C-ITS: The Future of Driving

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THE FUTURE WE DESERVE

BRIGHT SCENARIOS FOR EIGHT OF TODAY'S HOTTEST TECHNOLOGIES
PLUS WHAT COULD POSSIBLY GO WRONG?

IEEE
Where will driving be in 30 years?

Driverless Cars: Optional by 2024, Mandatory by 2044

Autonomous driving will push humans into the passenger seat

By Philip E. Ross
Posted 29 May 2014 | 16:00 GMT

Sixty years ago this month, Isaac Asimov published a short story about a self-driving "automobile" called Sally who had not only judgment but feelings, which spelled doom for the man who loved her.

It will happen—and it won’t. Fully automated cars will be common. Those cars will have judgment, and this will upend our lives, our work, and our cities. But cars will have no more feeling than IBM’s Deep Blue had back in 1997, when it beat the human world chess champion Garry Kasparov.
Learning to think
Sixty-five years of automotive baby steps

1948 Modern cruise control invented

1966 Mechanical antlock braking installed in a standard production car, the British Jensen FF

1968 Electronic cruise control invented

1987 Electronic stability control invented by BMW, Bosch, and Mercedes

1995 Mitsubishi Diamante introduces laser-based adaptive cruise control

2001 Nissan Cima introduces lane-departure warning system

2003 Toyota Harrier comes with precrash mitigation system

2007 DARPA’s third driverless-car competition, the DARPA Urban Challenge

2010 Google Car debuts. It takes a blind man for tacos

2012 Nevada offers licenses for autonomous cars

2013 Mercedes “Bertha” AG takes itself on a road trip. Mercedes S-Class gets highway autonomy (but requires attentive driver as a backup)

2014 NHTSA issues draft of proposed rule making for autonomous driving

2020 Limited self-driving expected to begin, starting with traffic-jam assist

2025 Fully autonomous cars (with driver backup) tested

2030 Fully autonomous cars (with no driver backup)

2032 Half of all new cars are autonomous

Illustration: James Provost

GNSS Futures, UNSW, 7-8 July 2014
Cooperative Intelligent Transport Systems

• Why?
  – Road safety
  – Road use efficiency
C-ITS Road Map

Use of Positioning in Vehicles is going from Passive to Active... from simple navigation to information about traffic to warnings about hazards to actively avoiding hazards.
Examples
Applications: US

1. Emergency Electronic Brake Light (EEBL)
2. Forward Collision Warning (FCW)
3. Intersection Movement Assist (IMA)
4. Blind Spot Warning + Lane Change Warning (BSW + LCW)
5. Do Not Pass Warning (DNPW)
6. Control Loss Warning (CLW)
Applications: Europe

- V2V applications
  - intersection safety application
  - safe overtaking application
  - head-on collision warning
  - rear-end collision
  - speed limitation and safety distance
  - frontal collision warning
  - road condition status
  - curve warning
  - vulnerable road user detection and accident avoidance.

- V2I applications
  - speed alert
  - hazard and incident warning
  - intelligent cooperative intersection safety
  - road departure
  - safety margin for assistance and emergency vehicle.
Required Navigation Performance (RNP) Parameters

- accuracy
- integrity
- continuity
- availability
- interoperability
- timeliness.
Positioning + Wireless Comms

- V2V with GPS is a new type of all-around object detection sensor
- Reduced cost and complexity
- Extended range up to 300 meters
- Immune to false alarms and extreme weather conditions
- Enables new types of driver assistance features

(Source: Grimm, GM, 2008)
Autonomous Sensors

- Long range radar/lidar
- Front/Rear vision
- Front/Rear short range radar/lidar
- Side short-range radar/vision
- Side mid-range radar/vision

(Source: Grimm, GM, 2008)
## Detailed requirements

<table>
<thead>
<tr>
<th>Type</th>
<th>Level</th>
<th>Accuracy Requirement</th>
<th>Research prototype</th>
<th>Communication Latency (second)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V2I: absolute</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road-level</td>
<td>95 % confidence level (m)</td>
<td>Metre</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>Lane-level</td>
<td>Root means square (order)</td>
<td>Sub metre</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Where-in-lane-level</td>
<td>Root means square (order)</td>
<td>Decimetre</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>V2V: relative</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road-level</td>
<td>95 % confidence level (m)</td>
<td>Meter</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Lane-level</td>
<td>Root means square (order)</td>
<td>Sub metre</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Where-in-lane-level</td>
<td>Root means square (order)</td>
<td>Decimetre</td>
<td>0.01-0.1</td>
</tr>
</tbody>
</table>
Candidate Techniques

• **Technique A**: Standalone (Global Navigation Satellite System) GNSS absolute positioning and V2V relative positioning with low cost GNSS receivers
• **Technique B**: Space Based Augmentation System (SBAS) absolute positioning and/or V2V relative positioning with low cost GNSS receivers
• **Technique C**: Smoothed Differential GNSS (DGNSS) absolute positioning and/or V2V relative positioning with low cost GNSS receivers
• **Technique D**: Real Time Kinematic (RTK) positioning with dual-frequency receivers
• **Technique E**: Precise Point Positioning (PPP) and V2V relative positioning with high-end GNSS receivers.
### Techniques...

<table>
<thead>
<tr>
<th>Tier</th>
<th>Technique Option</th>
<th>Status</th>
<th>Accuracy range</th>
<th>Cost</th>
<th>C-ITS applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Standalone GPS (SPS)</td>
<td>Standalone multiple GNSS</td>
<td>10-20 m</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>Standalone GNSS (PPS), Code DGPS</td>
<td>Standalone multiple GNSS positioning</td>
<td>1-10 m</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>Current WAAS Commercial WADGPS</td>
<td>Future SBAS design for multiple-GNSS</td>
<td>0.1-1m (utilising SBAS and V2V relative positioning)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Smoothed DGPS</td>
<td>Smoothed DGNSS</td>
<td>0.1-1 m</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>RTK</td>
<td></td>
<td></td>
<td>Medium to High</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>PPP</td>
<td>Combined PPP and RTK (seamless)</td>
<td>0.01-0.1m</td>
<td>Medium to High</td>
</tr>
<tr>
<td>5</td>
<td>Advanced D and E</td>
<td>Static positioning</td>
<td>Sub-centimetre RTK with multi-GNSS signals</td>
<td>0.001-0.01m</td>
<td>High</td>
</tr>
</tbody>
</table>
## Required Infrastructure

### Table 4.2: Additional infrastructure required for support C-ITS roll out on Australian roads

<table>
<thead>
<tr>
<th>Technique</th>
<th>CORS</th>
<th>SBAS signals and/or messages</th>
<th>Terrestrial positioning infrastructure</th>
<th>DSRC roadside units</th>
<th>Wide area wireless networks (3/4G)</th>
<th>Enhanced digital road map database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique A</td>
<td></td>
<td></td>
<td>Optionally yes</td>
<td>Yes</td>
<td>Optionally yes</td>
<td>Optionally yes</td>
</tr>
<tr>
<td>Technique B</td>
<td>Yes</td>
<td>Yes</td>
<td>Optionally yes</td>
<td></td>
<td>Yes</td>
<td>Optionally yes</td>
</tr>
<tr>
<td>Technique C</td>
<td>Yes</td>
<td></td>
<td>Optionally yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Optionally yes</td>
</tr>
<tr>
<td>Technique D</td>
<td>Yes</td>
<td></td>
<td>Optionally yes</td>
<td></td>
<td>Yes</td>
<td>Optionally yes</td>
</tr>
<tr>
<td>Technique E</td>
<td>Yes</td>
<td></td>
<td>Optionally yes</td>
<td></td>
<td>Yes</td>
<td>Optionally yes</td>
</tr>
<tr>
<td>Would the additional infrastructure be shared by other industries beyond the road industry for use in C-ITS</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Other Key Findings:

- Standalone low cost GNSS cannot meet the positioning requirements
- Europe and USA have access to SBAS signals (Australia does not)
- International C-ITS applications may not work in Australia without wide area augmentation
- Australia must follow standards
- Levels of positioning accuracy, reliability, integrity etc. unknown – how many applications require how much, urban/ rural etc
DSRC for Relative Positioning

Vehicle’s DSRC Antenna

GPS Raw Data

Vehicle’s Reference Point (GPS Antenna)

SAE J2735

BSM Part I: Vital State Data (e.g. Lat, Lon)

BSM Part II: Safety Extension (e.g. RTCM)

Vehicle-to-Vehicle Relative Positioning
What's available?

• SBAS?
Cooperative Positioning (Conventional)

**Table 2-1. Conventional CP concerns for vehicular applications**

<table>
<thead>
<tr>
<th>Conventional CP</th>
<th>Concerns for vehicular applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>DGPS</td>
<td>multipath, thermal noise, signal coverage</td>
</tr>
<tr>
<td>A-GPS</td>
<td>GPS error and availability</td>
</tr>
<tr>
<td>RTK</td>
<td>multipath, frequent signal blockage, signal coverage</td>
</tr>
<tr>
<td>SBAS/GBAS</td>
<td>multipath, thermal noise, signal coverage</td>
</tr>
</tbody>
</table>
Cooperative Positioning (Modern)

Modern CP architecture
Network Topologies (VANET)

cluster, star topologies

(a)

(b)

semi-cluster, semi-star topologies for CFO positioning

(a)

(b)
UNSW Research

• >20 papers
• Extensive examination of the use of DSRC in positioning
  – As a medium for GNSS measurement exchange
  – As a positioning signal
• Conclusion: not the silver bullet
The Roadmap: High Performance Positioning Framework for C-ITS

- Rizos, Dempster, Kealy, Feng, Dixit
- I: NPI, governance
- II: MOPS, connectivity
- III: Sensors, interoperability, infrastructure
- IV: Fault detection, response
- V: Test beds, devices, platforms, scenarios
Disruptive Technologies

• GPS Navigators

20 years coming

Ubiquitous

Redundant
Driverless Cars For $10,000? This Startup Is Challenging Google With A Simple Sensor

The Cruise Automation system mounted on an Audi. A computer is also installed inside the trunk. (photo via Cruise Automation)
The Sensor Pod

The Cruise RP-1 sees the road and cars around you through the sensor pod mounted on the roof of your car. Through a combination of cameras, radar, and other measurement systems, the Sensor Pod relays what it detects back to the Cruise Computer to make real time decisions on where to go.

Features

Precision steering
Motors mounted near the steering column make gentle corrections to keep you in your lane.

Advanced car and lane tracking
The RP-1's sensors monitor the lane markers and the vehicles around you to keep you safe.

Adaptive speed control
RADAR tracking of nearby vehicles ensures a safe following distance.

Collision Avoidance
Your vehicle will automatically slow down, or even stop completely, if you encounter traffic or a stopped vehicle.
Australia’s Role

• Driving (!) requirements
• HPPF
• Waiting for international progress on standards for
  – C-ITS
  – V2V, V2I comms
  – (Australian conditions? SBAS?)
• But good on automation of…
Mining

Still from GPSat Systems video

Driverless trucks at Rio Tinto’s Pit A
Ports

• Patrick Stevedores – world’s first automated straddle carrier
• 24 hour/ all conditions port operation
Agriculture

- Driverless tractor: no air-conditioning, no seats, doors, windscreen, dashboard, suspension…
The End