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Carnegie Mellon®
TARTAN
RACING

Winner of the Urban Challenge 2007

Dr.-Ing. Michael Darms

BOSS – Autonomous Vehicle, Team Tartan Racing



www.tartanracing.org

Dr.-Ing. Michael Darms
Chassis & Safety Division, BU Passive Safety and ADAS
www.tartanracing.org, www.continental-corporation.com



Why Grand Challenges?

- ▶ Drive collaboration
- ▶ Build Technology
- ▶ Build Market
- ▶ Raise all ships



SpaceShipOne and White Knight



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Urban Challenge

- ▶ Race of autonomous vehicles through urban environment
- ▶ Organized by DARPA
 - ▶ Defense Advanced Research Projects Agency
 - ▶ Central research and development organization for the US Department of Defense



Prize Money

1. 2.000.000 USD
2. 1.000.000 USD
3. 500.000 USD



www.darpa.mil

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Urban Challenge

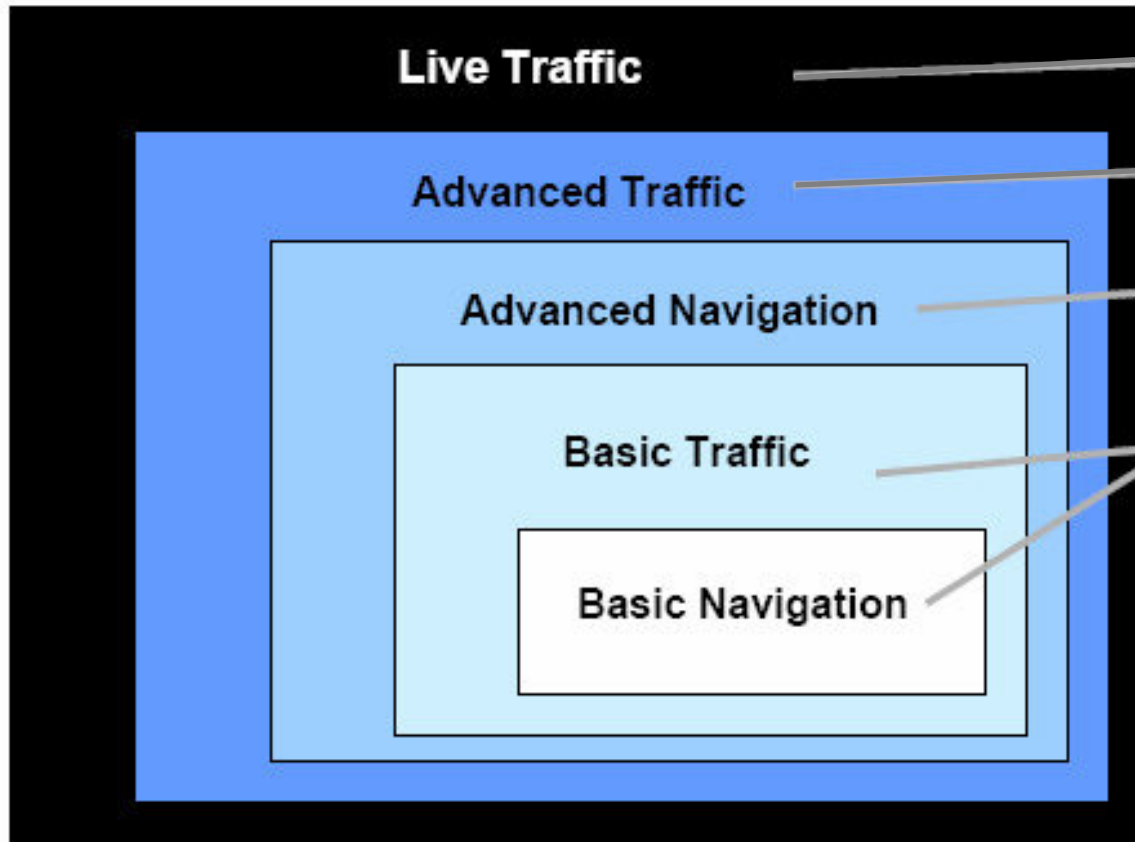
- ▶ 60 Miles in less than 6h
- ▶ Traffic and blockages
- ▶ Drive safe & efficient
 - ▶ No Collisions
 - ▶ Minimize Penalties
- ▶ Out of scope:
 - ▶ Pedestrians
 - ▶ Bikes
 - ▶ Traffic lights
 - ▶ Railroad crossings
 - ▶ Cross country driving
- ▶ Maximum 30 mph



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Urban Challenge

▶ Required Behaviors (Examples)



Final Event (November)

- All Robots on course (!)
- +50 Vehicles

National (October) Qualification Event

- Road Blockages
- Parking (with traffic)
- Pull into moving traffic

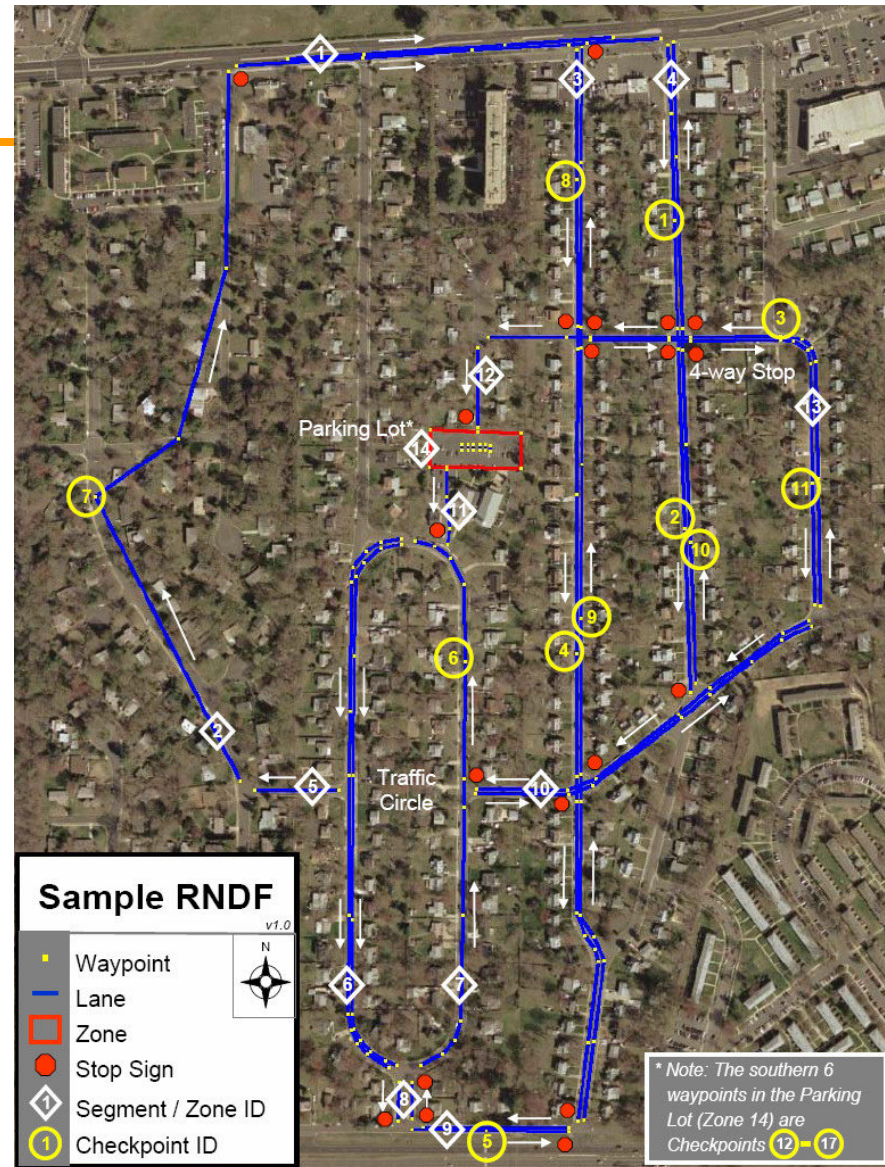
Site Visit (June)

- Stay in lane
- Intersections with traffic
- Circumvent obstacles

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Urban Challenge

- ▶ **What is given:**
 - ▶ **Road Network Definition File**
 - ▶ Connectivity between locations
 - ▶ Coarse geometry
 - ▶ **Mission Definition File**
 - ▶ Ordered list of checkpoints to visit
 - ▶ **Overhead imagery**
 - ▶ Can be used to provide fine geometry for RNDF



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Urban Challenge

- ▶ **Allowed to use:**
 - ▶ **Commercial RF signals**
 - ▶ GPS
 - ▶ Correction signals
 - ▶ No private transmitter
 - ▶ **Environment Perception**
 - ▶ Any non harmful environment sensor



Team Tartan Racing



**Pittsburgh, Pennsylvania
close to Continental, Auburn Hills**



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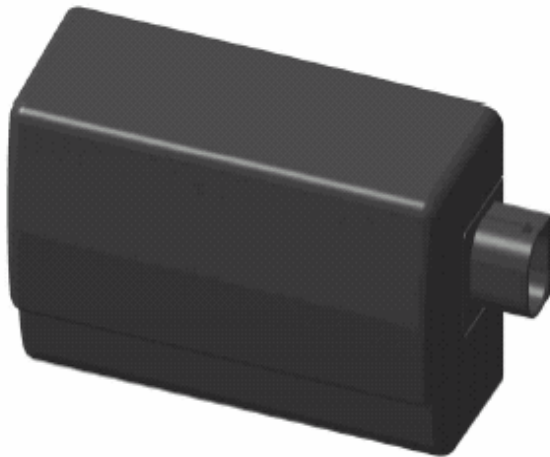
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Team Tartan Racing - Sponsors



- ▶ **Gold Sponsor of the Team**
- ▶ **One “Embedded Engineer” in the Team**
 - ▶ **Dr.-Ing. Michael Darms/Advanced Engineering**
 - ▶ **Responsible for Sensor Fusion and Tracking Algorithms**
 - ▶ **On Site in Pittsburgh for Project**
- ▶ **Provides Technology/Products**



ARS300 Radar Sensors
(5 per Vehicle)



ISF172 Laser Sensors
(2 per Vehicle)

► Provides Technology/Products



Continental Self Sealant Tires
(General Grubber UHP)



Continental Active Booster
(Tandem Active Booster
Gen.2 (9.5"))

Team Tartan Racing

▶ People



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BOSS – Autonomous Vehicle

- ▶ 2 identical vehicles (backup & parallel development)



- ▶ Development started begin of 2006, development on vehicle Oct 2006
- ▶ GM Chevy Tahoe named “BOSS”
 - ▶ In honor of Charles “Boss” Kettering (co-founder of DELCO)
- ▶ High precision GPS, Radar, Laser, Camera
- ▶ CompactPCI computing with 10 Intel Core2Duo blades, Ubuntu 6.10
- ▶ 1 TB onboard Storage
- ▶ 350PS, 2 t, 4 free seats

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Development



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Sensors on BOSS



Velodyne multi-plane scanning lidar



Continental ISF 172 fixed beam lidar



Applanix GPS/INS



High dynamic range camera



IBEO Alaska XT scanning lidar

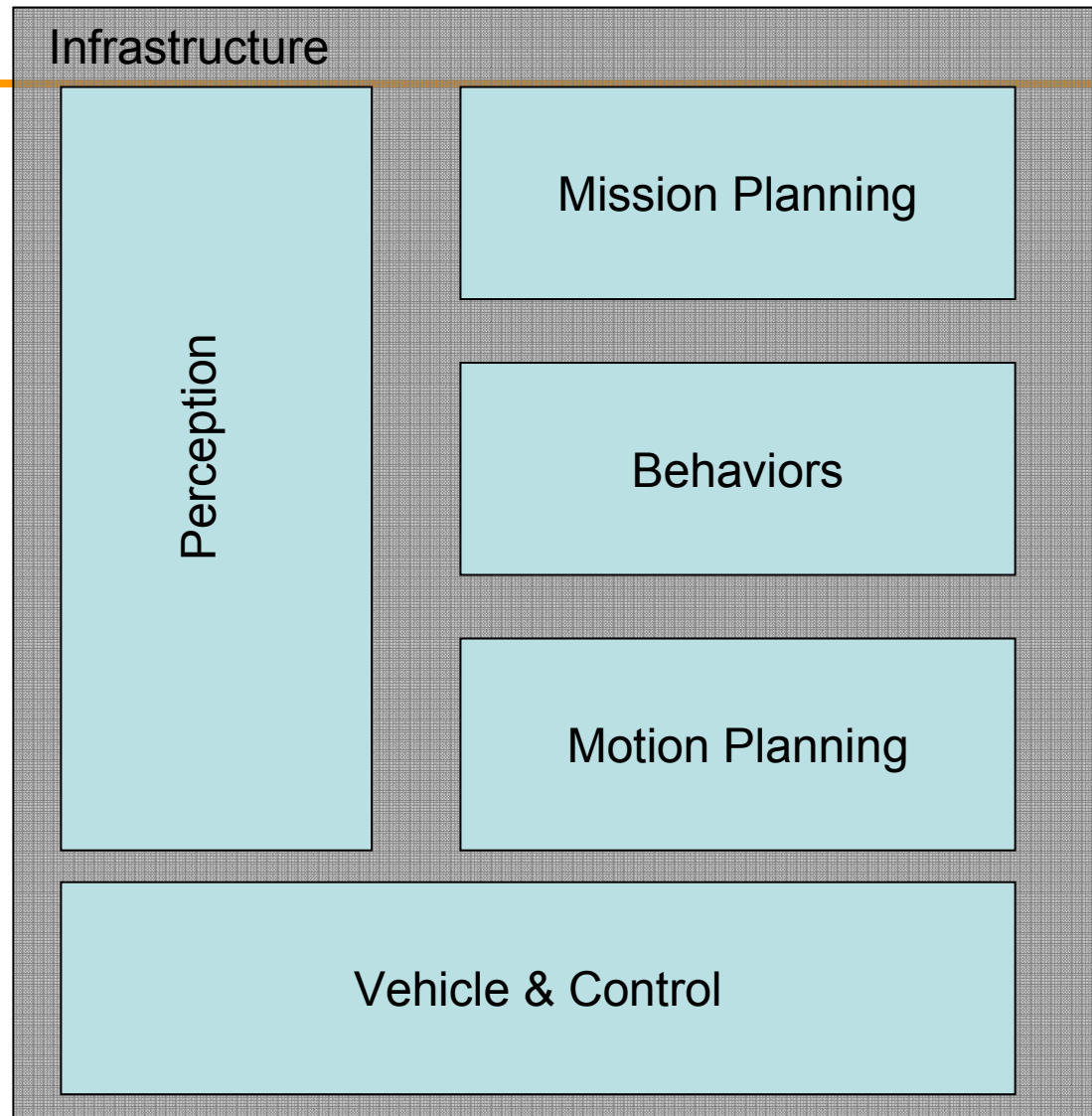


Continental ARS 300 scanning radar

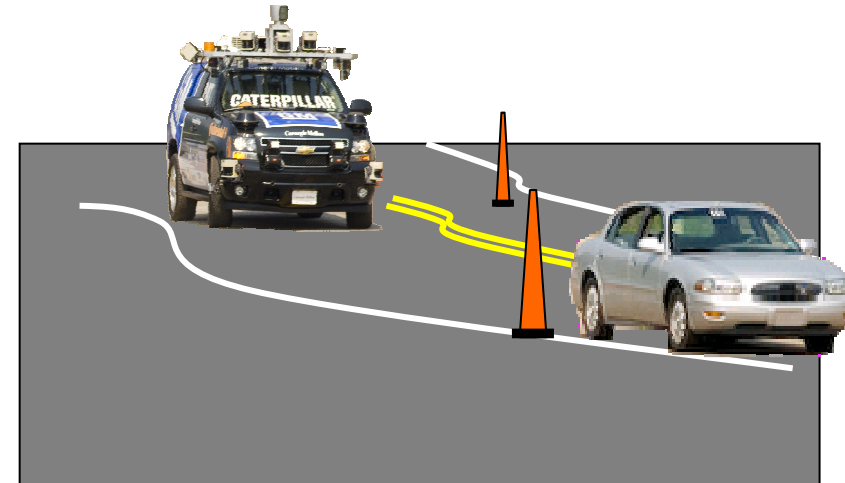
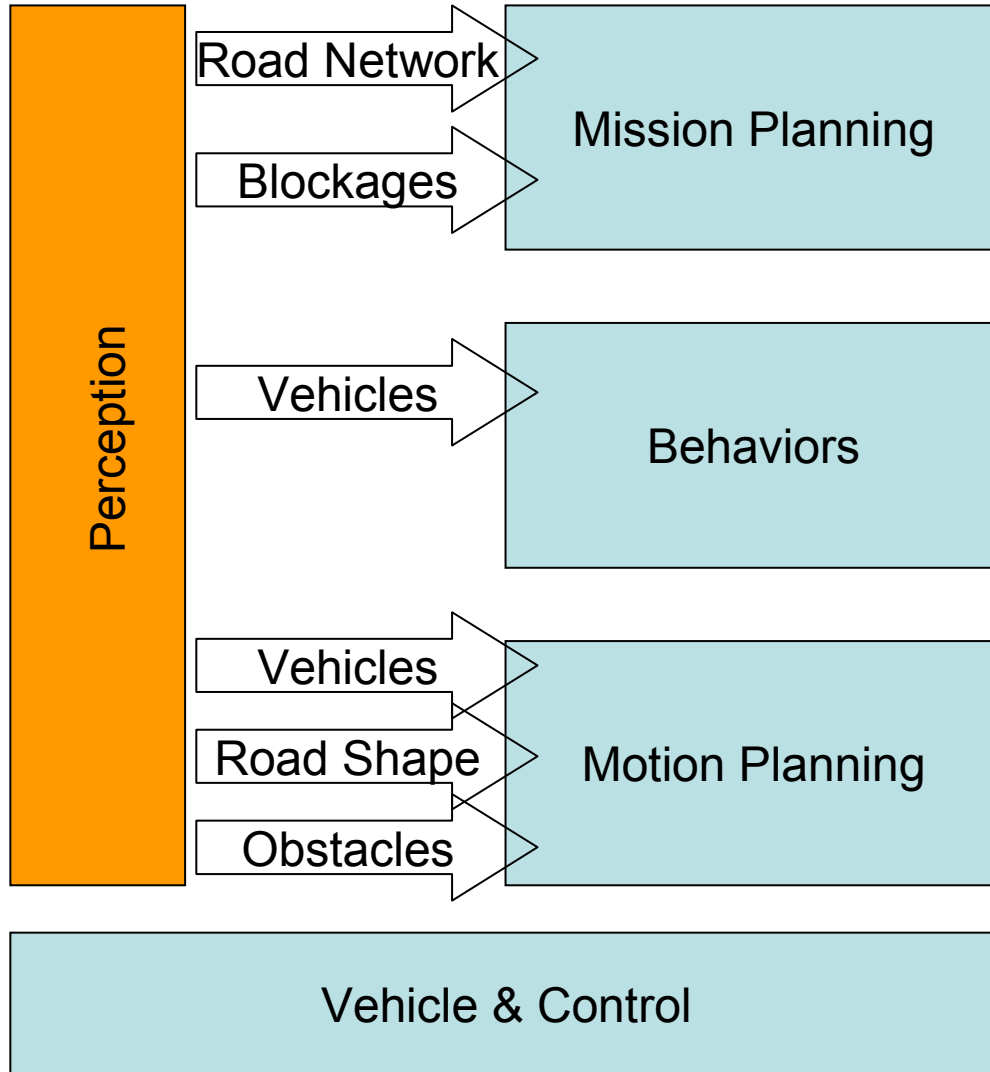


SICK LMS scanning lidar

Software



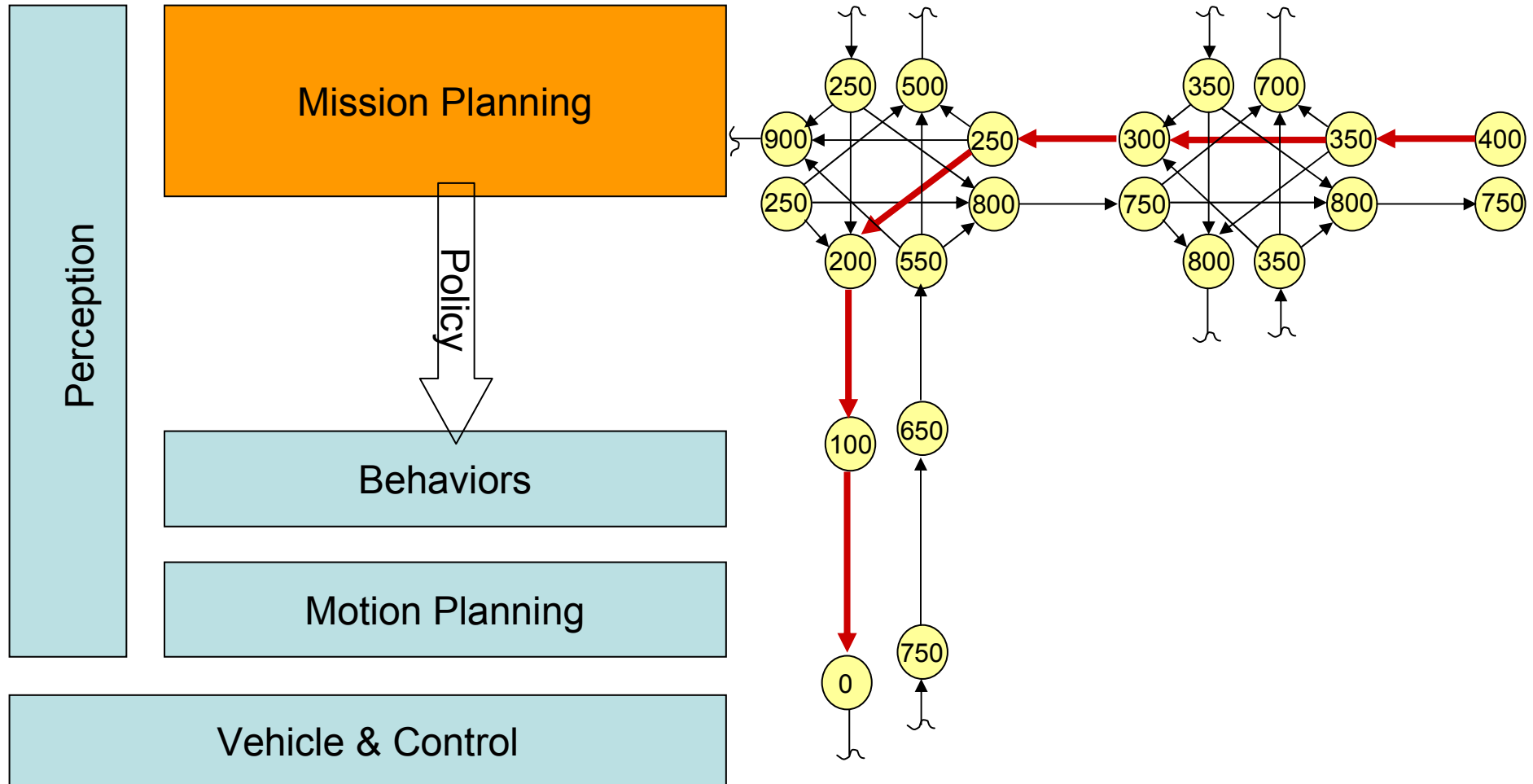
Software



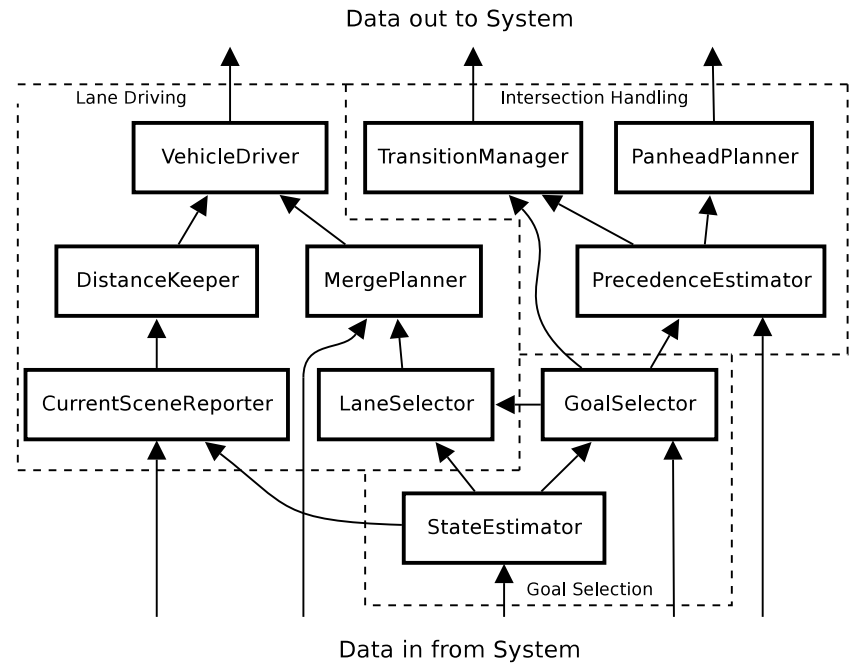
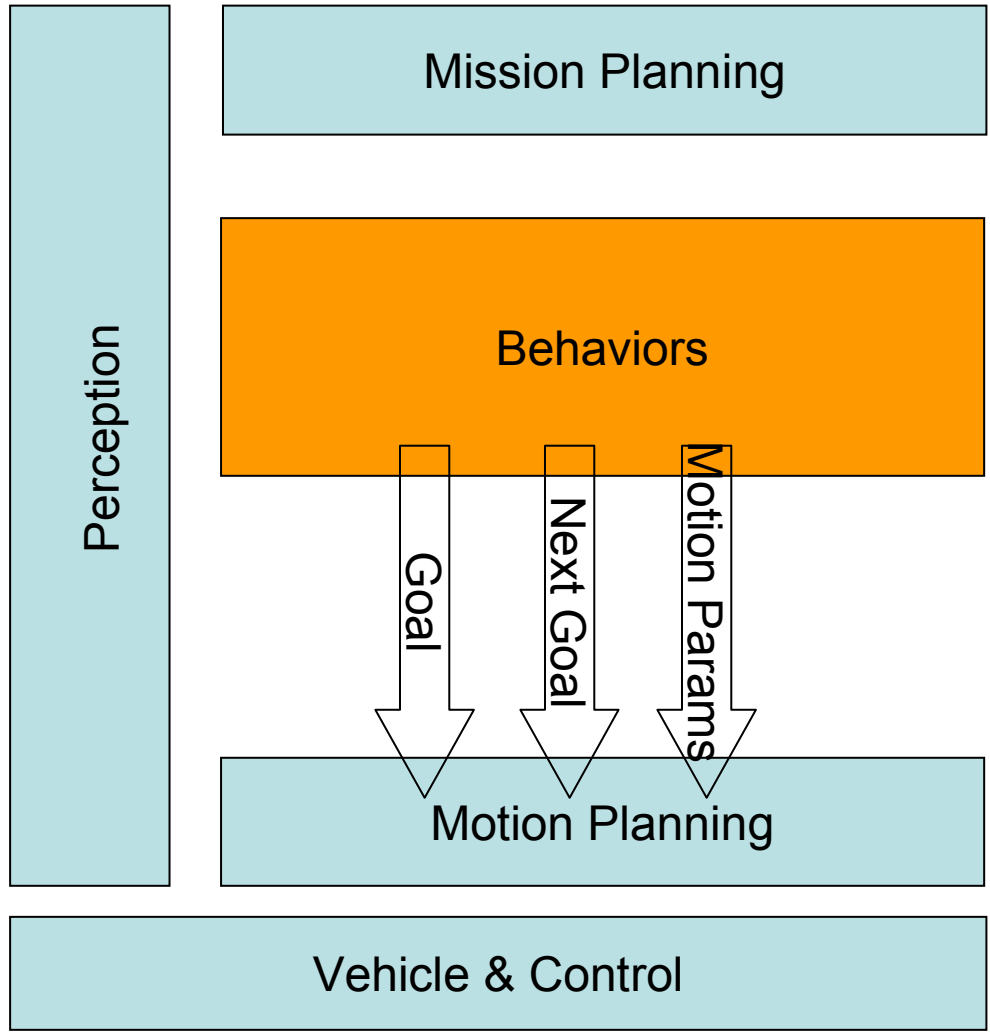
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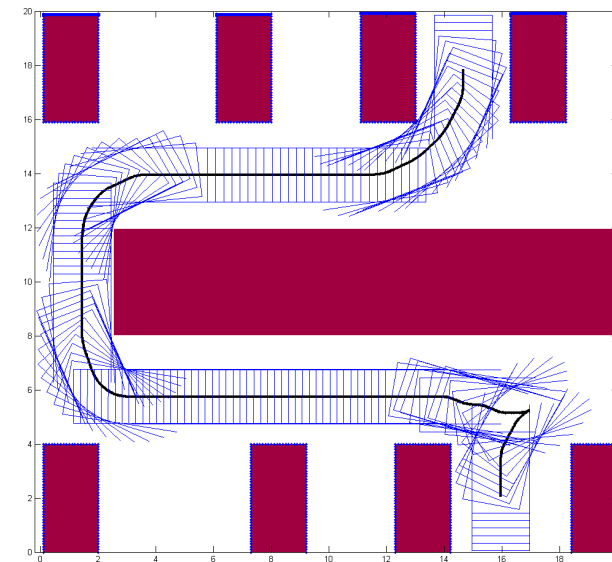
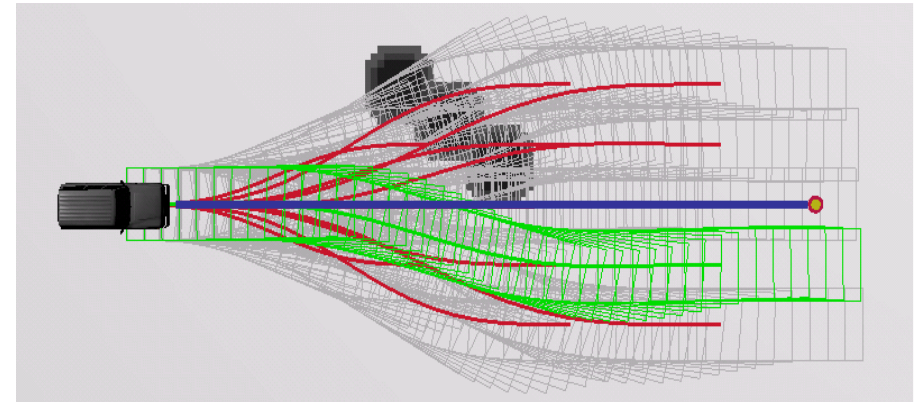
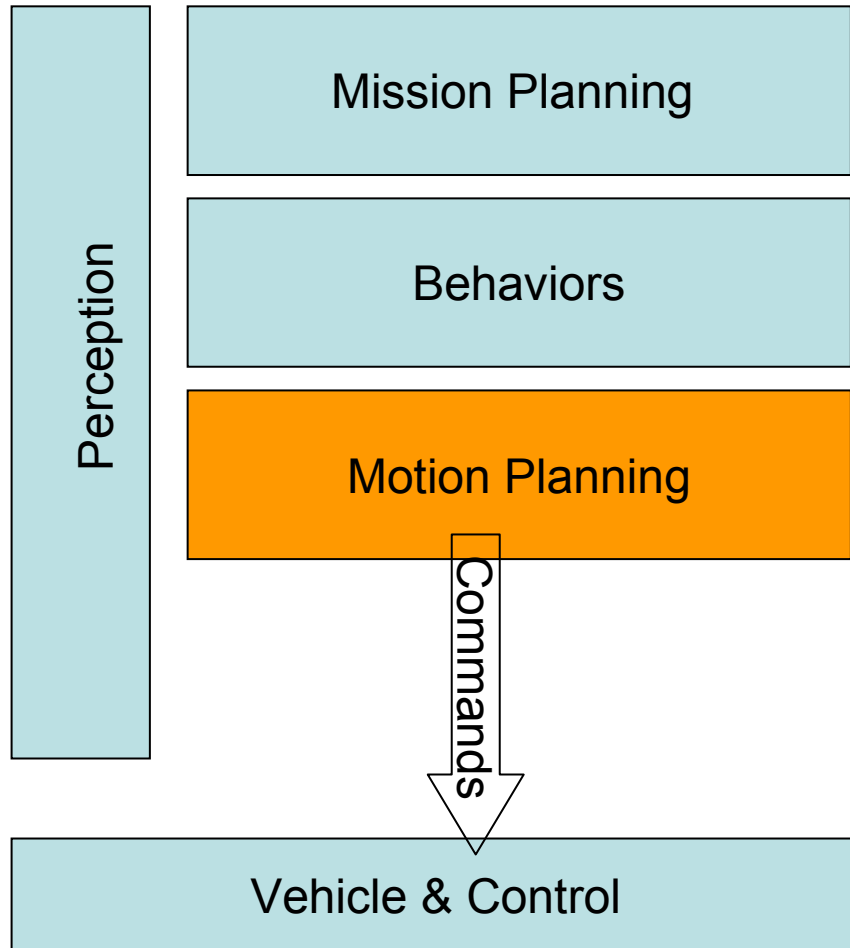
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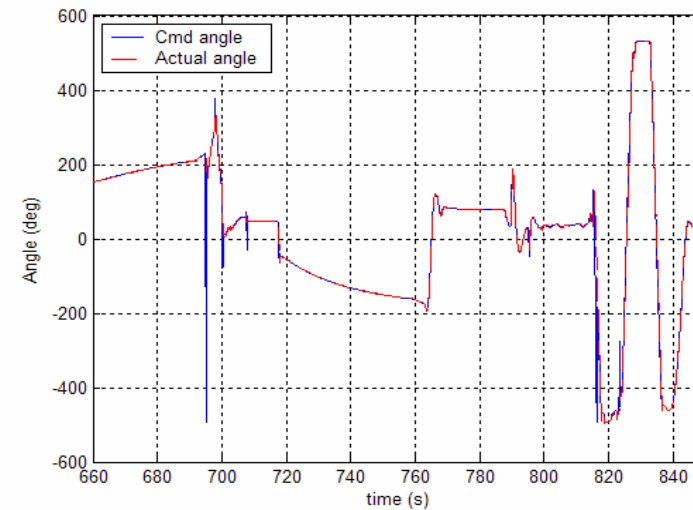
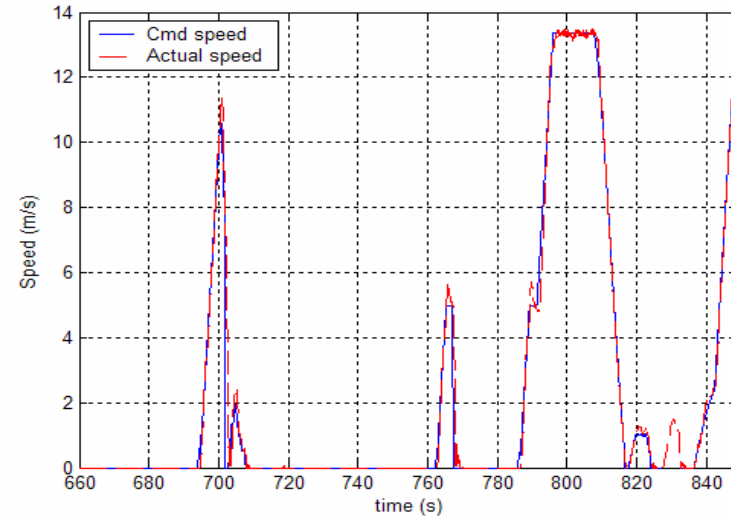
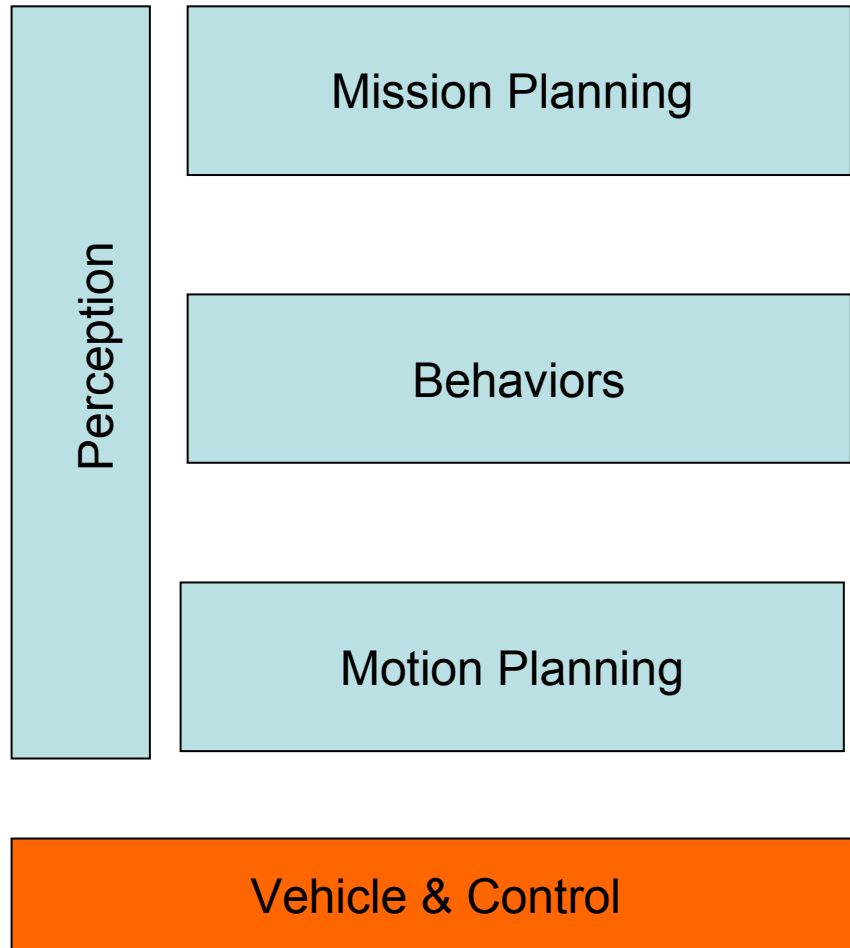
Software



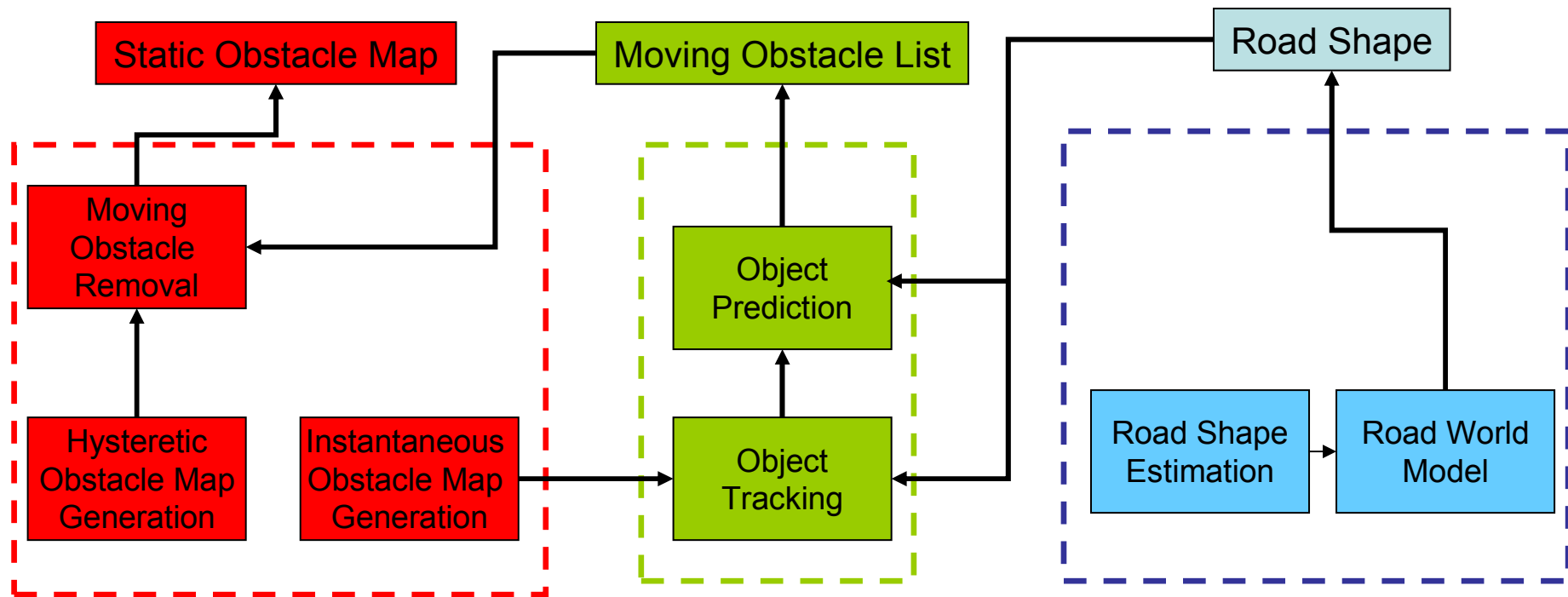
Software



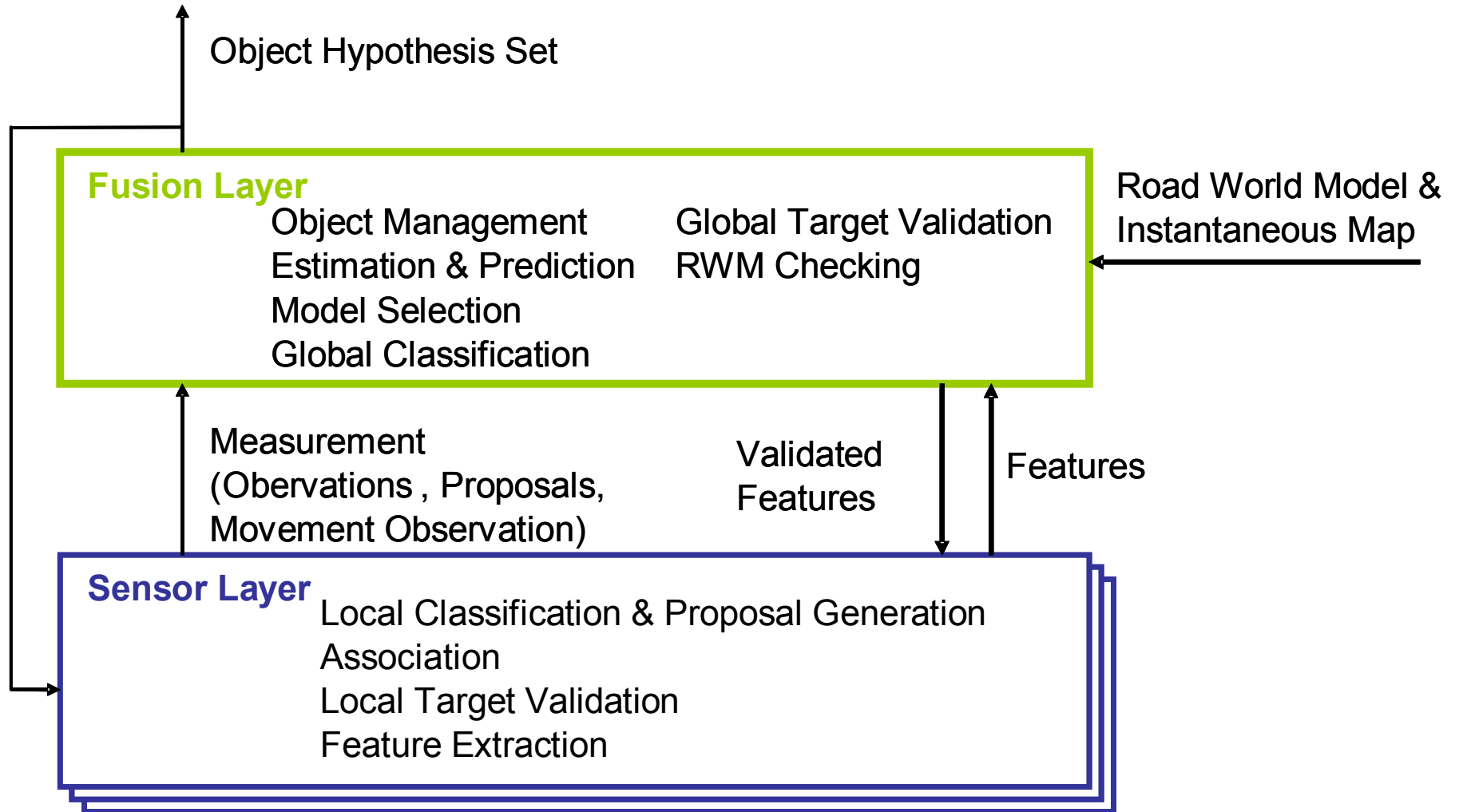
Software



Perception Architecture



Vehicle Tracking



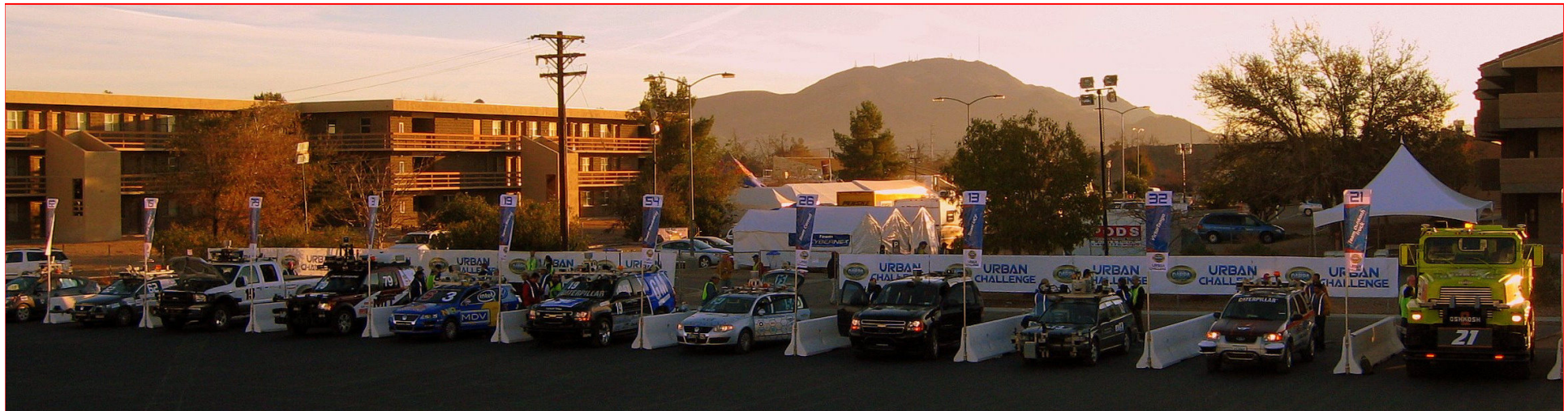
Examples

Videos on www.youtube.com: search for Tartan Racing

Urban Challenge

- ▶ Competition started with 83 Teams
- ▶ 53 Teams made it to Site Visit in June
- ▶ 36 Teams were selected for National Qualification Event end of October (35 participated)

Race Day – November 3rd 2007 – after 18 months of development time



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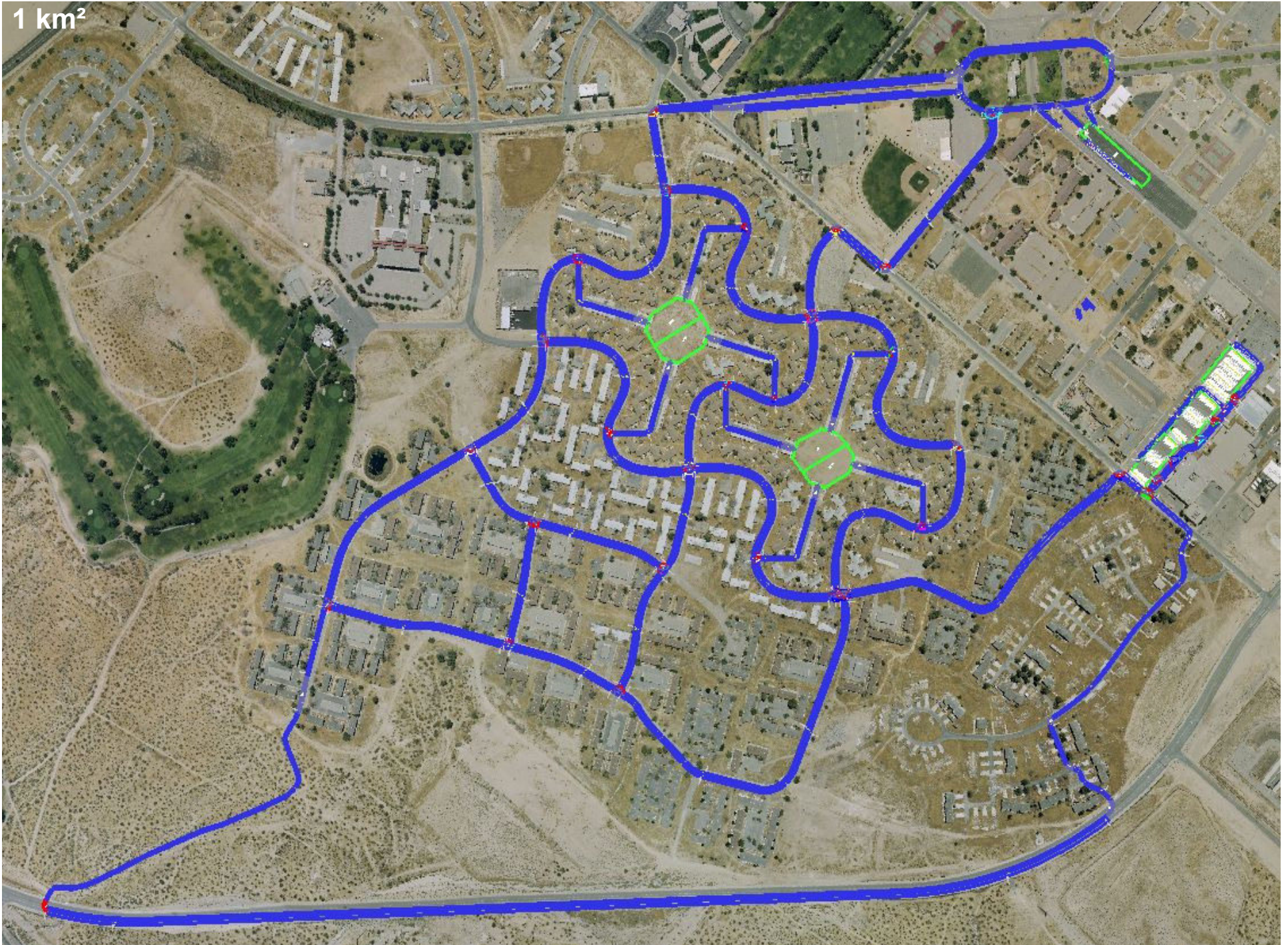
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Race Course

- ▶ **Former George Airforce Base, Victorville California**
- ▶ **Closed Area**
- ▶ **All robots and 50 stunt car drivers on the course**
- ▶ **Course was unknown until one day before the race**

1 km²



Urban Challenge

- ▶ 11 teams were selected for the race
- ▶ 6 arrived at the finish line – 3 in the time allowed by the rules
- ▶ Nobody was perfect, all were great
- ▶ Tartan Racing finished ~20 minutes quicker than 2nd over the ~4 hour run



After the race: Conti Sealant Tires helped to win the Challenge...



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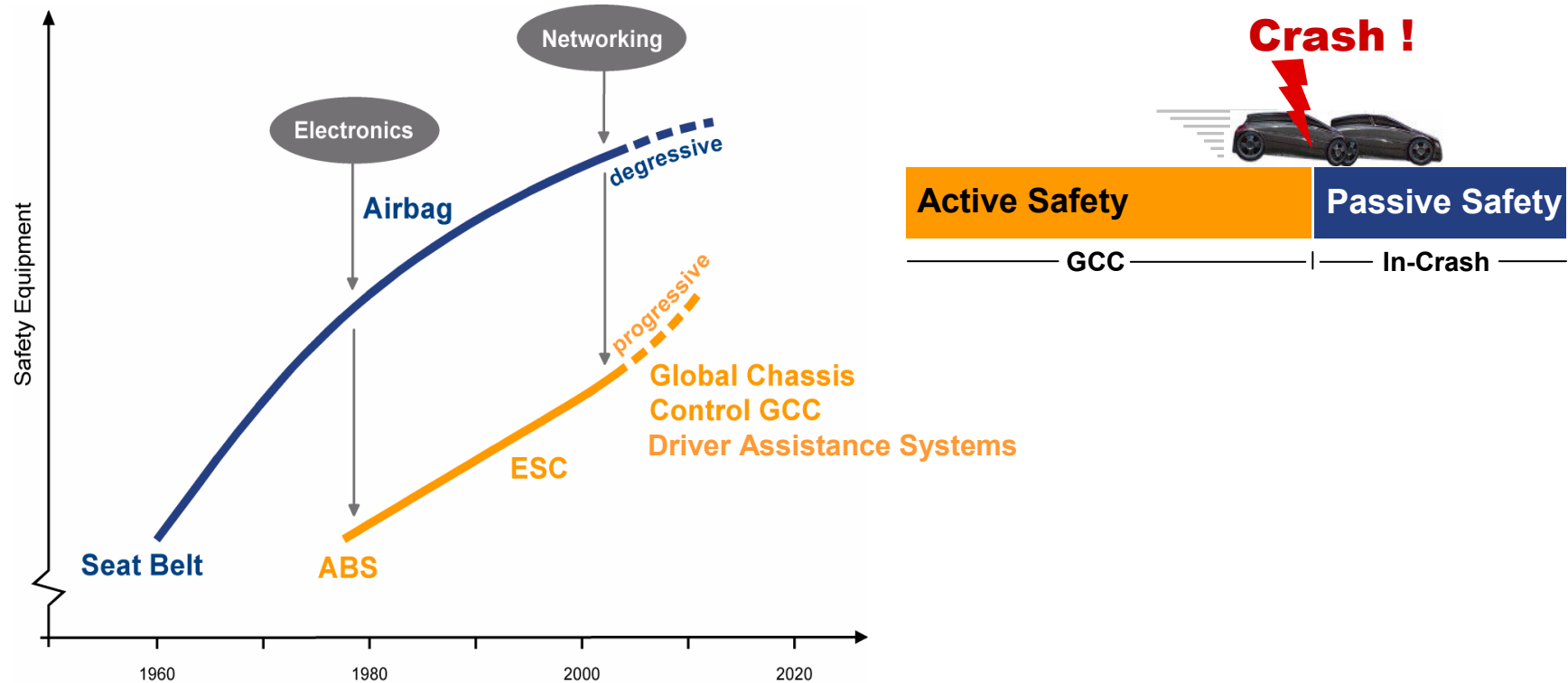
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Why did Continental participate?



Technologies to reduce Crashes and Fatalities (Today)

Active Safety to come !



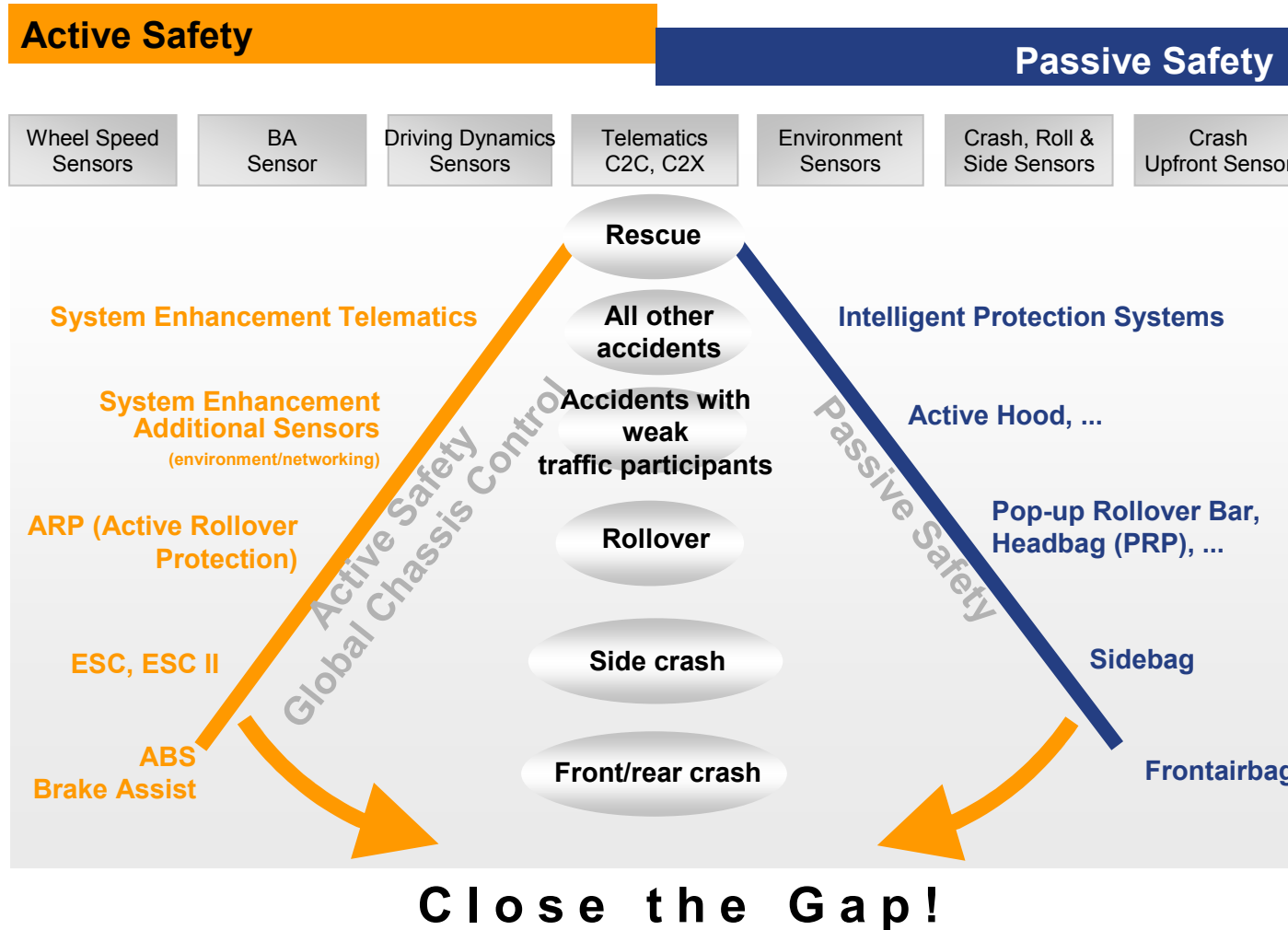
Active Safety

All measures to prevent an accident or to minimize the effects of an accident

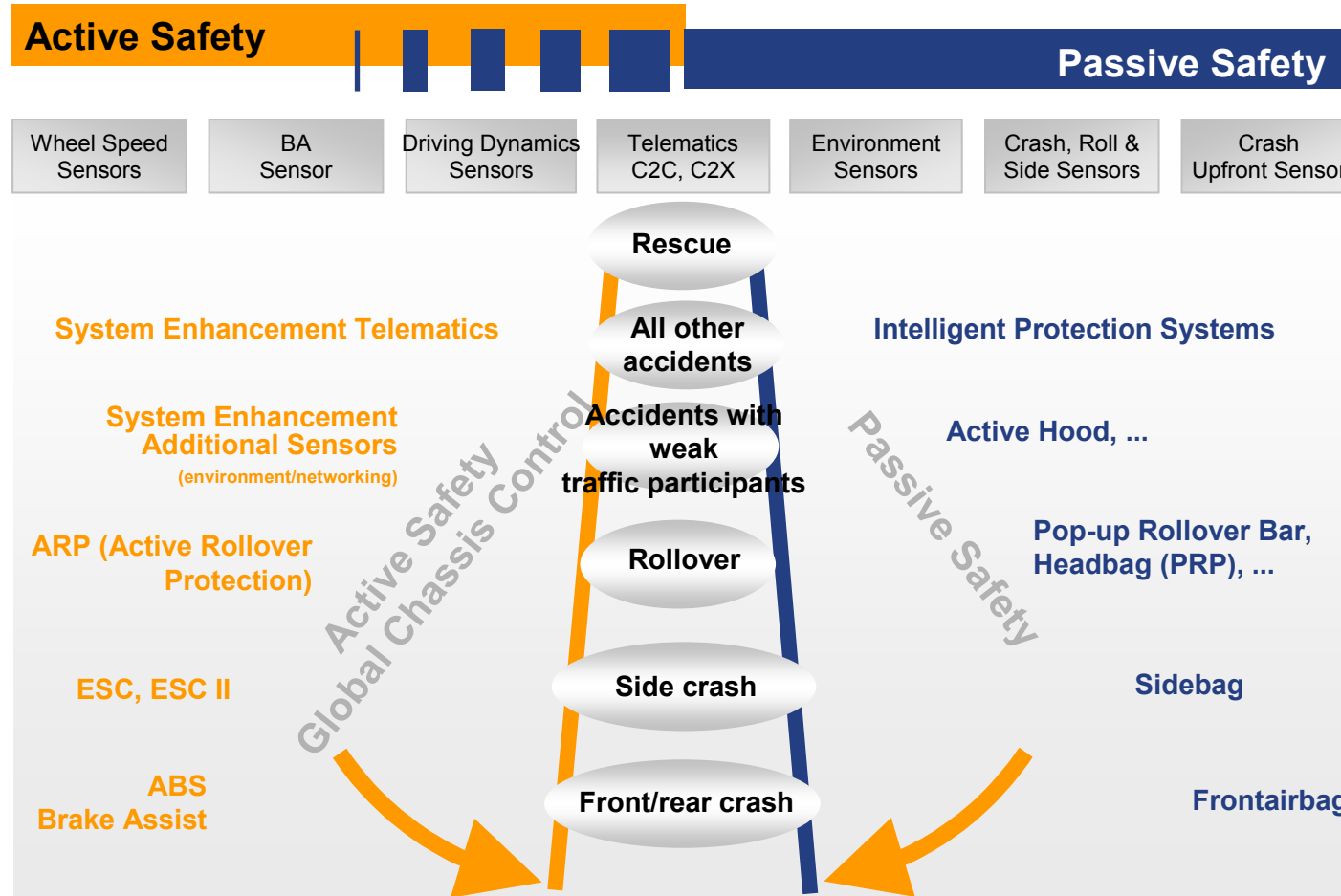
Passive Safety

All measures to protect the occupants and vulnerable traffic participants against injuries caused by an accident

Two Tasks, Two Players, One Goal

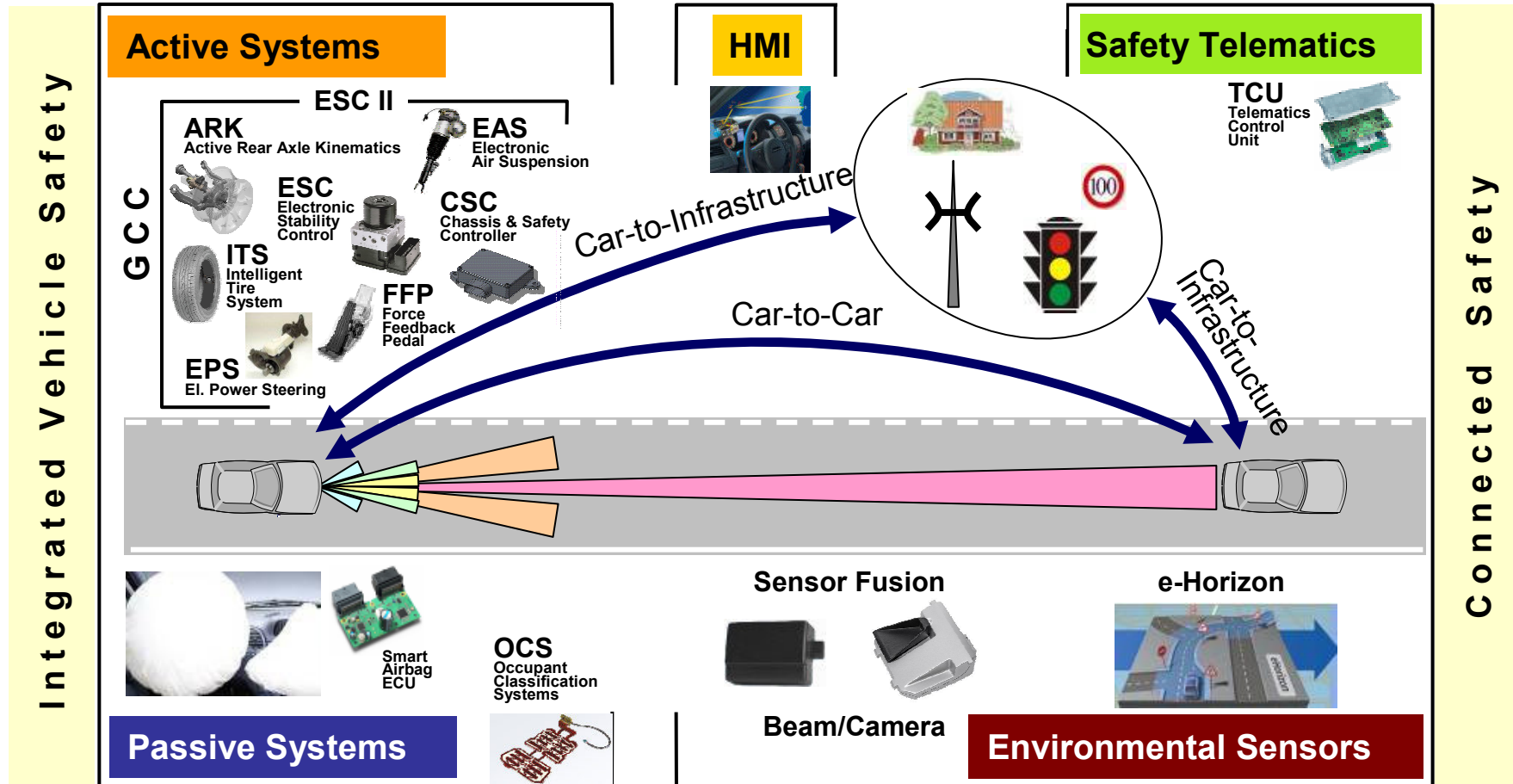


Two Tasks, Two Players, One Goal



Pre-Crash measures with Environmental Sensors and Telematics to close the Safety Gap!

Integrated Vehicle Safety, Connected Safety – The Way to the Accident & Injury Preventing Vehicle



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Conclusions

- ▶ Autonomous vehicles can be reality someday
- ▶ The technologies will definitely be used to increase safety & comfort today
- ▶ Continental's philosophy: ContiGuard
 - ▶ Integrated vehicle safety, connected safety → The way to the accident & injury preventing vehicle



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