CPS and Automotive Vehicle Controls

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Advanced Engineering

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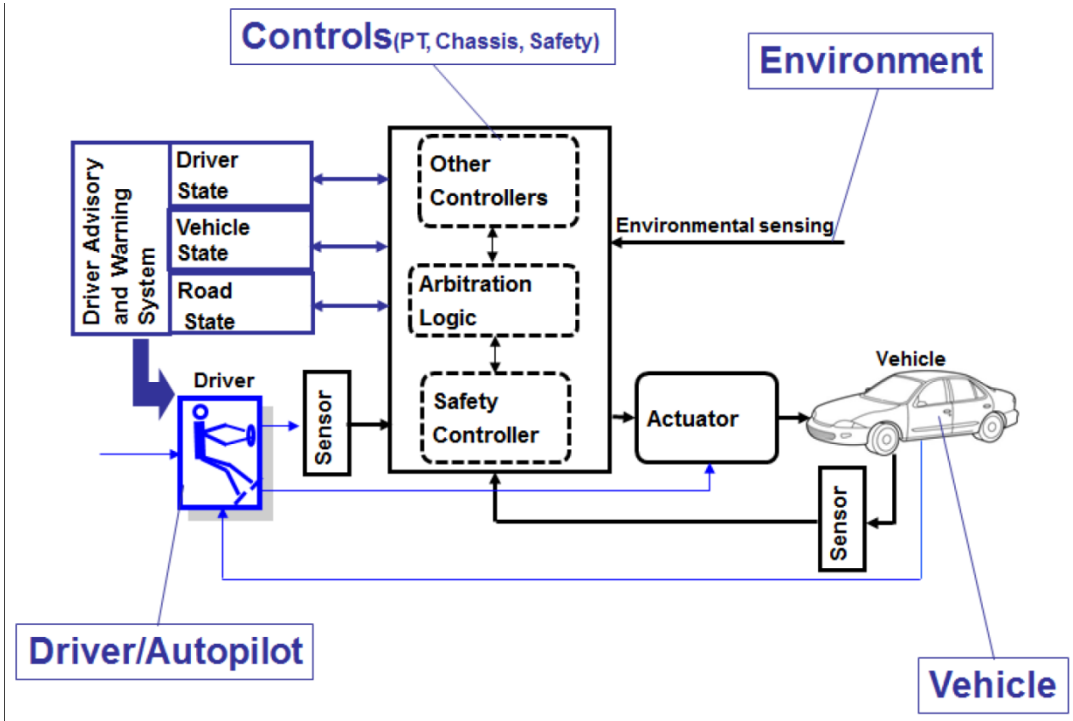
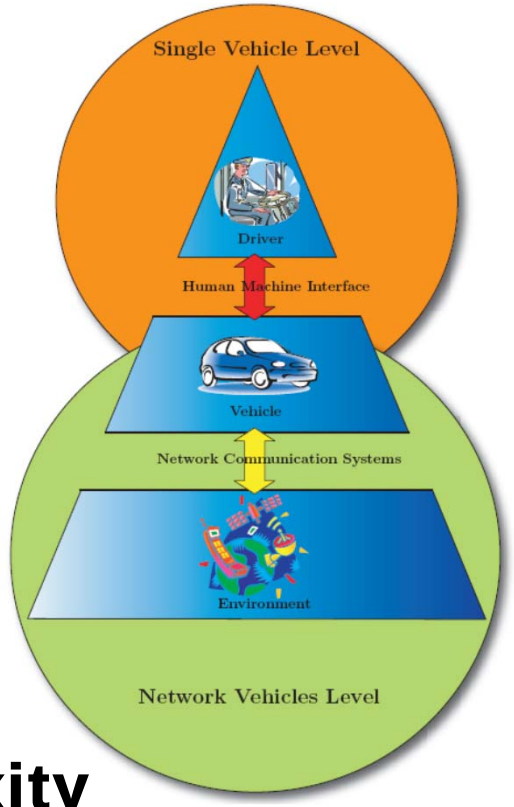
Multiple Levels of Interaction





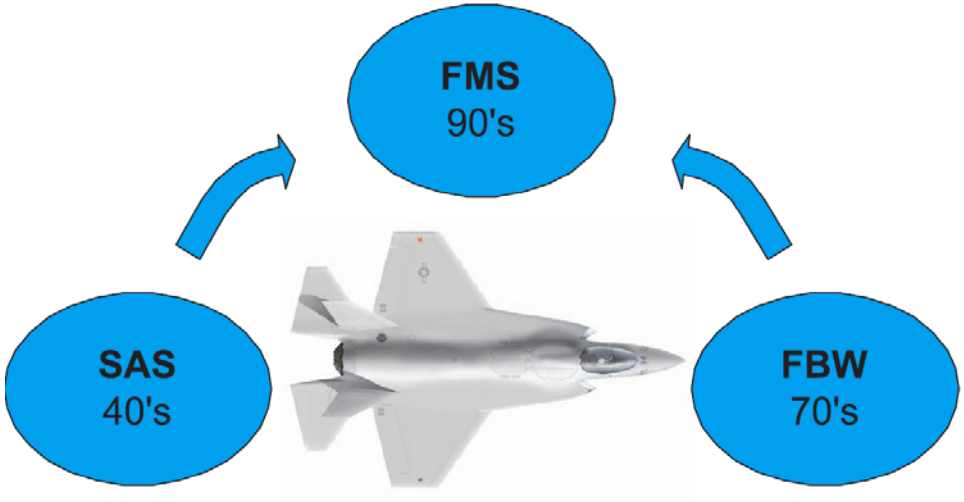
- Vehicle-driver
- Driver-DMS
- Vehicle-traffic
- DMS-vehicle
- etc

Problem complexity

- Data deluge
- Interactions
- Event upsets
- Too many options if use static architecture (V&V issues)

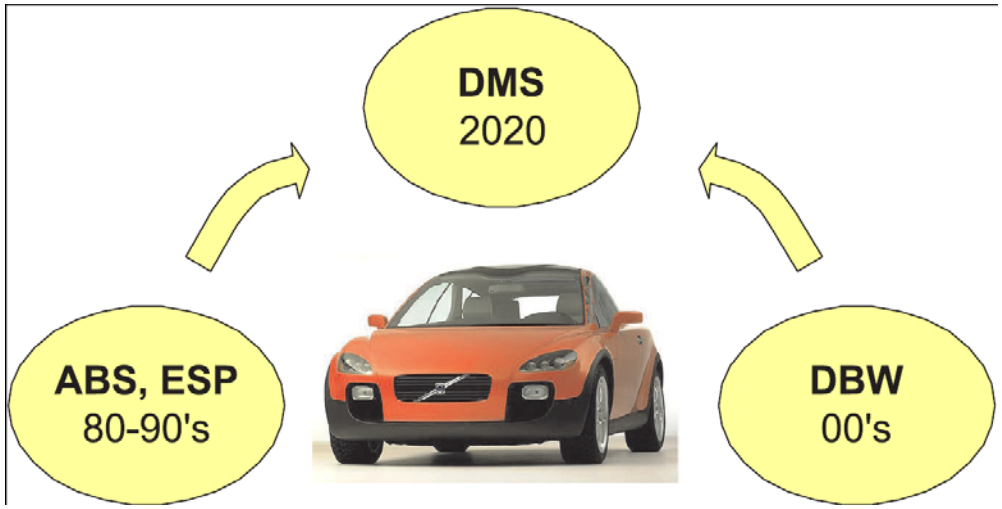
DCSL

From Aerospace to Automotive



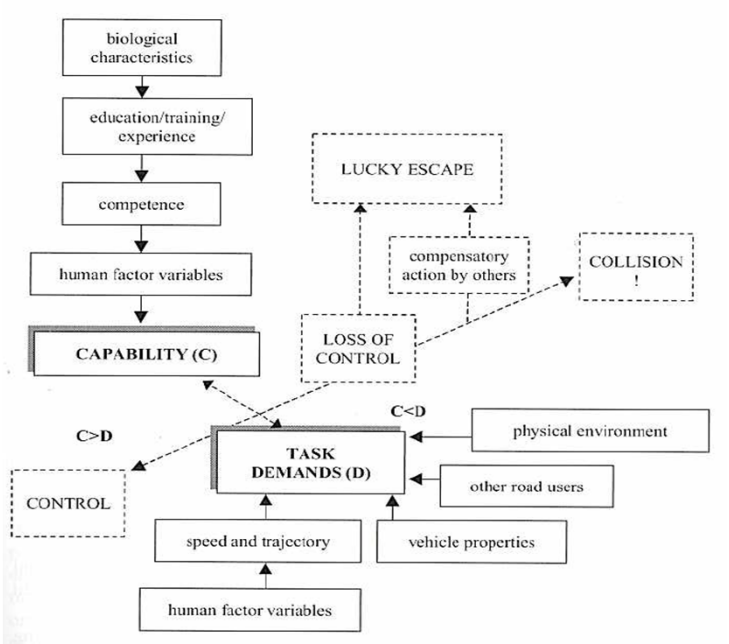
- **SAS:** increase stability of a/c modes (damping and natural freq of the short-period mode, increase damping of dutch-roll mode, etc).
- **FBW:** computer-in-the-loop
- **FMS:** alleviate pilot from excessive workload; envelope protection

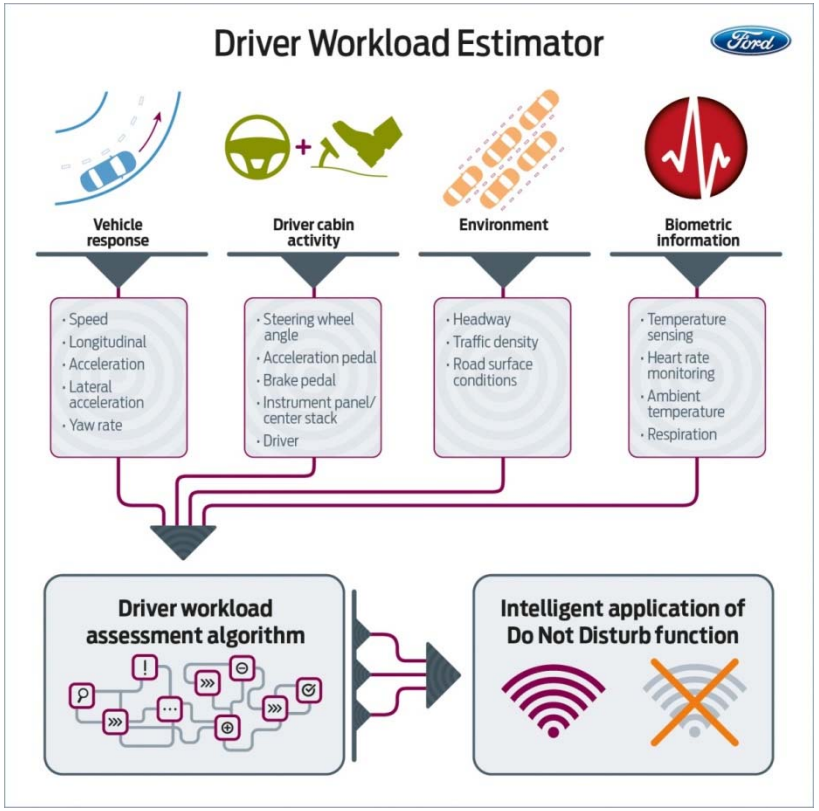
- **ABS, ESP:** braking, yaw-stability, roll-over avoidance
- **FBW:** computer-in-the-loop
- **DMS:** driver warning; proactive intervention. envelope protection;



Automation vs Autonomy

- When and how?
- Level of intervention (normal conditions or not)
- Accident avoidance
- Stability vs maneuverability
- Warning vs. intervention





→ **Driver's capability determination needs real-time driver model**

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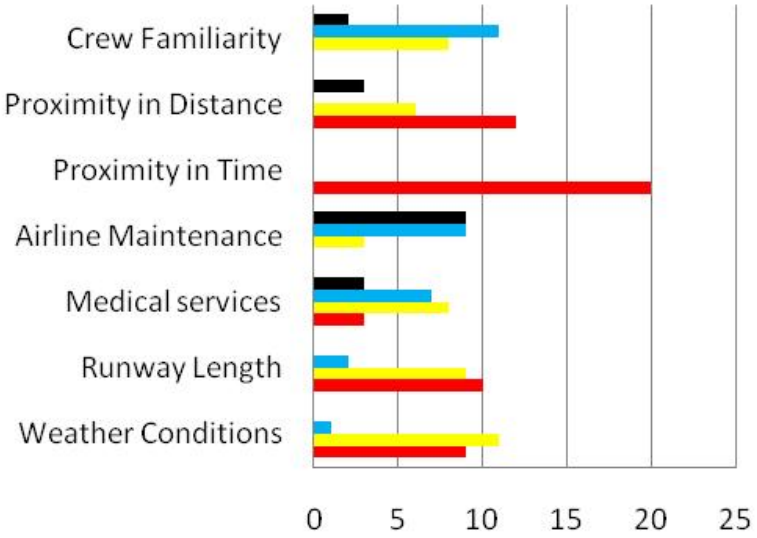
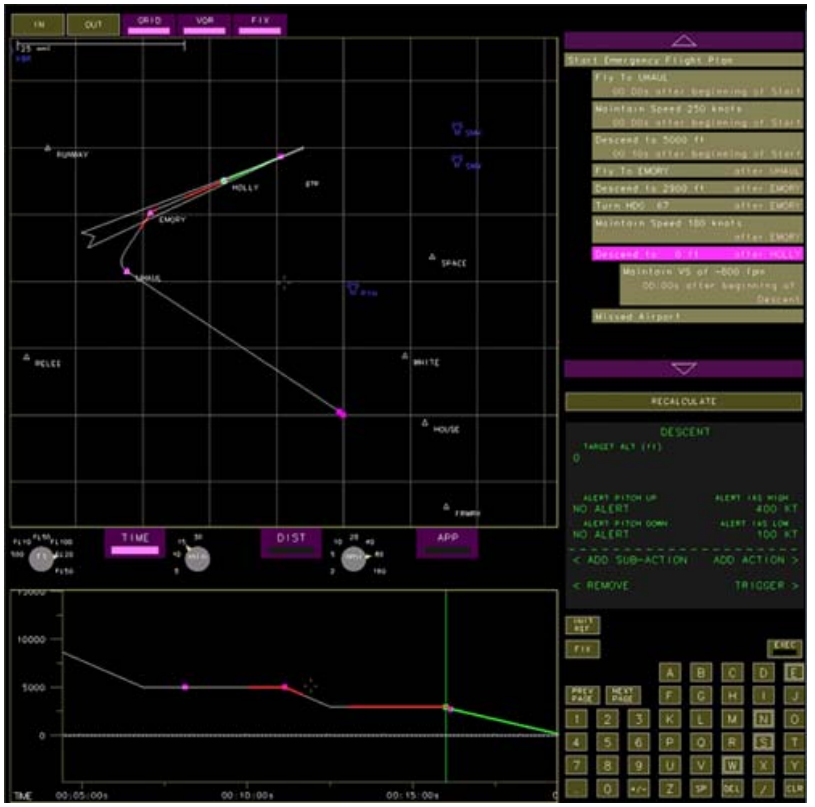
What do Pilots Think?

- Some feedback from commercial airline pilots

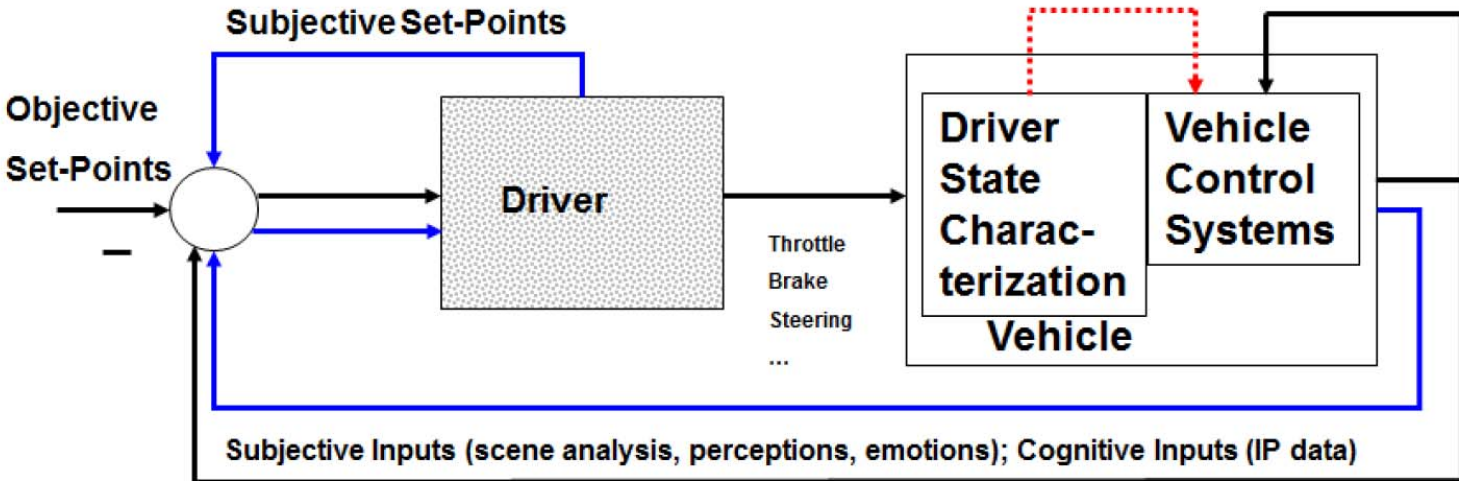




- 21 pilots participated
- Either captain or first officer
- At least 6,500 flight hours
  (ave ~13,000 flight hours)
- Majority flying B7#7 aircraft
- Additional feedback from attending Delta Airlines pilots' B777 training certification sessions

DCSL

Personalization and Adaptation



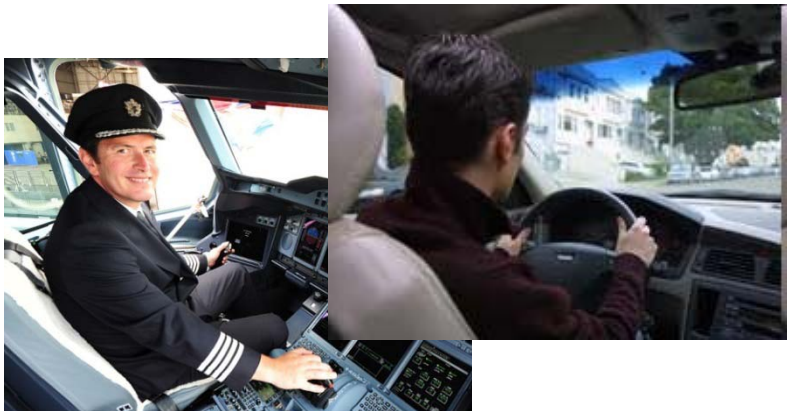
To **sense, learn and anticipate** driver's wants, habits, intentions, and adapt accordingly.

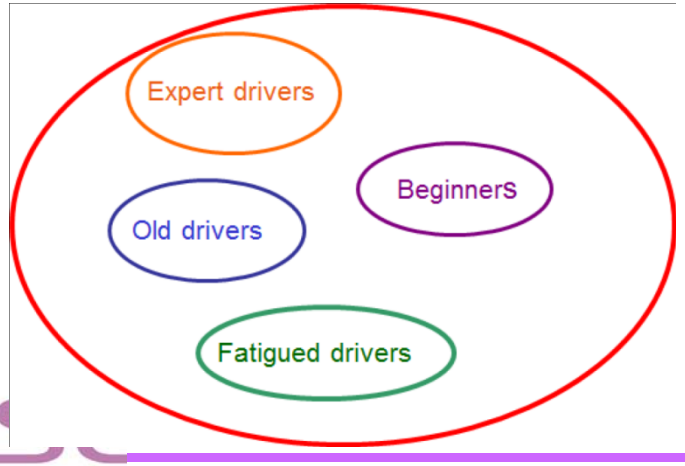
- Control **mode blending** based on driving style
- Gain scheduling safety systems accommodating **driver experience levels**
- HEV energy management corresponding to **driving habits** under alternative route and traffic conditions

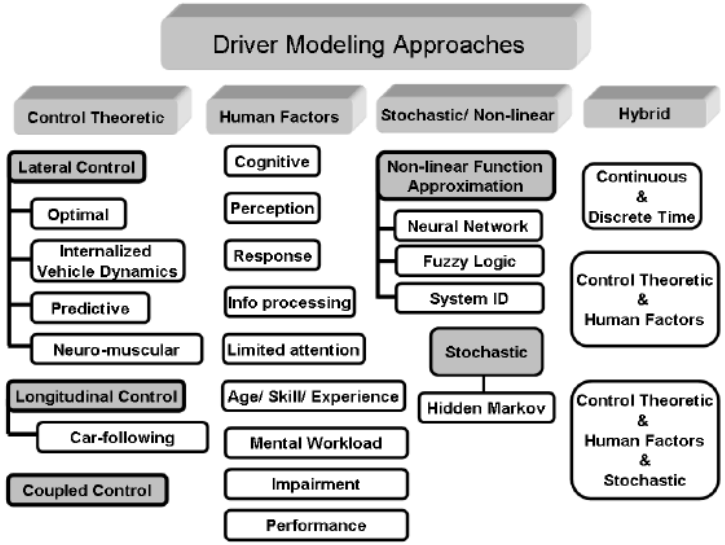
→ **Electronic controls needs to model the driver for control adaptation**

Uniformity Issues

- Short term condition
- Long-term habits
  - A lot of prior work in modeling human drivers
  - Are these suitable for active safety control design?
- Pilots vs drivers
- Towards a more like “human-like” driver-assist?
- Customer opinion







P. Boyraz, A. Sathyanarayana, and J. H. L. Hansen, “Driver behavior modeling using hybrid dynamic systems for ‘driver-aware’ active vehicle safety,” in Enhanced Safety for Vehicles, (Stuttgart, Germany), June 13 – 15 2009.

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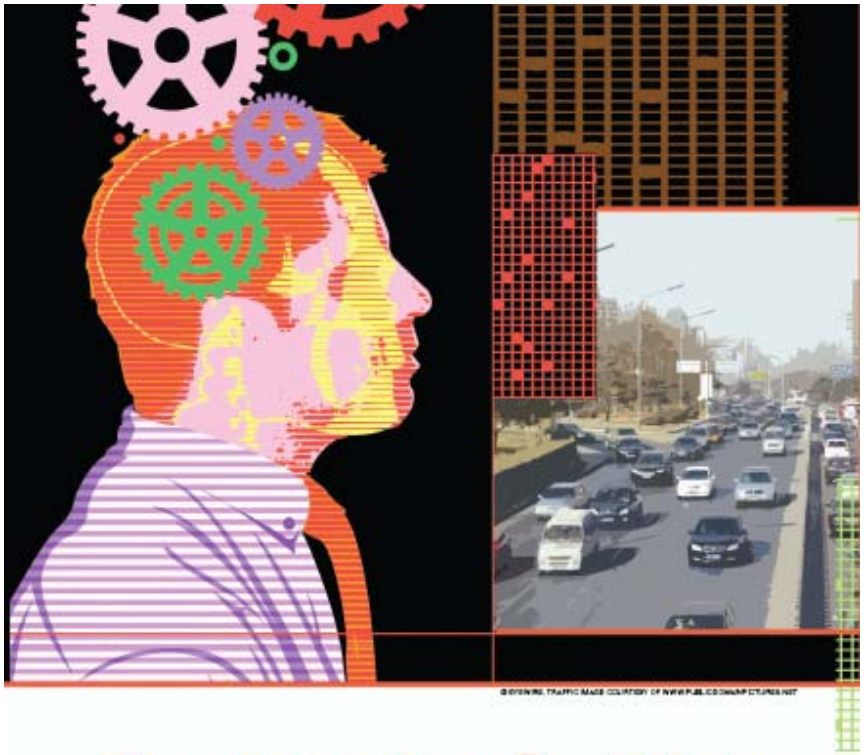
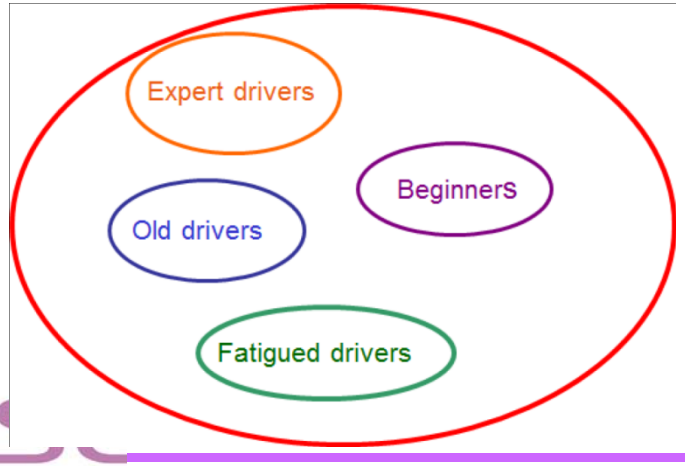


The Attentive Co-Pilot:
Towards a Proactive Biologically-Inspired Advanced Driver Assistance System



Software Challenges

- Complex computing: premium car software reaches currently 100, soon 200~300 million lines of code
- Large number of ECUs: 70 to 100; virtually independent
- Customer "app" mentality: expecting increasingly sophisticated functionality in "the palm of their hands"; expecting prompt action; wanting more (market pull)
- Must be capable of dealing with upsets and abnormal driving
- Future mobility demands even more software to deal with information rich transportation systems

?Continue enhancing current systems or pursuing alternative?

An alternative:

→utilizing new information

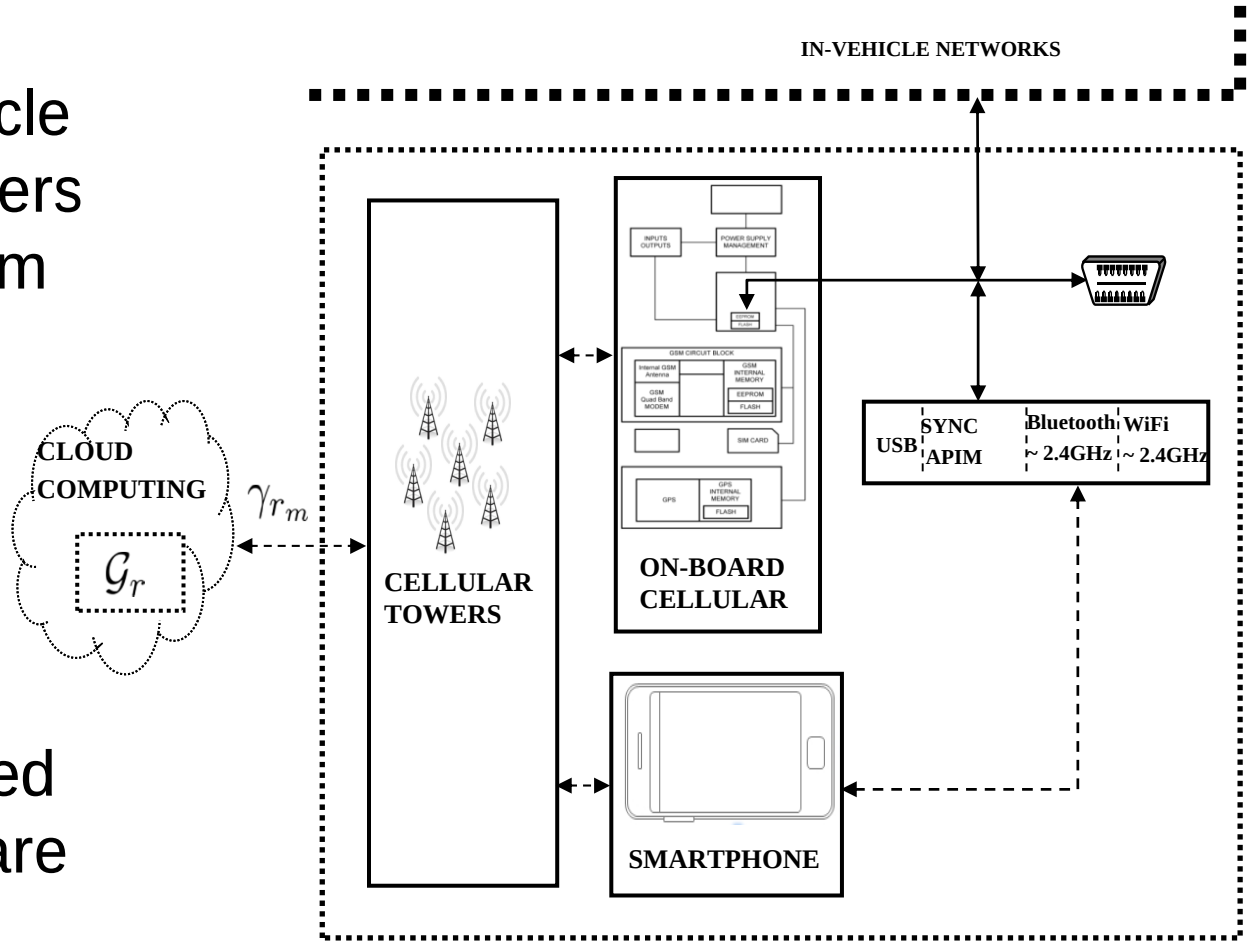
→using flexible but powerful computational resources

How does one certify "human-like" autonomous systems?

Vehicle-Cloud Interaction

Interfacing cloud server with in-vehicle networked controllers needs a new system consisting of

- cloud enabled hardware
- communication device
- services provided by cloud software agents



- D. Filev, J. Lu and D. Hrovat, "Future Mobility: Integrated Vehicle Control with Cloud Computing," ASME Dynamic System & Control Magazine, No.1, Vol. 1, pp.18-24, 2013 (inaugural issue)