Winner of the Urban Challenge 2007

Dr.-Ing. Michael Darms
BOSS – Autonomous Vehicle, Team Tartan Racing
Why Grand Challenges?

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

Dr.-Ing. Michael Darms
Chassis & Safety Division, BU Passive Safety and ADAS

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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
Urban Challenge

**Required Behaviors (Examples)**

- **Final Event (November)**
  - All Robots on course (!)
  - +50 Vehicles

- **National (October)**
  - 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
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
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
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
Development
Sensors on BOSS

- Velodyne multi-plane scanning lidar
- Continental ISF 172 fixed beam lidar
- IBEO Alaska XT scanning lidar
- Continental ARS 300 scanning radar
- Applanix GPS/INS
- High dynamic range camera
- SICK LMS scanning lidar
Software

Perception

Road Network
Blockages
Vehicles

Mission Planning
Behaviors

Motion Planning

Vehicle & Control
Software

- Mission Planning
- Behaviors
- Motion Planning
- Vehicle & Control

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Software

- Mission Planning
- Behaviors
- Motion Planning

Vehicle & Control
Vehicle Tracking

Object Hypothesis Set

Fusion Layer
- Object Management
- Estimation & Prediction
- Model Selection
- Global Classification
- Global Target Validation
- RWM Checking

Measurement
(Obervations, Proposals, Movement Observation)

Sensor Layer
- Local Classification & Proposal Generation
- Association
- Local Target Validation
- Feature Extraction

Features

Validated Features

Road World Model & Instantaneous Map
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
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
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…
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

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Two Tasks, Two Players, One Goal

Active Safety

- Wheel Speed Sensors
- BA Sensor
- Driving Dynamics Sensors
- Telematics C2C, C2X
- Environment Sensors
- Crash, Roll & Side Sensors
- Crash Upfront Sensor

System Enhancement Telematics

- System Enhancement Additional Sensors (environment/networking)
- ARP (Active Rollover Protection)
- ESC, ESC II
- ABS Brake Assist

Rescue

- All other accidents
- Accidents with weak traffic participants

Rollover

Side crash

Front/rear crash

Passive Safety

Intelligent Protection Systems

- Active Hood, ...
- Pop-up Rollover Bar, Headbag (PRP), ...

C l o s e t h e G a p!

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**System Enhancement Telematics**

**System Enhancement Additional Sensors**
(environment/networking)

**ARP (Active Rollover Protection)**

**ESC, ESC II**

**ABS Brake Assist**

**Rescue**

**All other accidents**

**Accidents with weak traffic participants**

**Rollover**

**Side crash**

**Front/rear crash**

**Intelligent Protection Systems**

**Active Hood, ...**

**Pop-up Rollover Bar, Headbag (PRP), ...**

**Sidebag**

**Frontairbag**

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

Active Systems

- ESC II
- ARK
- EAS
- ESC
- ITS
- FFP
- CSC

HMI

- Sensor Fusion
- Beam/Camera
- e-Horizon

Safety Telematics

- TCU

Passive Systems

- OCS
- Smart Airbag ECU

Integrated Vehicle Safety

Connected Safety

Environmental Sensors

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Carnegie Mellon TARTAN RACING

Continental

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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
Contact Information

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