DRIVERLESS FUTURES
Scenario-Based Intelligence

Fall 2014

www.strategicbusinessinsights.com
Overview

Self-driving road vehicles represent a disruption that is unprecedented in both magnitude and scope.

At the same time, the extent and timing of self-driving vehicles’ commercialization depends on the outcome of many uncertain forces that will play out in ways that no one can accurately predict.

Strategic Business Insights (SBI) has a proven process for considering the wide range of issues and uncertainties surrounding self-driving vehicles in a systematic way.

Driverless Futures uses this process to address the question: What is the future of driverless cars, trucks, and other road vehicles from a global perspective?
### US NHTSA Autonomy Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Function-Specific Automation</th>
<th>Combined Function Automation</th>
<th>Limited Self-Driving Capability</th>
<th>Full Self-Driving Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electronic stability control</td>
<td>Stop-and-go cruise control</td>
<td>Vehicle controls all safety</td>
<td>Vehicle is in total control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with automatic steering</td>
<td>functions some of the time;</td>
<td>at all times; human only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>driver must occasionally</td>
<td>provides destination input</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>assume control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Definition</td>
<td>System Example</td>
<td>Vehicle Example</td>
<td>Google driverless car</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2010); experimental</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>vehicles from automakers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and universities</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Select models from major</td>
<td>Google driverless car</td>
<td>Zoox Yolo; Google driverless</td>
</tr>
<tr>
<td></td>
<td></td>
<td>automakers</td>
<td>(2014); similar concept vehicles</td>
<td>vehicle (2014); similar</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>concept vehicles</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examples: Levels 1 and 2

TOYOTA
- The only manufacturer to have integrated driver-attention-monitoring system into the “signal path” for level-1 and level-2 autonomous systems
- Infrared cameras monitor driver’s head position, helping the system determine if the driver is paying attention and informing system response

SUBARU
- Deployed first stereo-camera array for enabling level-1 stop-and-go cruise control

AUDI
- Offers drivers a choice between different degrees of autonomous control when engaging self-steering cruise control

NISSAN
- First manufacturer to offer a “hands-free” level-2 driving experience
Examples: Level 2

MERCEDES

- Manufactures the most capable level 2 autonomous vehicle commercially available today
- Key Mercedes system differentiators:
  - Steering-assist functionality engages together with cruise control (does not require separate activation), delivering a better user experience
  - Seamless functionality across large speed range (0-124 mph)
  - System tracks and responds to adjacent-lane vehicles and obstacles

![Diagram of Radar, stereo camera and ultrasonic systems]

More sensors – more protection
Examples: Level 2.5

TESLA

• When engaged, Autopilot system:
  — Keeps the car centered in its lane of travel
  — Changes lanes automatically at driver’s direction (turn signal)
  — Manages speed automatically according to real-time traffic conditions, optical traffic-sign recognition, and fused multisensor input
  — Uses a single camera for lane, sign, and signal recognition

• All Tesla Model S vehicles in production as of Fall 2014 come equipped with all hardware necessary to run Autopilot

• New features can be rolled out over the air as they are developed and validated
Examples: Level 3

**GOOGLE**

- Most high-profile level-3 autonomous fleet
- Large amount of highway testing; very limited urban testing
- Precision navigation relies on multiple probe-vehicle lidar passes and server-based data processing
- Drivers are very bad at “taking control”
- Autonomous mode cannot handle rain, fog, or snow; Google has no current plans for how to address this
- Vehicles are now licensed in California

**AUDI, MERCEDES**

- Have received level-3 vehicle licenses in California
Examples: Level 4

GOOGLE
- Two-passenger light vehicle limited to 25mph
- Initial testing will be on Google’s main campus in Mountain View, California
- Test vehicles must retain manual controls (including steering wheel and pedals) to satisfy California regulators

ZOOX
- Concept rendering only
- Bidirectional – either end is “front”; Passengers face each other inside
- Each quadrant of car has its own computer, camera, and lidar system
- Vehicle can operate safely even if one lidar system goes offline
Net impacts could be enormous.

In the United States alone, driverless cars could save

- $563 billion in costs from injuries and fatalities
- $158 billion in fuel costs
- $149 billion in costs from roadway congestion
- $422 billion in lost productivity
- 28,800 lives

Every year. — Morgan Stanley

“Our vision is that no one is killed or injured in a new Volvo by 2020.” — Ander Eugensson, Head of Govt. Affairs, Volvo
Many industries could be disrupted.

Agriculture
- Manufacturing
- Sales/Leasing
- Financing
- Service
- Materials

Automotive
- Manufacturing
- Sales/Leasing
- Financing
- Service
- Materials

Entertainment

Energy
- Conventional
- Natural Gas
- Smart Grid
- Energy Storage

Health Care
- Connectivity
- Cybersecurity
- Internet of Things
- Telematics

Human Resources

Information Tech
- Construction
- Management

Insurance
- Vehicle Insurance
- Health Insurance
- General Liability

Logistics
- Urban Planning
- Public Safety
- Land Use

Manufacturing

Public Administration
- Personal
- Transit
- Trucking
- Multimodal
- Railway

Retail & Hospitality

Transportation
No one knows when the biggest disruptions will occur.

“In less than a year, you’ll be able to go from highway on-ramp to highway exit without touching any controls.” — Elon Musk, CEO Tesla

“Completely driverless cars are 20 to 30 years away.” — John Capp, Dir. Active Safety, GM

Series-built cars with autonomous functions “will be technically feasible this decade.” — Rupert Stadler, CEO Audi

“Nissan will be ready with … Autonomous Drive in multiple vehicles by the year 2020.” — Nissan USA

“Self-driving cars that include driver control are expected … before 2025 and self-driving ‘only’ cars are anticipated around 2030.” — IHS

“Self-driving vehicles [will comprise] 75 percent of the traffic stream by 2040.” — IEEE
Many hundreds of forces influence the timing and nature of the outcome.

Here are just a few:

- **Technology Readiness** — Will self-driving cars work? How well will they work?
- **System Cost** — Will they be affordable? If so, when? By whom?
- **Regulations** — What will be permitted? Where will it be permitted? When?
- **Customer Acceptance** — Will people trust, resent, and/or exploit self-driving cars?
- **Connectivity Requirements** — How much bandwidth is needed? How often?
- **Markets** — Who will be the customers for self-driving technologies?
- **Urban Adaptation** — How will cities welcome/leverage/limit self-driving cars?
- **Business Models** — Who will own the cars? How will people pay to access them?
SBI’s scenarios provide a sound basis for addressing uncertainty.

Conventional forecasts, including “most likely” cases, fall short.

Scenarios are not predictions. Scenarios are descriptions of alternate plausible futures.
Scenario-based roadmaps illustrate the whole business environment.

<table>
<thead>
<tr>
<th>Example</th>
<th>High-Level Roadmap: Scenario B</th>
<th>High-Level Roadmap: Scenario C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing</strong></td>
<td>2017 2020 2025 2030</td>
<td>2017 2020 2025 2030</td>
</tr>
<tr>
<td><strong>Business Models</strong></td>
<td>Consumer Lease-Only Consumer Sales (Luxury) Consumer Sales (Mainstream)</td>
<td>Consumer Lease-Only Consumer Sales (Luxury) Transportation-as-a-Service</td>
</tr>
<tr>
<td><strong>Regulations</strong></td>
<td>Regulatory Capture (Taxi Industry) Manufacturer Liability Driver Liability</td>
<td>Regulatory Capture (Service Providers) Lobbying (Taxi Industry) Driver Liability Provider Liability</td>
</tr>
<tr>
<td><strong>Technology Readiness: Sensing</strong></td>
<td>LIDAR (Conventional) LIDAR (Solid-State) Distributed LIDAR</td>
<td>LIDAR (Conventional) LIDAR (Solid-State) Advanced Machine-Vision Panoramic Machine-Vision</td>
</tr>
<tr>
<td><strong>Communications Infrastructure</strong></td>
<td>Ubiquitous 4G 5G Ubiquitous 5G V2C2V Advanced V2X V2X</td>
<td>Ubiquitous 4G “5G” (in quotes) V2C2V V2V Limited VII V2V+VII</td>
</tr>
</tbody>
</table>

© 2014 Strategic Business Insights, Inc.
Detailed charts show connections between roadmap elements.

### Autonomous Road Vehicles Product/Service/Technology Matrix

<table>
<thead>
<tr>
<th>REQUIRED TECHNOLOGIES</th>
<th>B2B Products/Services</th>
<th>End-Consumer Products/Services</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1: Example Product</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T2: Another Example</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T3: A Third Example</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T4: Fourth Example</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T5: Another Example</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T6: Example Technology</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T8: Example Tech 12</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T9: Example Technology 72</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T10: A Technology Example</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T11: Example of a Technology</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T12: Technology Example 29</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T13: Tech Example: Example</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T14: More Examples</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T15: Exemplary Example Technology</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T16: Technology Example 42</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T17: Stand-In for a Technology</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
<tr>
<td>T18: Tech Example 95</td>
<td>Example Product</td>
<td>Example Product</td>
<td></td>
</tr>
</tbody>
</table>

© 2014 Strategic Business Insights, Inc.
Roadmaps reveal discontinuities between possible futures.

<table>
<thead>
<tr>
<th><strong>Example</strong></th>
<th><strong>High-Level Roadmap: Scenario B</strong></th>
<th><strong>High-Level Roadmap: Scenario C</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing</strong></td>
<td>2017</td>
<td>2020</td>
</tr>
<tr>
<td><strong>Business Models</strong></td>
<td>Consumer Sales (Luxury)</td>
<td>Consumer Lease-Only</td>
</tr>
<tr>
<td><strong>Regulations</strong></td>
<td>Regulatory Capture (Taxi Industry)</td>
<td>Manufacturer Liability</td>
</tr>
<tr>
<td><strong>Technology Readiness: Sensing</strong></td>
<td>LIDAR (Conventional)</td>
<td>LIDAR (Solid-State)</td>
</tr>
<tr>
<td><strong>Communications Infrastructure</strong></td>
<td>Ubiquitous 4G</td>
<td>5G</td>
</tr>
</tbody>
</table>
Examining discontinuities helps companies identify strategic needs.

**EXAMPLE**

**STRATEGIC NEED IDENTIFIED:** Ability to capitalize on new sensor technologies

**Response:** Increase investment in technology licensing capability

2014  2017  2020  2025  2030

Discontinuity: 
new sensing tech

License and commercialize new tech

Enter market with Level 4 new tech

2025  2030

Lidar-based guidance technology strategy (existing)

License key machine-vision technologies

Enter market with Level 4 machine vision guidance

Discontinuity: 
machine-vision displaces lidar
Companies use scenarios and roadmaps to:

- **Enhance** strategic awareness
- **Develop** robust strategic action plans
- **Validate** technology and research investments
- **Identify** promising new business opportunities
- **Match** internal capabilities to future market needs
- **Monitor** events that impact successful plan implementation
- **Propagate** long-term strategic thinking
- **Consider** an outside view
Scenario A — Three scenarios consider the wide range of issues and uncertainties surrounding self-driving vehicles and form the basis of the comparative roadmaps. Infographics, narratives, and supporting material bring the scenarios to life.

Comparative Roadmaps — Three roadmaps (one per scenario) show the timing and progress of key elements, illustrating links between elements, discontinuities between scenarios, and the impacts of potential future developments. Covering the whole business environment, roadmaps provide a basis for developing robust action plans and monitoring events that may impact successful implementation.
Driverless Futures deliverables: (cont’d)

- **Detailed, Research-Based Analyses of Three Select Discontinuities** — Three reports, sourced from SBI’s internal knowledge base and original research, further explore discontinuities, their potential causes and timing, and their potential impacts.

- **Online Access to Rapid-Fire Updates** — Continuously updated database tracks developments relevant to the select discontinuities, providing clients with ongoing updates and analysis of new developments and their implications.

- **Client Briefing** — Client-private; hosted at client or SBI facility.

- **Consultation** — Direct access to analyst team.

- **Price:** $45,000
Why work with SBI?

- SBI has **decades of experience** in scenario planning for commercial and government enterprises.

- SBI’s scenarios teams include **consumer-behavior experts** from SBI’s world-leading VALS™ service.

- SBI works with clients to identify and map new opportunities based on emerging technology and market insights. **We combine ongoing research with consulting services.** Our research services operate across industries and cover a very broad range of technology, market, regulatory, economic, and social developments.

- SBI has a long **history of working with major automakers, their suppliers, regulators, and other stakeholders** in automotive, intelligent transportation systems, and related industries.

- SBI is the former Business Intelligence division of **SRI International** that has worked with clients on opportunities and change since 1958. Headquartered in Silicon Valley—with offices in Japan, the United Kingdom, and New Jersey—we have a global reach and work across a wide range of government and business sectors.