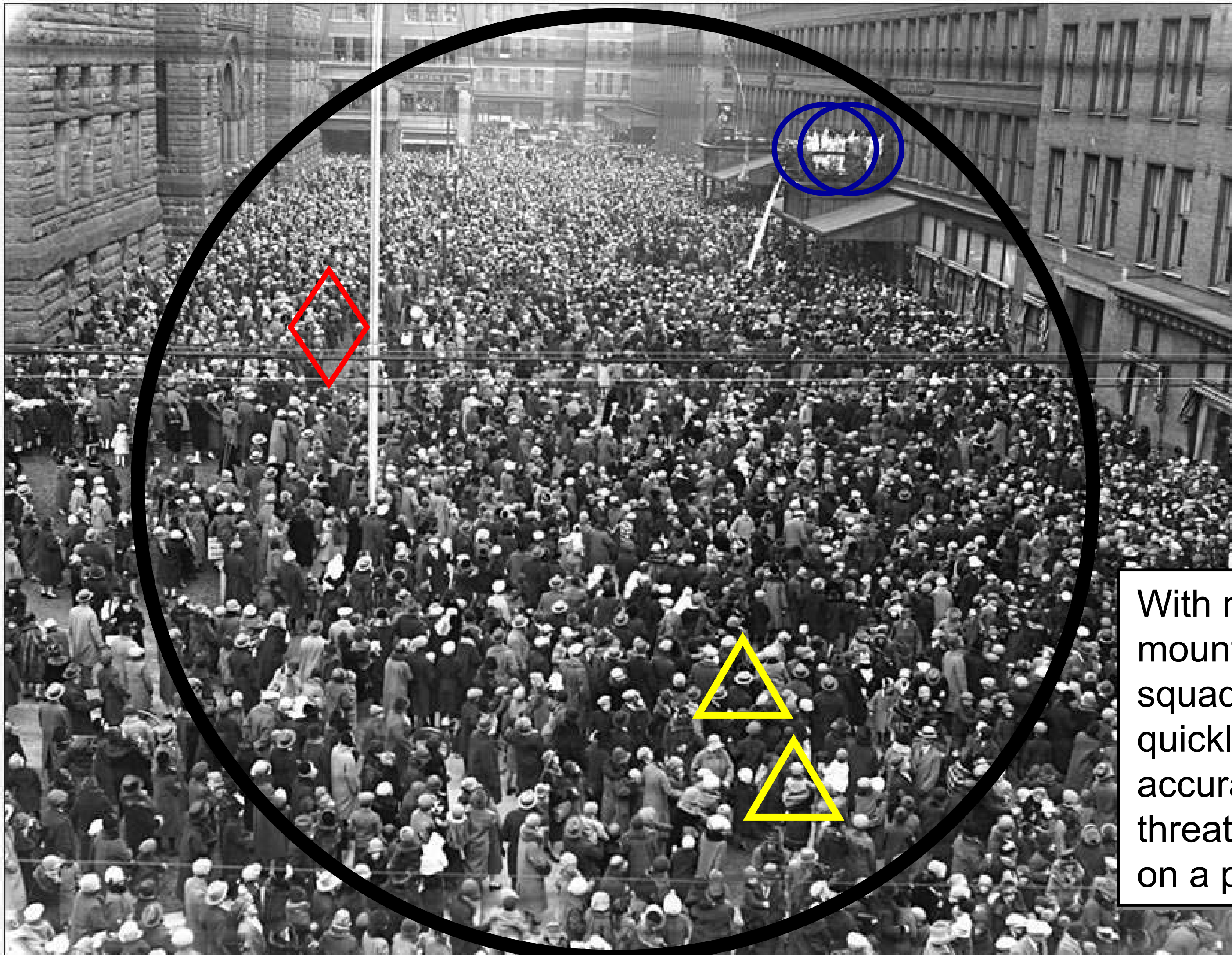
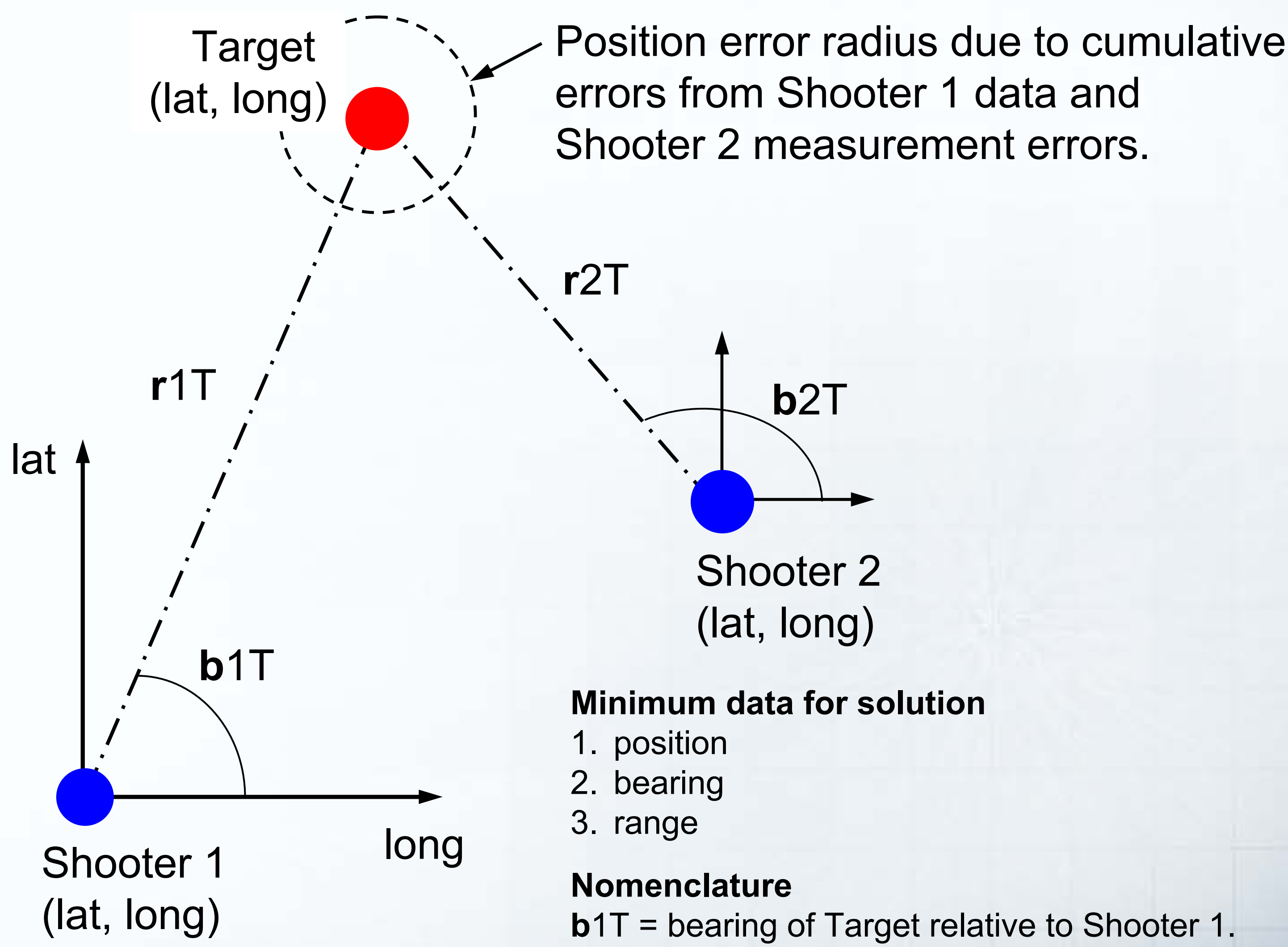
Problem Statement



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.

Maj. B. Gilchrist, DLR 5-5

Target Hand-off from Shooter 1 to Shooter 2



Minimum data for solution
1. position
2. bearing
3. range

Nomenclature
b1T = bearing of Target relative to Shooter 1.
r1T = range of Target relative to Shooter 1.

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[a]	0.05	1.0	2.0
DGPS[b]	0.05	1.0	0.50
HQ AHRS + DGPS[c]	0.05	0.1	0.50
Ideal	0.01	0.02	0.04

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

System Comparisons

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

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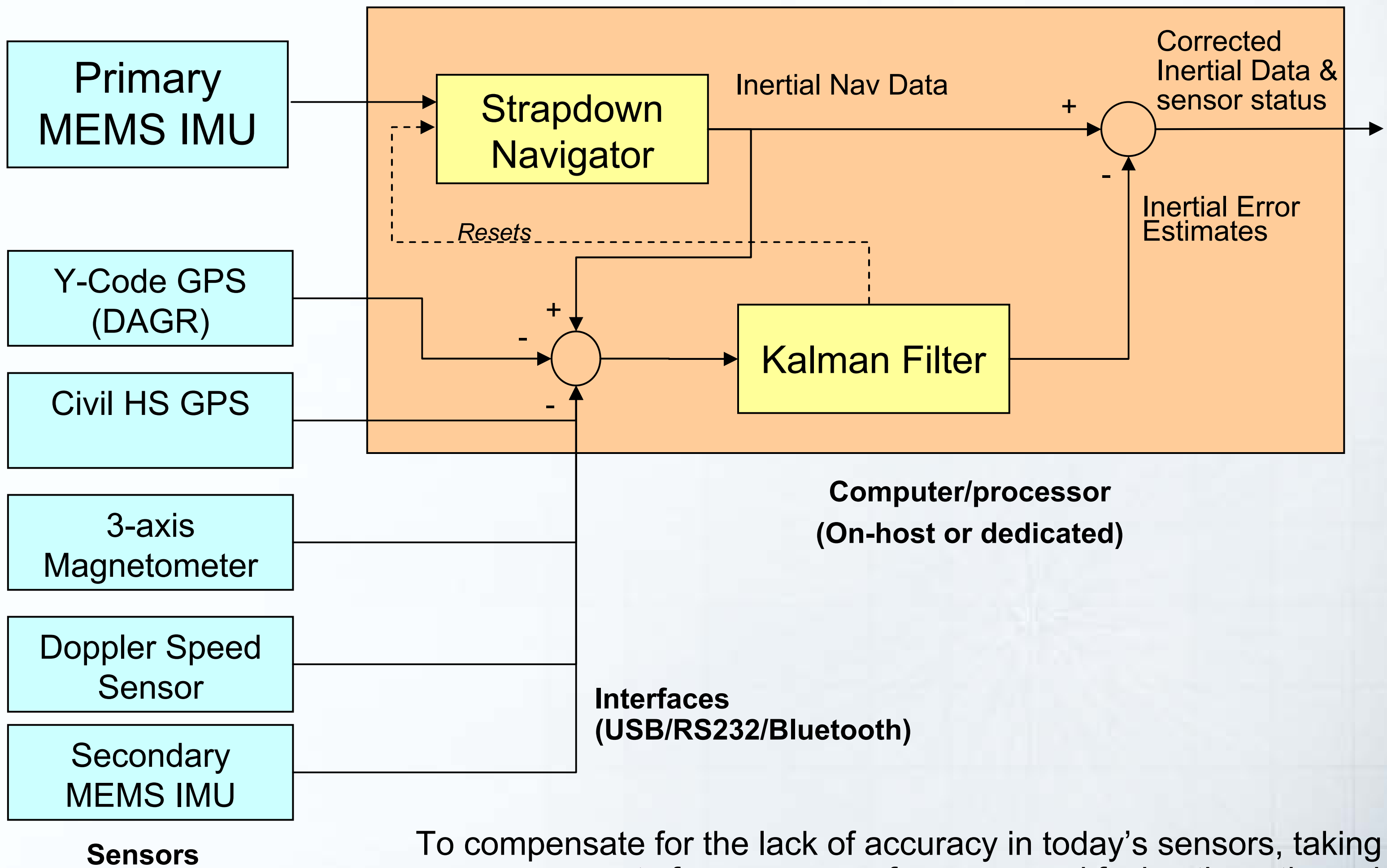
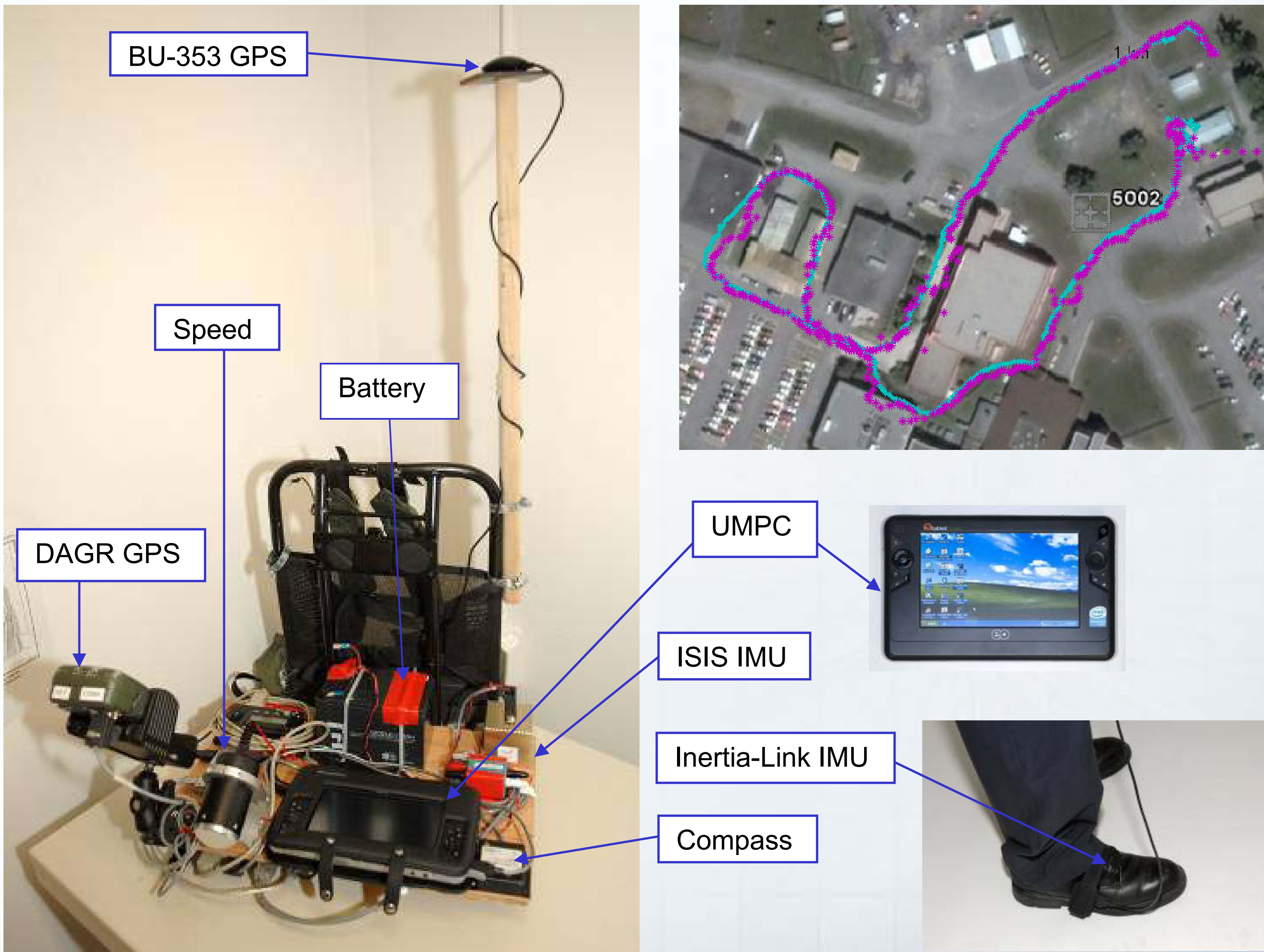


To compensate for the lack of accuracy in today's sensors, taking the measurements from a group of sensors and fusing them through an algorithm in the form of a Kalman Filter may allow better estimates of position, bearing and elevation to be calculated.

graphic from DRDC Ottawa

RPN-P: ROBUST PERSONAL NAVIGATOR
(Dismounted Soldier Navigation in GPS-Denied Environments)



graphic from DRDC Ottawa

MiPN Kalman Filter Architecture

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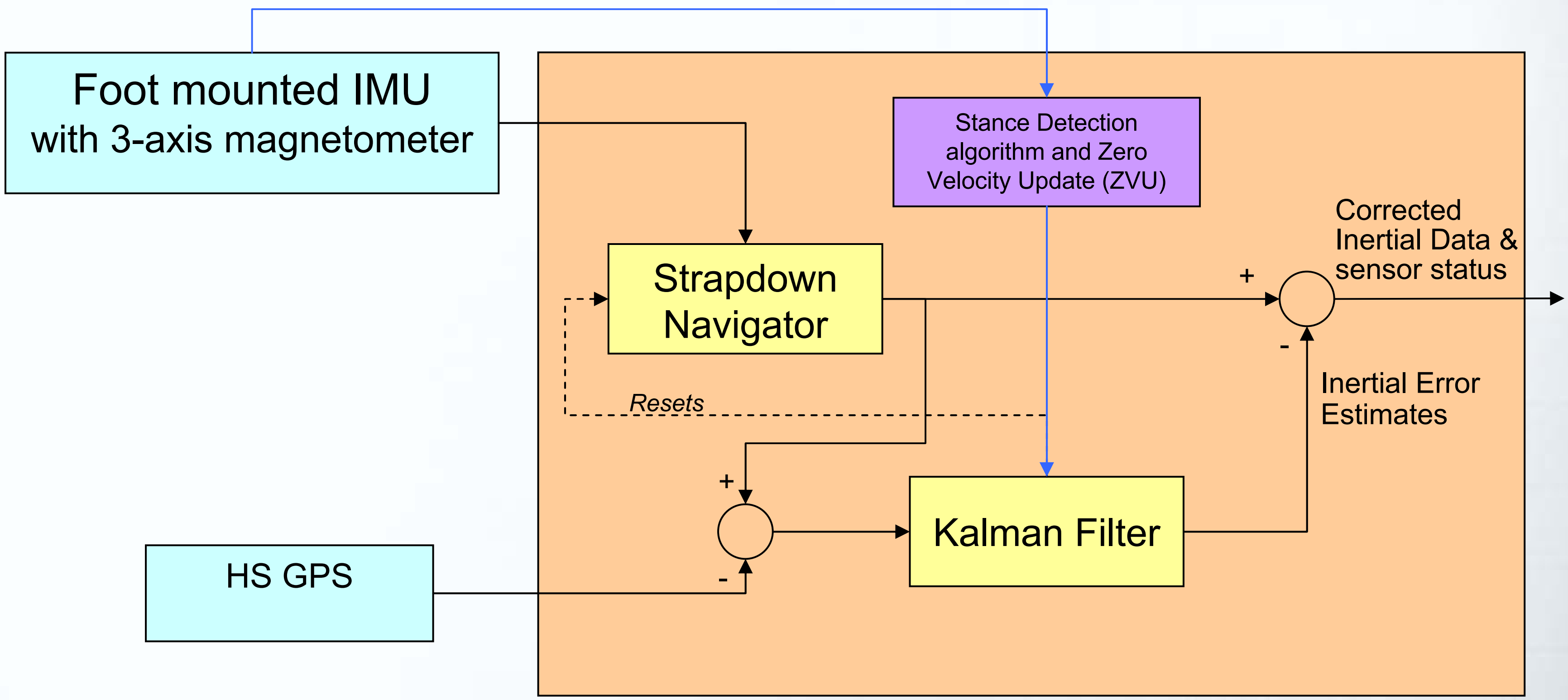

"Stance Detection" algorithm enables **Zero Velocity Updates (ZVU)** to be applied at almost every footfall allowing a reduced number of sensors to be used yet still retain good accuracy in the position estimation.

graphic from DRDC Ottawa

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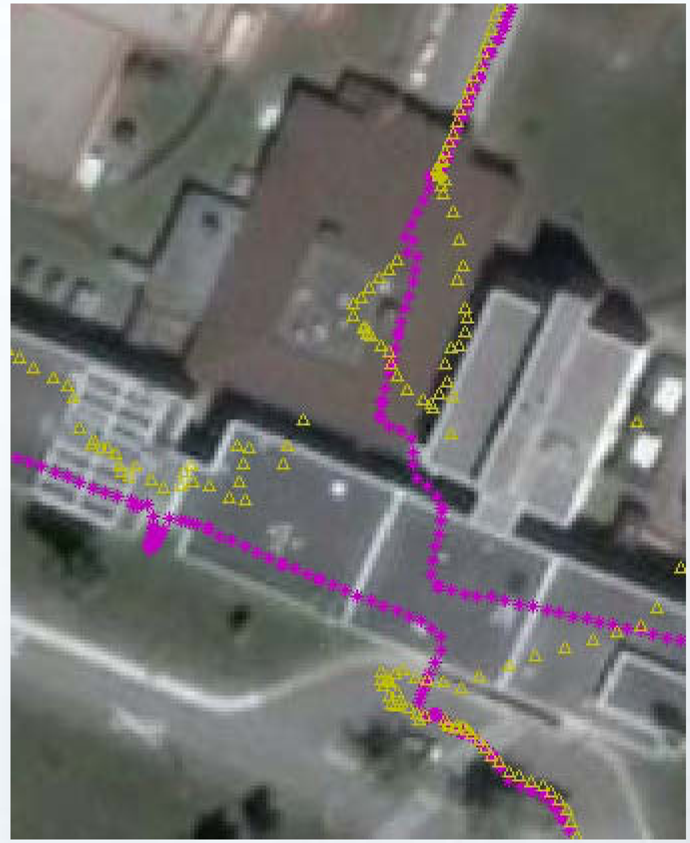
MiPN Minimal Personal Navigator Sensor Suite
(Non-GPS Reliant Indoor/Urban Nav for Dismounted Soldier)

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-θ, 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.