Purpose of US PNTAB:

Assuring PNT for all –

and

Exploiting GNSS for Future Applications

FACA Representing 100s of millions of diverse users and many scores of applications

Adm. Thad Allen (Chairman), Booz Allen Hamilton

Hon. John Stenbit (Deputy Chairman), former Assistant Secretary of Defense

Dr. Bradford Parkinson (1st Vice Chair), Stanford University)

Governor James E. Geringer (2nd Vice Chair), Environmental Systems Research Institute (ESRI)

What is important for PNT users now?

Two of the "Important Things" that I Listed earlier

An Initial List of Important Things 3

"Future Applications and Capabilities"

F1. Defining and publicizing power of 2nd (and 3rd) GNSS satellite signal lobe for SSV

F2 Progress and prospects of Intelligent Transportation Program (includes positive Train Control)

F3 Accelerate Progress on fielding Autonomous Vehicles – (e.g. large interstate trucks and consumer vehicles on expressways)

F4. How can GNSS help in integrating UAS and Urban Air Mobility (UAM) into the airspace system?

F5. Insuring protection for Powergrid Timing

F6. Ensuring Timing for the Financial community

F7. Ensuring scientific capabilities are preserved and enhanced, such as water vapor measurements and weather predictions

F4. How can GNSS help in integrating UAS and Urban Air Mobility (UAM) into the airspace system?

Rapidly growing UAS applications -

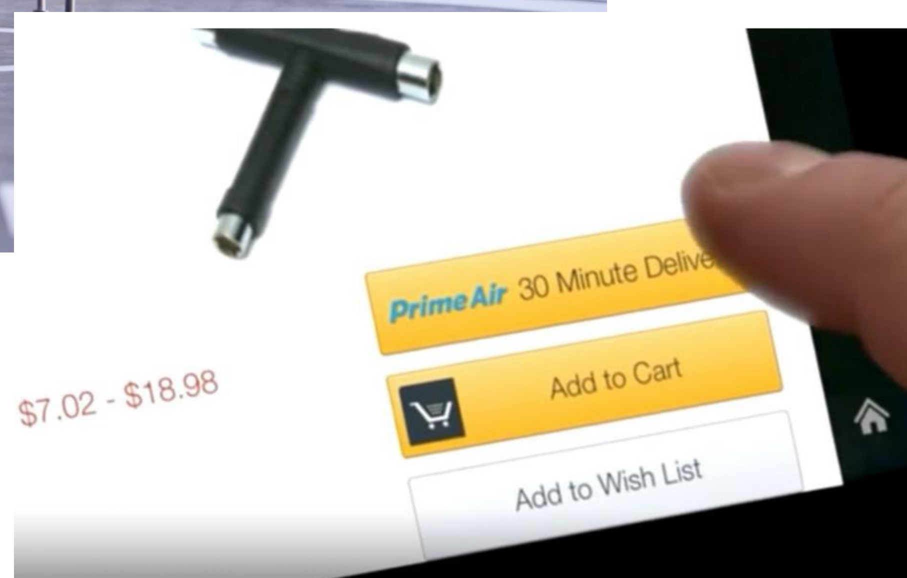
Significant Productivity Enhancements

- Power line inspection
- Agricultural Inspection
- Media coverage
- Security

Both UAS Control and Air Traffic Monitoring depend on GNSS

Autonomous Air Taxi - Volocopter now being tested in cities

PrimeAir Coming to a house near you?



A Problem: What non-UAS Applications spend time flying close to the ground?

(Where collisions with UASs are most probable)

- Commercial Airplanes during takeoff and landing
- Wildfire Tankers/Helicopters
- Law Enforcement Helicopters
- General Aviation – particularly a small or remote airfields

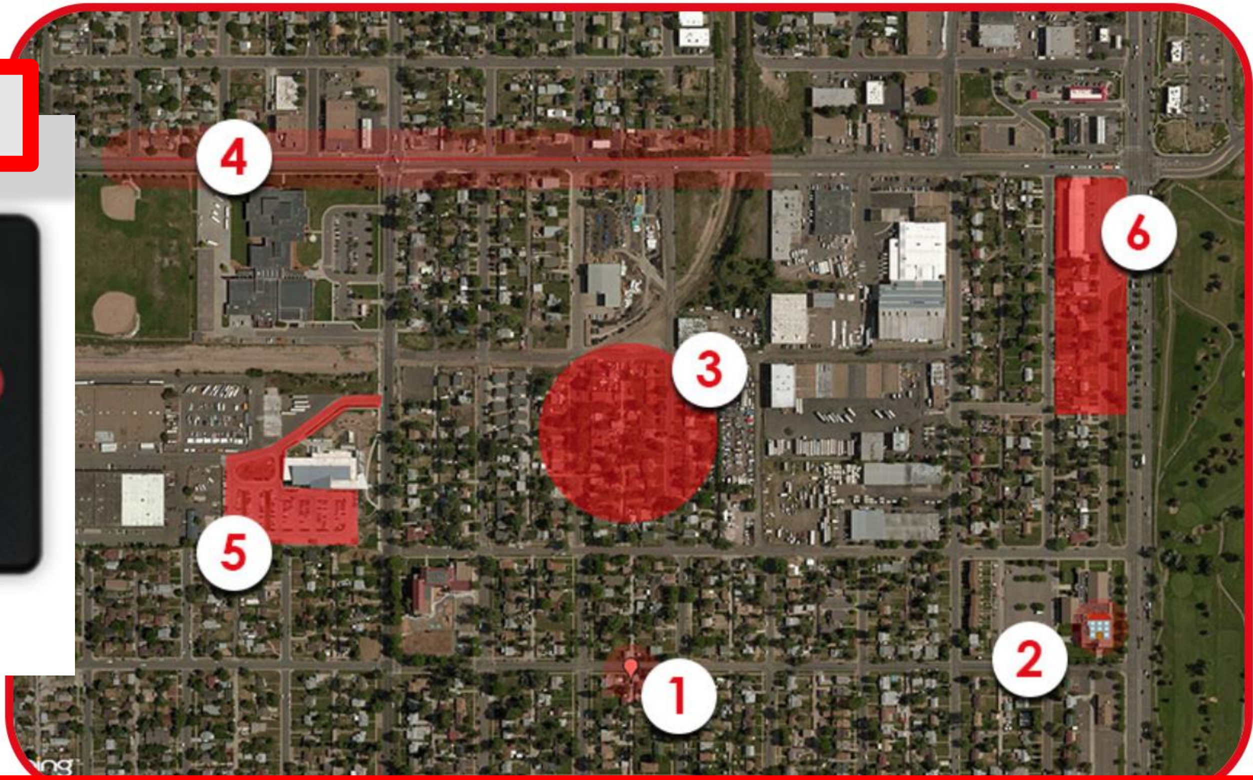
Firefighting Aircraft are significant users of low-altitude airspace

14 Firefighting Aircraft Grounded by Drone, Operator Faces 14 Felony Charges

Part of Solution? - GNSS based Geofencing - commercial products already available

~ 3 inches

GPS Satellite View



Need 3D and rapid exclusion assignment - enforcement?

- Robust GNSS is key enabler

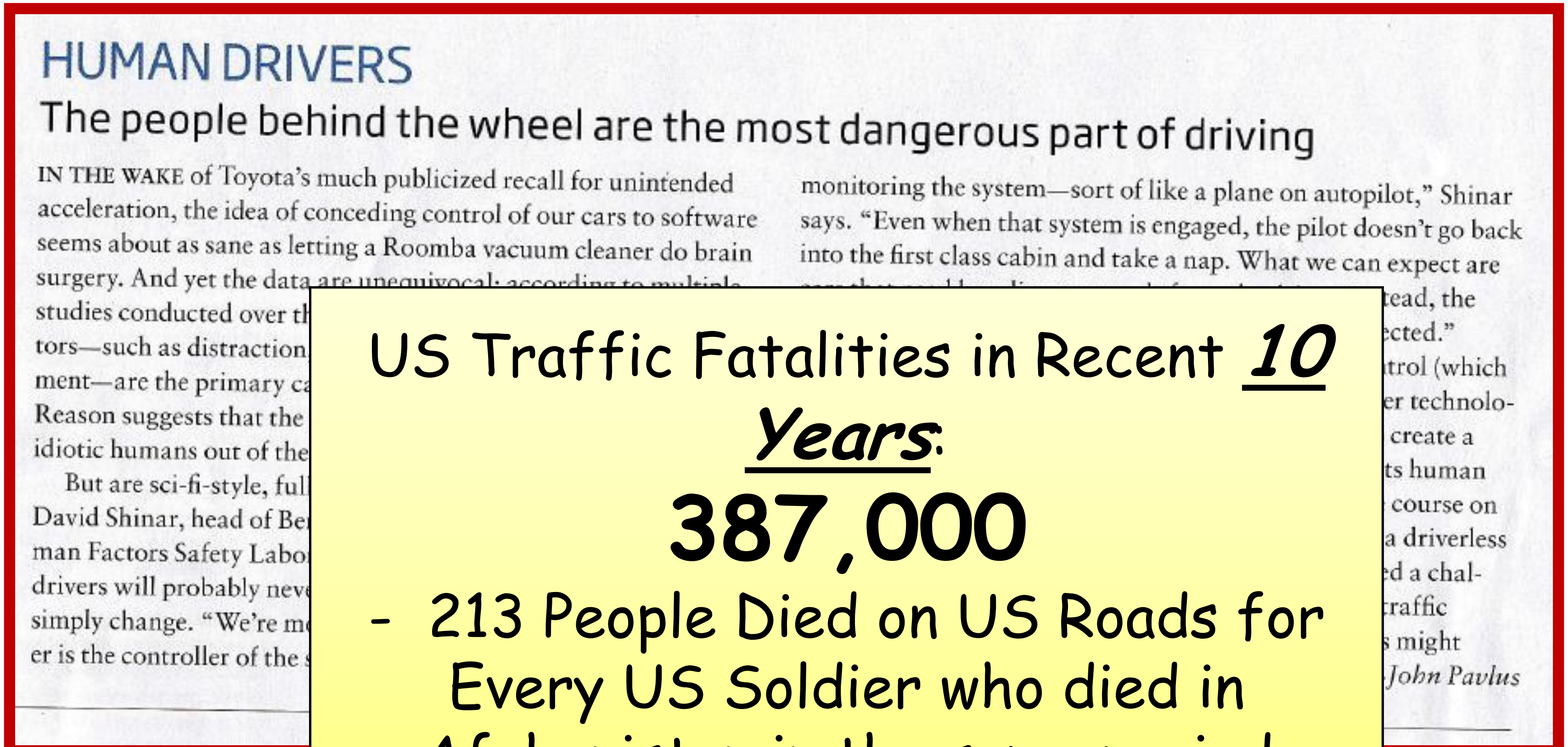
By 2022 the Federal Aviation Administration (FAA) expects that there will be 2.9 million drones flying in the United States. (CNBC 2019)

UAS/UAM regulation by FAA in US is evolving-amid safety and security concerns

- No simple answers but PNT/GNSS is at the heart of the problem and solution
- BVLOS not authorized, but certainly feasible and desirable for civil applications
- "Geofencing" has well established products and systems for ground fleet management
  - GNSS as Position measurement/location
  - Adaptation to UAS/UAM?
  - Static and dynamic fences?
  - Feasibility of fail safe UAS control?

F3. Accelerate Progress on fielding <u>Autonomous Vehicles</u> – (especially large interstate trucks and consumer vehicles on expressways)

A Humanitarian Opportunity



HUMAN DRIVERS

The people behind the wheel are the most dangerous part of driving

IN THE WAKE of Toyota's much publicized recall for unintended acceleration, the idea of conceding control of our cars to software seems about as sane as letting a Roomba vacuum cleaner do brain surgery. And yet the data are unequivocal: according to multiple
studies conducted over th
tors—such as distraction
ment—are the primary ca
Reason suggests that the
idiotic humans out of the
But are sci-fi-style, full
David Shinar, head of Be
man Factors Safety Labo
drivers will probably neve
simply change. "We're m
er is the controller of the s

monitoring the system—sort of like a plane on autopilot," Shinar says. "Even when that system is engaged, the pilot doesn't go back into the first class cabin and take a nap. What we can expect are
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John Pavlus

US Traffic Fatalities in Recent ***10 Years***:

387,000

- 213 People Died on US Roads for Every US Soldier who died in Afghanistan in the same period

Implementing "Brilliant Autos" (Auto-guided Automobiles) and "Brilliant Semis" (Auto-guided long-haul trucks/lorries)

- Use all GNSS Position Signals
- Vector Kinematic Receivers (10 cm or better)
- MEMS/IMU
- 360° Radars
- Cooperative Tracking of other vehicles (V2V)

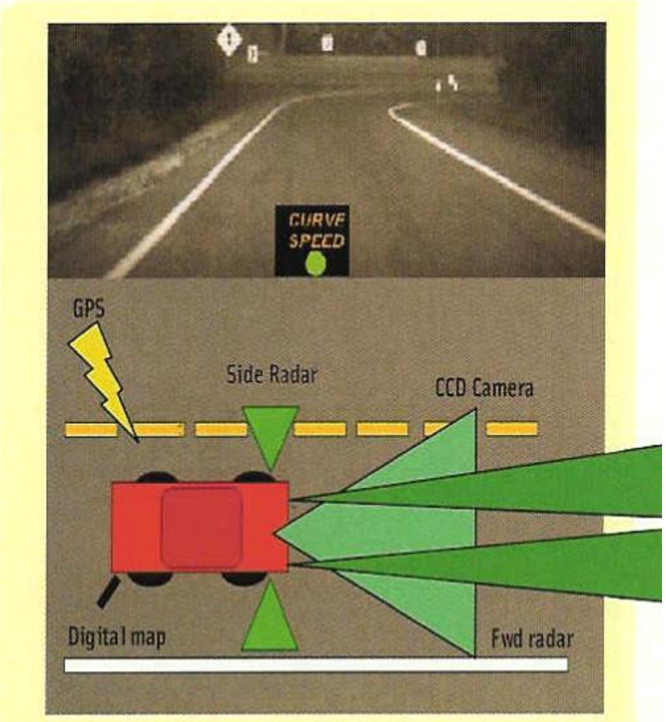


FIGURE 2 Road Departure Crash Warning Sensor Suite

"Brilliant Vehicles" – GNSS will be an essential part - Needs Phased Introduction (underway!)

- **Phase I**: Alerts and Warnings (especially for low-vis)
  - **Lane Drifting**
  - **Adjacent Vehicle Hazards**
  - **Traction**
  - **Curves**
  - **Vehicles**
  - **Road Hazards**
- **Phase II**: Auto Steering/Throttle/Braking with manual over-ride
- **Phase III (for Cargo Trucks)**: No Driver

F3. Status and enablers for Autonomous Road Vehicles - specially Semi's

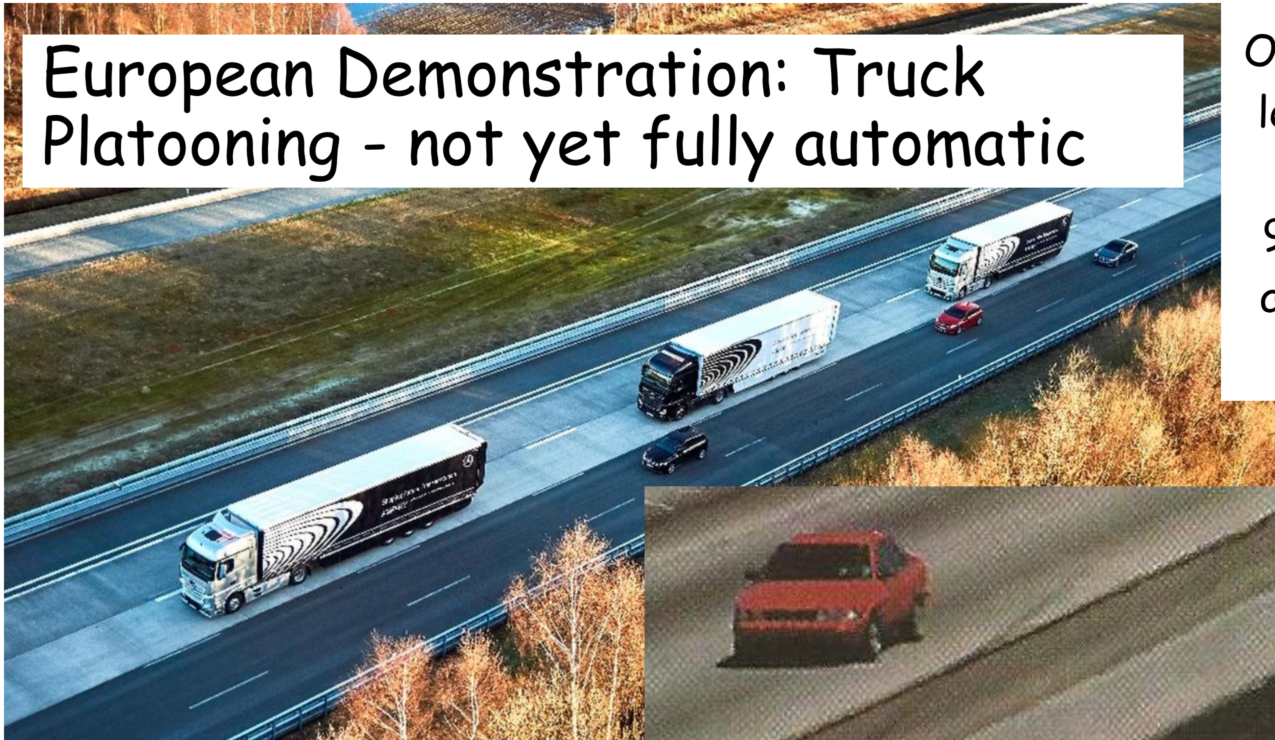
- "The Freightliner"
- Daimler-Benz *Prototype*
- GNSS *plus*
- Stereo Camera Reads Lanes
- Short and Long Range Radars

- The World's First Self-Driving Semi-Truck Hits the Road (May 2015)

- Including: V2V

Vehicle to Vehicle Communications – What are adjacent vehicles doing?

European Demonstration: Truck Platooning - not yet fully automatic

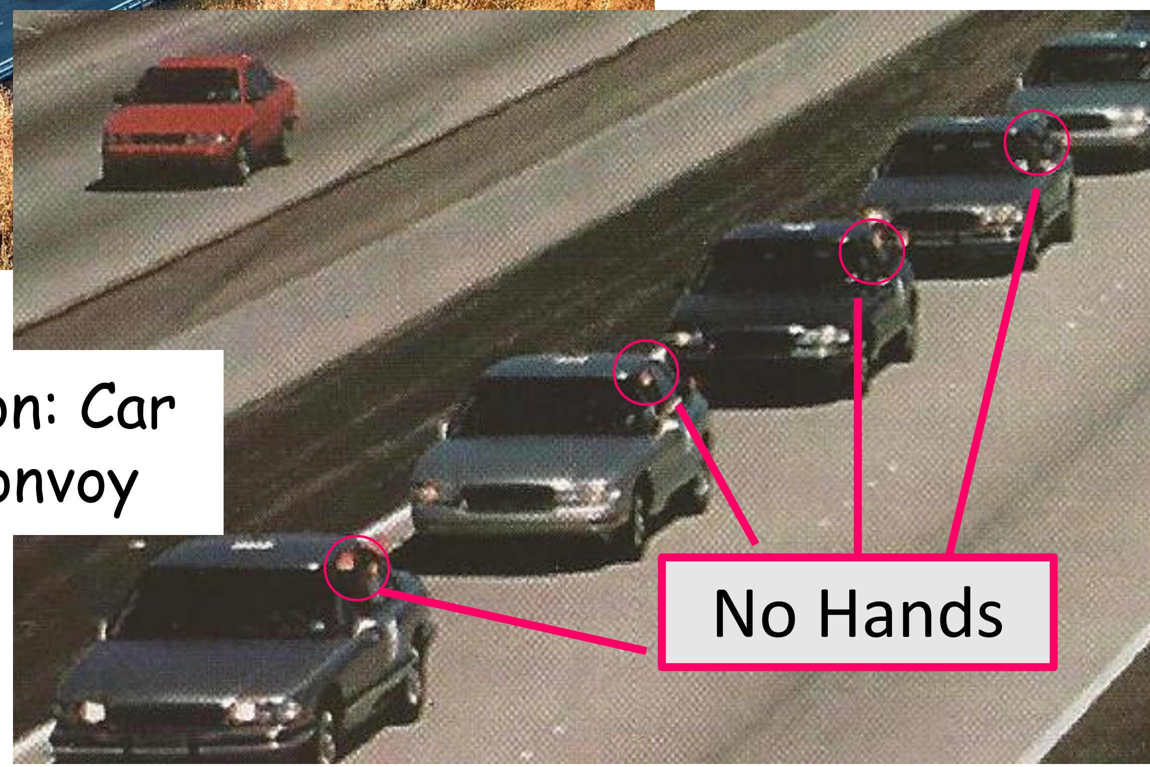


On average 10 percent less fuel per journey.

…

90 percent of driving accidents are caused by human error…

Demonstration: Car Autopilot Convoy



Payoffs of Autonomous Long-haul Trucks

Economic

- Drivers Cost ~100K$+/yr.
  - Can run for < 12 hours/day
- 3 Million Full-time drivers in US
- Predict Shortage of 240,000 drivers by 2020
- Platooning saves Fuel

Safety

- In 2012 in USTrucks involved in ~ 330,000 Accidents
  - ~ 4000 people killed – mostly in cars
  - **90% were driver error**
- Safety Features being installed: Lane Control, Automatic Braking

- **"Let the trucks drive themselves, and you can improve safety, meet increased demand, and save time and fuel."**

(Wired Magazine May 2015)

Many Issues to be resolved with self-driving vehicles

- Safety
- **Integrity**
- **Accuracy**

GNSS can help with these issues

- Affordability
- Certification
- Public/Political Acceptance

Conclusion:

GNSS can contribute for both F3 & F4

- **<u>Continue Improvements in Availabilty (ARAIM)</u>**
  - ***Frequency diversity*** (e.g. using dual frequency measurements on L1/L5 for GPS),
  - ***Geometry diversity*** (e.g. using as many GNSS constellations as possible in order to reach the required levels of satellite availability),
  - ***Use of an Integrity Support Message (ISM)*** send safety assertions for each of the core GNSS to the sovereign responsible for a given airspace,
- **<u>Accelerate Interchangeability</u>**

  (for Integrity, Availability and Accuracy)

  - 4 Satellite Ranges from 4 ***<u>Different</u>*** Constellations yields the ***<u>same Positioning Accuracy</u>*** as 4 Satellite Ranges from one constellation or:

    4 from 4 ≅ 4 from 1 - **<u>"Any four will do"</u>**