FORD PERSPECTIVES ON MOBILITY & AUTONOMY

Mobile Sources Technical Review Subcommittee
Washington, DC
October 18th, 2016

Presented By: John Viera, Global Director
Sustainability and Vehicle Environmental Matters
Changing Societal Trends Will Shape The Future Of Our Industry, And Will Transform The Way We View Innovation And Mobility
Fortifying And Transforming Core Business Enables Expansion Into Emerging Opportunities
While Our Industry & World Continue To Evolve Faster Than Ever, Our Entire Team Remains Fully Committed To Keeping Sustainability At The Heart Of Our Strategy

“Contributing to a better world always has been a core value at Ford, and our commitment to sustainability is a key part of our company DNA. Ultimately, our vision is to make people’s lives better by changing the way the world moves, just as Henry Ford did more than a century ago.”

“With sustainability deeply embedded in our overall strategy, we remain committed to running a strong and responsible business that treats our customers, our employees, our communities and our planet with respect.”
Ford Smart Mobility Strategy

Changing how the world moves... again.

Leverage Insights Across Connectivity, Autonomy, & Full-service Mobility Solutions To Provide Innovative Experiences Loved By Customers, Enabling A Better World
Mobility Solutions And Fuel Economy / CO$_2$

Innovations To Help Complement Vehicle Technology Improvements to Address CO$_2$ Reductions
Our New Common Data And Analytics Platforms Are Also The Foundation For Emerging Opportunities

**Connectivity**
- Vehicle Performance Insights
  - Vehicle prognostics
  - Vehicle diagnostics
  - Driver behavior

**Mobility Solutions**
- Mobility
  - Dynamic shuttle
  - GoDrive
  - GoPark
  - Data / Yield management
  - FordPass

**Autonomous Vehicles**
- Autonomous and Driver Assist Technology
  - Advanced driver assistance systems
  - Computer vision for vehicle perception
  - Deep learning for autonomous driving
  - Sensor fusion
Connectivity
Gaining a better understanding of how customers use their vehicles will enable development of products, services and experiences that excite and delight, as well as enhance sustainability.

Connectivity Blueprint

**Near-Term**
Build on SYNC, MyLincoln Mobile and MyFord Mobile

**Mid-Term**
Connect vehicles and expand capabilities
- Embedded Modem
- Connected vehicles
- Global infrastructure

**Long-Term**
Fully integrated connectivity
- Experiences get better over time

Business Model Development and Implementation
Mobility
Innovation In Mobility

Facilitate Flexible Ownership & Usership

- CAR SHARING
- FRACTIONAL OWNERSHIP
- PAY-AS-YOU-GO SOLUTIONS

Provide Multi-Modal Urban Solutions

Smart Mobility Key Strategic Areas: Flexible Use & Ownership Of Vehicles, And Multi-Modal Transportation
Transforming To Auto And Mobility Company Allows Significant Revenue Growth Potential

- Traditional Auto Revenue: $2.3 Trillion
- Other Transportation Services Revenue: $5.4 Trillion

Ford Share: 6%

Ford Share: 0%
The Move From Traditional

Each minute in the U.S. ...

30 New vehicles sold

But...

- 9 million miles traveled
- 125K taxis / Ubers on the road
- 60K “shared” rides
- 450K bytes of vehicle data from a connected vehicle
- 500K+ gigabytes of data transmitted on the Internet
- 350K cell phone apps downloaded

Source: Estimates based on government and industry data

There Are Significant Opportunities For Participation In Far More Transactions
Our Traditional Business Is Selling Cars To Individuals And Fleets; Our Emerging Businesses Are About Providing Transportation For Passengers And Goods

Own

Share

Car
Truck
Fleet

Ride share
Ride hail
Ride pooling
Vehicle sharing
We See A New Business Model By Leveraging Our History To Take Advantage Of The Full Mobility Value Chain

Ford’s Historical Orientation

walk bike automobiles shuttle bus planes spaceship

Ford’s Mobility Orientation
What We’ve Done So Far...In Mobility...

**Ford Smart Mobility**
- Consumer experience
- Flexible usership
- Social collaboration
- Open innovation
- Technical developments
- Established an independent, new Ford entity

**Greenfield Labs**
- Draws on existing Ford resources and selected new talent
- Focuses on consumer experience in shared transportation
- Explores and launches new businesses using design thinking methodology

**New Announcements**
- New City Solutions organization to foster low-friction multi-modal travel in cities
- Purchase of Chariot – Bay area shuttle-based commuter transit
- Partnership in San Francisco with Motivate Bike Share

**30 global experiments**
Part Of A Mobility System For Customers And Cities

Layers of value in mobility

- 9 million miles traveled
- 125K taxis / Ubers on the road
- 60K “shared” rides
- 450K bytes of vehicle data from a connected vehicle
- 500K+ gigabytes of data transmitted on the internet
- 350K cell phone apps downloaded

Where we will play and win

- Dynamic shuttle
- City solutions
- Bike sharing

Source: Estimates based on government and industry data
Dynamic Shuttle Services

Market leader in vans and commercial / government fleets

Shuttle will beam route and use information to the cloud for storage and analytical design

Routes are dynamic; driven by user demand. This allows us to produce yield pricing opportunities.

Dynamic Shuttle Leverages Global Van And Fleet Strength With Chariot Acquisition To Grow Rapidly
Dynamic Shuttle Provides Near-Taxi Convenience At A Near-Mass Transit Price

China Market Example

More passengers per Km

Higher passenger cost per Km

- Personal vehicle
- Taxi
- Dynamic shuttle
- Mass transit
Mobility Key Takeaways

1. As we move from our traditional sales business, there are significant opportunities to increase our interactions with many more customers.

2. Ford Smart Mobility focused on two business models – owned and shared, which will provide transportation for passengers and goods.

3. Dynamic shuttle will capitalize on Ford’s existing strengths in vans and large fleets.

4. We are leveraging key technology platforms – connectivity, data / yield management, autonomy – to support the owned and shared business model.

5. Where to play and win will initially focus on city solutions, dynamic shuttle and data and customer experiences from bike sharing.
The Transition From Driver Assist Technologies Toward Autonomous Driving Is Progressing Rapidly

Autonomous – DAT To Full Control

Driver Assist Technologies (DAT)
- Active Park Assist
- Rear Cross-traffic Alert
- Lane Departure Warning with Lane Keeping Aid
- Blind Spot Monitoring

The Transition From Driver Assist Technologies Toward Autonomous Driving Is Progressing Rapidly
Focus On High Volume, SAE Level 4

Autonomous Vehicle For Ride-Hailing Or Ride-Sharing In 2021

- Announced our intent to have a high-volume, fully autonomous Society of Automotive Engineers (SAE) Level 4-capable vehicle in commercial operation in 2021
- Initial application in a ride-hailing or ride-sharing service, with personal use to follow at a later date
- Vehicle being specifically designed for commercial mobility services without a steering wheel or gas and brake pedals
- Investing or collaborating with four startups on autonomous vehicle development
AV Technology Will Lower TaaS Prices And Increase Access And Usage

Transportation as a Service Evolution

<table>
<thead>
<tr>
<th>Mode</th>
<th>Price Per Mile</th>
<th>Number of Rides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
<td>$6.00</td>
<td></td>
</tr>
<tr>
<td>Uber</td>
<td>~$2.50</td>
<td></td>
</tr>
<tr>
<td>Personal Ownership</td>
<td>$1.50 - 0.70</td>
<td></td>
</tr>
<tr>
<td>AV TaaS ~</td>
<td>$1.00</td>
<td></td>
</tr>
<tr>
<td>Ride Hailing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass Transit</td>
<td>$0.30</td>
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</tr>
</tbody>
</table>

TaaS = Transportation as a Service, point to point mobility for a fee
Initial Deployment Will Be In Large Geo-fenced Urban Markets And With Geo-fenced Corridors

New York City Geo-fenced Area With Corridors
- Manhattan
- Brooklyn
- Queens
- EWR
- LGA
- JFK
- Staten Island

Detroit Geo-fenced Area With Suburbs Linked By Corridors
- Brighton
- Metro Detroit
- Detroit
- Ann Arbor
- DTW
Autonomous Vehicles Might Account For Up To One In 10 Miles Traveled And One In Five Sales

<table>
<thead>
<tr>
<th>Year</th>
<th>U.S. Autonomous Miles Traveled (Percent of Total)</th>
<th>U.S. Autonomous Annual Sales (Percent of Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>2030</td>
<td>10%</td>
<td>20%</td>
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</tbody>
</table>

Go Further
Low Volume AV TaaS Vehicles, In 2018, Pave The Way For A High Volume All-New Product In 2021

<table>
<thead>
<tr>
<th>Year</th>
<th>Development</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>2018</td>
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<td>2022</td>
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<tr>
<td>2023</td>
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SAE Level 4 - With Safety Driver
Fusion AV

SAE Level 4 – No Safety Driver Or Controls
All-New Product
Our Position As A Leading OEM In Autonomous Vehicle Technology Will Allow Us To Lead Commercialization

AV Expertise

- 1st Ford On-Road Vehicle Testing
- Velodyne Use of LiDAR
- Desert Challenge with F-250 AVs
- Academic AV Partnerships
- Urban Challenge with F-250 AVs
- DARPA
- Ford Research on Fundamental Algorithms
- RWTH Aachen University Academic AV Partnership
- Mcity
- 2nd Gen AV Fusions
- Civil Maps
- SAIPS Algorithmic Solutions
- Velodyne LiDAR

Advanced and Production Engineering Staffing

- Research
- Advanced and Production Engineering


**Ford To Introduce AV Technology At A SAE Level 4**

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assisted driving steering or accel/decel</strong></td>
<td><strong>Assisted driving steering or accel/decel</strong></td>
<td><strong>Autonomous with human driver backup required</strong></td>
<td><strong>Key to TaaS economic model</strong></td>
<td><strong>Autonomous with driver not required; not geo-fenced</strong></td>
</tr>
</tbody>
</table>
| Examples:  
• Lane keep assist  
• Adaptive cruise control  
• Automated emergency braking | Examples:  
• Traffic jam assist  
• Autopilot  
• Highway cruise | Functionality between Levels 2 and Level 4  
Requires human driver backup | **AV TaaS** | Future state as Level 4 technology develops and expands |

**Ford current focus**
We Are Using Mediated Perception Methods With Direct Perception To Correctly Determine Driving Solutions

**Direct Perception**
- Use of sensors to develop real-time view of environment to use in conjunction with mediated perception to correctly determine driving solutions.
- Combination of sensors covers full environment from day to night, from distant to near, from still to moving, from metallic to organic.

**Mediated Perception**
- Comparison of real-time LiDAR mapping to existing HD map to determine which direct sensed objects are of concern and which are not.
- Provides baseline “rules of the road” for driving solutions of current environment.

**Sensors**
- **Cameras**
  - Visible sensing for object classification and color recognition.
- **LiDAR**
  - Near-infrared laser detecting and tracking distant and night objects.
- **Ultrasonic**
  - Close proximity.
- **Radar**
  - Radio wave detection of moving objects.
- **HD maps**
  - 3D map of geo-fenced area including “rules of the road” and permanent object classification.
We Are Focusing On Solving Scenarios Instead Of Accumulating Miles

Testing Coverage

- A scenario is a vehicle maneuver in a driving environment combined with ‘noise’ factors.
- Ford is focused on correctly solving the scenarios an AV will encounter in its operational environment.
- Mileage accumulation is an outcome, not a goal, of our AV technology development.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Operational Miles</th>
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<tr>
<td>10%</td>
<td>95%</td>
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Scenario Example Illustrates The Benefits Of Our Direct And Mediated Perception Approach

Ford’s Approach

- 3D maps lay the foundation (rules of the road and fixed objects in the environment)
- LiDAR is primary sensor for localization and for providing a real-time $360^0$ view of the environment and objects at long distances
- Radars, cameras and LiDARs combine to identify and track moving objects
- Cameras provide short to mid-range object and scene characterizations
- The Virtual Driving System integrates the 3D map and direct perception data to create a more robust mediated perception

Scenario: Making a right turn at a stoplight with a left turn lane in an urban environment with moderate density of pedestrians and vehicles
# Autonomy Key Takeaways

1. Ford believes the potential for the AV business is very large
2. Ford has been a leading player in AV technology development for more than 10 years
3. Ford is testing Level 4 AVs with safety drivers on the road right now
4. Ford is in a unique position to marry our AV technology expertise with our proven ability to commercialize at scale in the automotive environment
5. Ford intends to have a high volume, dedicated Level 4 AV in production in 2021
6. Ford’s initial approach will support AV Transportation as a Service
Our Sustainability

GREAT PRODUCTS – STRONG BUSINESS – BETTER WORLD