Beyond the Traditional Digital Map: Digital Horizon Data for Automated Driving

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The Enabling Technologies for Marketable Digital Horizons Are Becoming Available

In some markets, digital horizon data will be in vehicles in 2017 for fuel economy, safety, and comfort in-vehicle control processes

- The dominant barrier is data communications costs
  - The spread of carrier Wi-Fi will make practical probe data communications for static road geometry data
  - Over the next few years, many vehicles will be sold with built-in data communications capabilities
- High-speed, multi-core processors will continue to improve in-vehicle processing capacity while costs are reduced
- High-capacity data storage will become a commodity

Needed: An Approach That Is Very Different from Traditional Digital Maps

The digital horizon data can only be made by collecting probe data from vehicles

- **Data Collection**
  - Collecting probe data of the empty road and related road furniture from in-vehicle sensors
  - Transmitting mostly over carrier Wi-Fi through the vehicle's data communications capability and the vehicle manufacturer's back end
- **Data Consolidation**
  - Combining probe data to create an extensive digital horizon database of the static road network
  - Rating the reliability of each data element
- **Data Distribution**
  - Updating the in-vehicle digital horizon database for the driving area of each vehicle by sending only differences
  - Not sending traditional digital map structures such as tiles because the digital horizon database is a simple, flat structure
  - Transmitting mostly over carrier Wi-Fi through the vehicle manufacturer's back end
  - Tailoring the digital horizon database for specific in-vehicle control processes

Digital Horizon Data: Adding Images

Digital horizon data will evolve to add images of the empty road

- Initial deployment of digital horizon data will be conventional data elements and attributes
  - Flat file of road geometry and road furniture that is accessed as the vehicle moves along the road
  - For fuel economy, safety, and comfort in-vehicle control processes and initial deployments of HAD
  - Extensive, fresh, accurate and rated for reliability
- The main sensors for highly automated driving (HAD) are image sensors (camera, radar/lidar)
- For HAD, digital horizon data should also provide a reference of what those sensors 'see' in the way that they 'see' it
  - Initial digital horizon data will need to be complemented by image-based representations of the road ahead
  - Digital horizon data for HAD will have empty road reference views of what each sensor 'sees'

Cost Is a Major Factor for Probe Data Communications Requirements

- For HAD, support for the service life of the vehicle is likely to be necessary
- The cost of data communications must be carefully controlled using intelligent strategies
  - Big cost reductions for a vehicle manufacturer can come from small cost reductions per year per vehicle when data communications costs are paid with the sale of the vehicle for the life of the vehicle
- The protocol and frequencies used by the in-vehicle data communications device should be updatable over the air
  - Software-defined radio technology should be commercialized to avoid vehicle equipment replacement
  - Costs will also be reduced if the V2V DSRC protocol is mainstream TD-LTE Direct DSRC protocol

Data Communications Volumes Must Be Carefully Managed

- Compress image data highly
  - Possibly more than 1,000:1
- Do not send tiles or similar constructs
  - Not needed because the database is a flat file
- Communicate only differences between new data and existing data
  - Differences between in-vehicle database and new data
  - Differences between the master database in the server and the in-vehicle database
- Categorize and communicate data according to priorities – safety, distance from vehicle, etc.
  - Send safety-relevant data for the near area by cellular
  - Send non-safety-relevant or safety-relevant data about non-near areas by carrier Wi-Fi or other low-cost methods when they are available
    - Sending this data by cellular is also possible but is likely to be too expensive for to be practical until cellular carriers change their pricing models and options

Thank You