Reinventing the Wheel

The impact of the automotive industry’s mobility transformation on the chemical industry

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Several prior, but not too distant, disruptive events have shaped the current state of the chemical industry

• The rise of the Middle East petrochemicals industry
• The wave of chemicals investment in China
• The North American shale gas revolution

Might the future of mobility be the next major disruptor?
Reinventing The Wheel

• The Drivers of Future Mobility
• Ride Hailing & Car Sharing
• Autonomous Vehicles
• RTW Scenarios
• Preliminary Scenario Results
• Industry Impacts
The Drivers of Future Mobility
Reinventing the Wheel

Key global factors impacting the automotive industry ecosystem

- Regulation pressure
- Environment and climate issues
- Energy rivalry
- Societal change
- Congestion
- Technology development
- Economic uncertainty
- Autonomous
- Ride hailing
- Connectivity
How will these driving forces evolve and interact?

The changing face of mobility

- Mobility will be redefined
- New urban mobility
- Environmental drivers
- Oil prices
- Technology
- Autonomous vehicle
- Car and ride sharing
- Social values
- VMT changes
- New business models will materialize
- Battery cost

Technology and society drive fundamental change

Note: VMT = Vehicle miles traveled. Pictures used with permission of respective original equipment manufacturer.
The mobility issues shaping the future of the auto industry is the nexus driving major changes in the Energy and Chemicals industries

- How will auto sales volumes be impacted?
- How will automotive companies evolve?
- Is transport a new frontier for power demand growth?
- At what scale?
- Will oil demand peak sooner and quicker than many think?
- How will upstream supply be impacted?
- How will the chemical industry react to changing feed stocks?
- To changes in the automotive materials supply chain?
The two parts of the RTW Research Study encompass content from all three industries

**Part I**
Assess the driving forces of a changing automotive ecosystem and develop two scenarios to 2040

**Part II**
Success or Failure?
Big questions and choices facing the Automotive, Energy and Chemicals Industries

- Automotive
- Energy: Oil, gas, & Electric Power
- Chemicals
Ride Hailing, Ride Sharing, & Car Sharing
Ride Hailing/Sharing Definitions and Types

**Ride-Hailing**
- Online platform provider
- Drivers providing own cars
- Riders booking cars
- Payment via platform provider
- Mainly short journeys
- City-focused

**Major players**
- Uber; Lyft; Didi; Ola; Grab; Mytaxi/Hailo

**Ride-Sharing**
- Online market-place
- Car owner offers ‘seats’ to destination
- Riders use marketplace to select destination
- Cost contribution to driver expense (fuel/toll)
- Mainly long journeys
- Inter-City focus

**Major Players**
- BlaBlaCar; Gocarshare; CoYatri; RidingO
Car-Sharing Definitions and Types

Return to Base

- Start and destination fixed, same station

Major Players:
- Zipcar, Hertz on Demand; Cambio; Autolib; EVCard/Net; Zoomcar; Orix; Park24

Free-Floating

- Start and destination flexible, defined by user

Major Players:
- Car2Go; DriveNow; Communauto; LeEco-Yidao

P2P Car-Sharing

- Consumers lend their private car (via agency or internet platform)

Major Players:
- Turo; WhipCar; Getaround; Drivy; Ridengine; PPZuche; ATzuche
In only 5 years, Ride Hailing reaches the market cap valuation of incumbent automakers

Market cap and estimated valuation comparison between automakers and new mobility entrants

Notes: Uber Technologies BlaBla, Grab, Lyft, Ola, and Didi Chuxing are estimated market valuations
Source: NYSE/Nasdaq, Bloomberg, TechCrunch
Autonomous Vehicles
Challenges autonomous vehicles hope to address

**Improve Safety**
- 35,092 killed in 6.3M crashes in the US in 2015,
- 94% driver fault
- 1.24M road deaths worldwide

Source: NHTSA, WHO

**High Cost of US Crashes**
- $277B in economic costs
  - 1.9% of GDP
- $871B in quality-of-life costs
  - 5.8% of GDP

Source: IRTAD, various estimates, 2010

**Improve Efficiency**
- $160B in US congestion costs
- 3.1B gallons of fuel burned in US due to congestion
- 6.9B hours wasted sitting in traffic

Source: Texas A&M Transportation Institute & INRIX, 2014

**Evolving Consumer Appetites**
- Connectivity
- Convenience
- Sustainability
- Mobility
- Choice
- Lower Cost
# Automation features different levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Automation Features</th>
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</table>
| L5    | Full Automation | - Fully autonomous driverless fleets  
|       | IHS Driverless car | - Mobility service business model |
| L4    | High Automation | - Fully autonomous autopilots  
|       | IHS Self-driving car | - Drivers disengage in more situations |
| L3    | Conditional Automation | - Advanced autopilots  
|       |                      | - Drivers intermittently disengage |
| L2    | Partial Automation | - Autopilot  
|       | Steering **and** Braking | - Traffic jam assist |
| L1    | Driver Assistance | - Adaptive cruise control  
|       | Steering **or** Braking | - Lane keep assist  
|       |                      | - Autonomous parking |
| L0    | No Automation | - Collision warning  
|       |                      | - Lane departure warning  
|       |                      | - Blind spot information |

*Increasing Automation*

*Based on Society of Automotive Engineers levels of automation (SAE J3016)*

*Note: IHS Markit Autonomous Vehicle forecasts use different structure but similar nomenclature.*

*SOURCE: IHS Automotive Autonomous Driving Service*
Cities are lining up for autonomous vehicle testing

VW
Mercedes Benz
Google
Delphi
Tesla Motors
Bosch
Nissan
GM
BMW
Honda
Ford
Faraday
Baidu
Valeo

Google
Hyundai
Uber/Otto
Mcity*
Ford, GM, FCA
Google
City of Boston
Uber/Volvo
VaTech
Audi
Florida Poly
Audi

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# Self-driving sounds good, but what about?

## Technology
- Easiest challenge to ‘solve’ but still takes time
- Artificial intelligence, computing, sensors get better and cheaper

## Regulation
- Developing regulatory framework in the US
- Adapting Vienna Convention in Europe and abroad

## Insurance
- New paradigm of product liability, not personal liability
- Adapting the insurance model to dynamic usage, multiple users

## Public Acceptance
- Value proposition brings mobility to more people at lower cost
- Trust in autopilot today a likely sign of wider acceptance over time

## Bad Press
- Early crashes and fatalities could delay acceptance
- Will consumers accept fatalities attributed to a robot?
 Autonomous capability blurs the lines between business models and use cases

**Past**
- Taxi For-Hire
- Rental
  - Owner/ Driver

**Present**
- Taxi For-Hire
  - Ride-hailing
    - Rental
    - Car sharing
  - Owner/ Driver

**Future**
- Autonomous on-demand mobility service
  - Owner/ Driver
Scenario Narratives
Reinventing the Wheel: Defining characteristics of our two scenarios to 2040

**Oil v. Electricity Rivalry**
- Electric vehicles (EVs) mainstream, but not dominant
- Internal combustion engines (IECs) remain competitive, but lose market share
- Personal car ownership still accounts for most car sales
- Ride-hailing revenue grows to $1+ trillion
- Slow, but gradual consumer acceptance of autonomous cars

**Mobility Revolution**
- Convergence of EVs, ride-hailing, and driverless technology fuel a mobility revolution
- Congestion and poor urban air quality leads to aggressive policies that encourage use of driverless electric cars (DECs)
- DECs accelerate EV adoption; EVs lower cost than ICEs
- Restructured industrial eco-system
- Social stress; mismatch between job destruction and creation
- Fleet sales overtake personal vehicle sales
Common features of Rivalry and Autonomy

- Government support of EVs necessary to establish market. Policy forces companies to make and sell EVs, at least in early years
- EVs, on their own, are not a disruptive technology
- Access to personal mobility via cars increases
- Ride-hailing grows increasingly important
- Reduction in road carnage due to more autonomous driving features
- High oil prices not essential to spur change
Preliminary Scenario Results
**US Motorisation Rate** is now expected to peak by the early 2020’s and decline inversely with the relative speed of growth of new mobility concepts in different scenarios.

**Motorization rate for US by Scenario**

- **US Base (Pre RTW)**
- **US Rivalry**
- **US Autonomy**

Total Vehicles per 1000 Population

Source: IHS Markit

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US on road vehicle fleet is now projected to be in decline after 2035

In Rivalry, on road fleet is reduced 9% by 2040 compared to the previous base case

In Autonomy, 2040 US on road vehicle fleet is the same size as in 2017

Source: IHS Markit
United States LDV sales by mobility channel

In Rivalry, new mobility accounts for 40% of US LDV sales by 2040

In Autonomy, new mobility accounts for 70% of US LDV sales by 2040

Source: IHS Markit
Autonomous ride hailing market push PEVs to take over the US market in Autonomy

- PEVs rise in both scenarios due to decreasing EV cost, and the greater adoption of EVs by Mobility as a Service (MaaS) providers.
- The competitive attributes of PEVs in Rivalry grow steadily but slowly. A modest impact of driverless MaaS.
- PEV sales rise in Autonomy as driverless electric vehicles are more economically attractive to fleet operators and a greater share of PAC sales.
Fleet operators prefer electric powertrains due to lower cost per mile, consumers still slower to adopt EVs

US powertrain sales mix by mobility channel, Rivalry 2040

US powertrain sales mix by mobility channel, Autonomy 2040

Source: IHS Markit
Part II - Industry Analyses
How will this impact your industry?

Automotive
Energy
Chemicals
How will new mobility trends impact Automotive?

- **Vehicle sales will be impacted.** Shared mobility may reduce vehicle sales while autonomy and new business models may increase utilization and market size. How these new modes interact at the local level will shape the automotive market.

- **Electrification will continue to increase its market share.** Climate change and air quality policy will continue to drive fuel economy and low emission technology. This shift in automotive energy supply will require greater cooperation across multiple energy industries – oil, power, and gas.

- **The vehicle itself will change.** Powertrain diversity and vehicle attributes will continue to evolve, driven by technology, policy, cost, and consumer preferences. The vehicle of the future could look very different than today’s offerings.
How will new mobility trends impact Energy?

• **Energy demand trends may not be linear.** For example, ride hailing and gasoline powered autonomous vehicles could significantly increase gasoline demand for a time. But this trend could be reversed later if electricity predominates in later model autonomous vehicles.

• **Technology choices and consumer behavior may differ across countries and also differ within countries.** This could mean there is no linear, uniform impact on energy demand trends globally.

• **Regardless of energy source, autonomous ride hailing could lead to a step change in vehicle miles traveled**—i.e. more miles traveled than is currently captured in energy outlooks.
Part II: Big questions and choices facing the Chemical Industry

• What will changes in **automotive powertrains** mean to the supply of feedstock to the chemical industry?

• How will **design changes** in the automotive sector affect the demand for chemicals and materials such as thermoplastic polymers and synthetic elastomers?

• What are the **strategic implications** for the chemical industry’s structure and participants?
How will new mobility trends impact chemicals?

- **Vehicle size and design trends** New design concepts driven by adoption of autonomous vehicles and changing power trains will impact the type and quantities of materials required from the chemical industry. For example, changes in vehicle size & weight will impact the quantity of synthetic rubber used to manufacture the tires, elimination of the gasoline tank as powertrains may change to electric, will decrease the industry’s demand for HDPE, etc.

- **Shared mobility and increased utilization will impact overall vehicle sales volumes** This, coupled with changes in vehicle size and design, will impact the overall quantities of materials required to be produced by the chemical industry for the automotive market sector.

- **Changes in power trains and increased fuel economy, coupled with resulting societal impacts on vehicle miles traveled, will change the volume, mix, and geographic distribution of the automotive energy supply** This will initiate ripple effects through the global refining and gas processing industries, and will result in changes in the price, volume and type of feedstock available to, and used by, the chemical industry.
For more information, please visit the RTW Kiosk at the Marketing Booth
RTW Glossary

- BEV  Battery Electric Vehicles
- DEC  Driverless Electric Cars
- EV    Electric Vehicles
- HEV   Hybrid Electric Vehicles
- HFCV  Hydrogen Fuel Cell Vehicles
- ICE   Internal Combustion Engines
- MaaS  Mobility as a Service
- NEV   New Energy Vehicles
- PAC   Personal Autonomous Cars
- PARC  On-Road Vehicle Fleet
- PEV   Plug-In Electric Vehicles
- PHEV  Plug-in Hybrid Electric Vehicles
- PMT   Passenger Miles Travelled
- PNAC  Personal Non-Autonomous Cars
- TNC   Transportation Network Companies
- VMT   Vehicle Miles Travelled
Questions