
Sensors: State Estimation and Navigation

Key Issues:

- Waypoint navigation
- Vehicle state estimation: velocity, acceleration, 6 DOF attitude
- Vehicle state: fuel, ABS, engine/oil temperature, tachometry, wheel rotation speed/slippage, internal temperature, etc.

Key Technologies:

- Global Positioning System (GPS)
 - Inertial Measurement Unit (IMU)
 - Vehicle internal computer (grab everything off the car computer)
-

Global Positioning System

- Waypoint finding
- Path planning/following
 - * Vehicle must stay within clearly defined corridor

Accuracy: ~ 3m on average

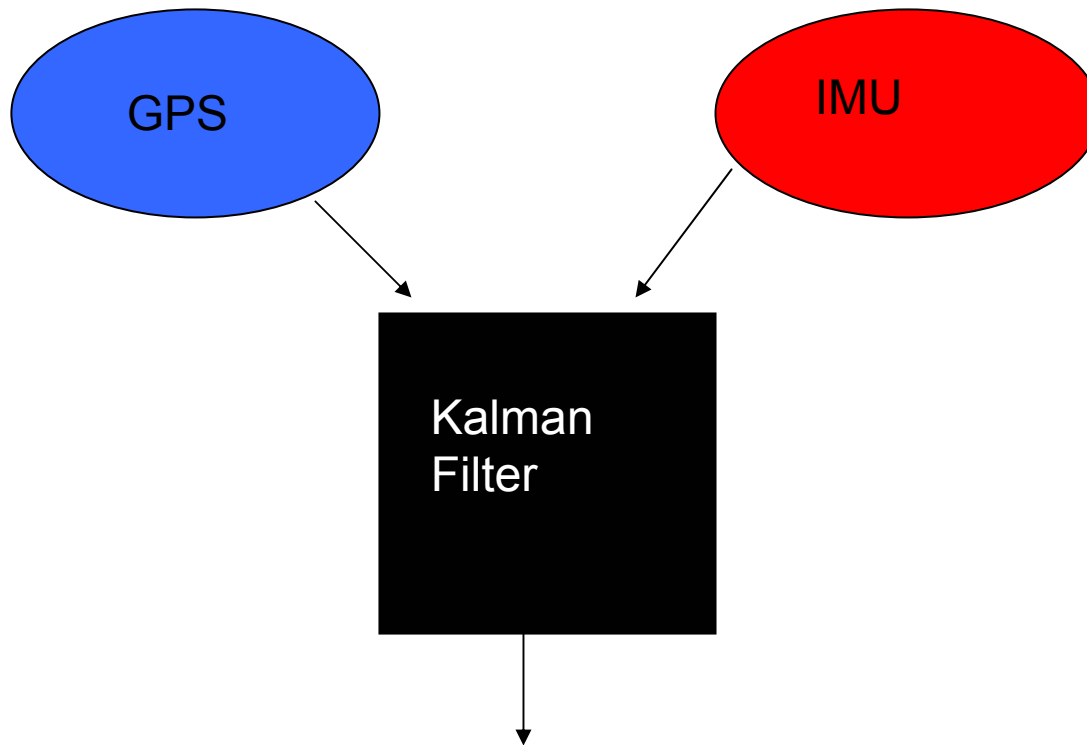
Advantages: Finite drift error, highly accurate

Disadvantages: Noise, not always available

Inertial Measurement Unit

- Measures vehicle attitude, velocity, delta-V, etc.
 - Accuracy: typically $\sim .1$ m/s, 1.5 mg
 - Advantages: low noise error, always available
 - Disadvantages: high drift error
-

Solution to all life's problems



Reliable, low noise, finite drift position data (we hope)

Solution to all life's problems, part deux

- Have a midget drive the car, or
- Have MIGITS drive the car (hardy har har)
- BEI Systron Donnor C-MIGITS III
- Price: ~\$24,000



C-MIGITS™ III
Miniature Integrated
GPS/INS Tactical System

[Applications](#)
[Physical Characteristics](#)
[System Performance](#)
[Environmental](#)

Digital Quartz Inertial Measurement Unit (DQI)
with 12-Channel, L1 C/A Code GPS Engine

Making Life Easy

Physical Characteristics

Size (Vol.)	53.5 in ³ (3.189"W x 3.530"D x 4.750"H) (81mm x 90mm x 121mm)
Weight	2.4 lbs. (1.1 kg)
Power	28 VDC at 18 watts
I/O	RS-232, AMRAAM IMU output, Host Vehicle I/O, DGPS input
Reliability@ 35°C	52,248 hr MTBF, ground; 9,900 hr MTBF, missile

System Performance

	C/A Config.	Differential
Position (SEP)	3.9m	3.0m
Velocity (1 sigma, horiz/vert)	0.1/0.1 m/s	0.1/0.1 m/s
Attitude (1 sigma)	1.0 mrad	1.0 mrad
Heading (1 sigma, in motion)	3.5 mrad	1.0 mrad
Time (1 sigma)	1 μ s	1 μ s

Making life even easier

Environmental	
Temperature Range	-40 to +71°C (operating)
Vibration	6-12 grms (performance-endurance)
Shock	20 g, 11 ms
Operating Range	± 1000 deg/s*; $\pm 20g$ (performance-endurance)**; Up to 1,000 m/s***

Advantages: Accurate, small, very tough, RS-232 interface, internal Kalman filtering

Disadvantages: Expensive, requires external RTCM SC-104 source for differential GPS, puts state sensing out of a job

Alternatives: Donated IMU from Northrop Grumman+ NAVCOM GPS?
JPL Kalman filtering software?

What's my Canyon Aero Doing?

- Use mechanic's diagnostic computer to read vehicle information straight from the vehicle's master computer and ABS computer.
 - Advantages: Easy, simple, cheap, gets everything we need
 - Disadvantages: Once again, puts state-sensing out of a job... don't we get to build anything?
-

Concluding Remarks

- In the age of one-click online shopping, who needs to build anything?
 - Items remaining: internal sensing? Computer temperatures, power bus voltage/current, etc.
 - Differential GPS input?
-