Disruptive Innovations in Technologies & The Tectonic Shift in the Landscape of Transportation

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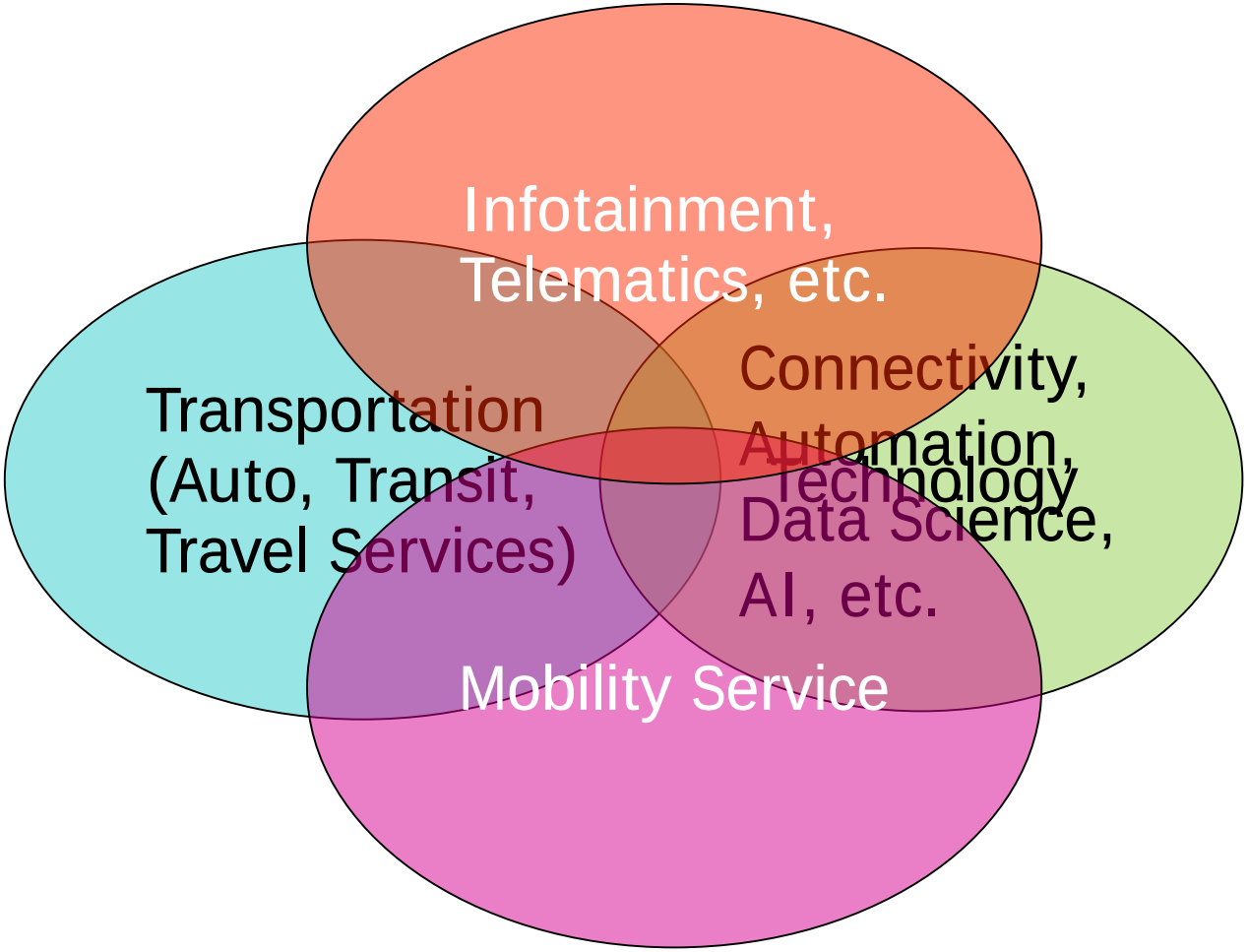
“創新與分配是矛盾的”

“創新是必要的，但也要有心理準備必須忍受一些問題”

“創新是分配最大的罪魁禍首”

- *臺積電董事長張忠謀，新聞報導 10/24/2016*

The Tectonic Shift in Transportation



Presentation Outline

- **Recent Investment Activities in Transportation**
  - **Rising Acquisitions and Investments**
  - **Cross-Currents between Auto and High-Tech**
- **Transformation and Disruption, Case Studies**
  - **Traffic Data and Traveler Information**
  - **Mobility Services**
- **Connected and Automated Vehicles**
  - **Functional Needs and Technologies**
  - **Renaissance of Mapping Sector**
  - **Artificial Intelligence**
- **A Look toward the Future**

A Craze for Acquisition

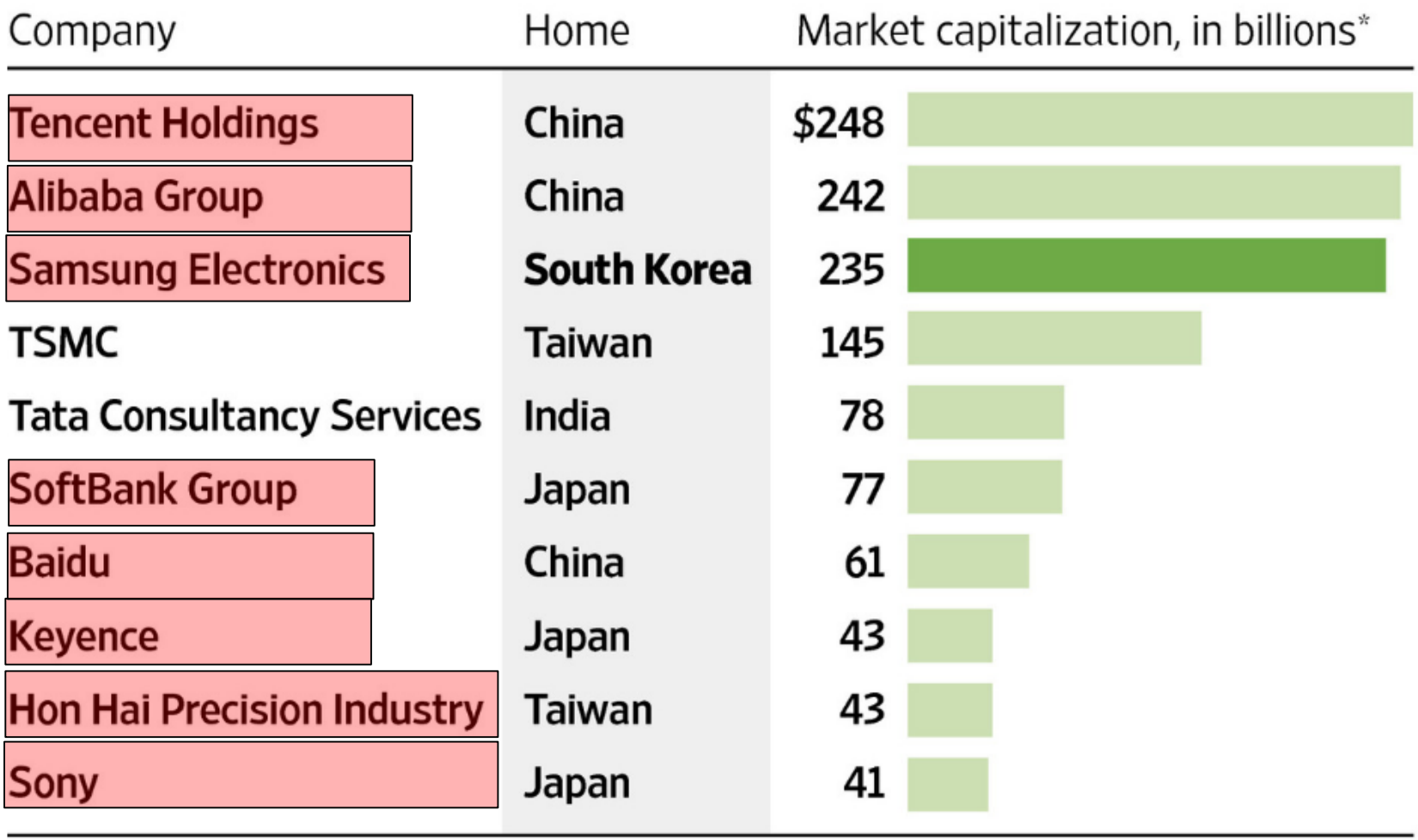
- **Total value of automotive-supplier deals in 2015 and 2016 was $74.4 billion, per Bloomberg.**
- **Each of those years far exceeding the $17.7 billions annual average in the previous 10 years.**
- **The number of transactions valued at $500 millions or more also skyrocketed to 18 in 2015, triple the level of the previous decade.**
- **There have been 12 (as of 09/16) such deals so far in 2016.**

Car and Tech Mega Deals, 2015-2016

Time	Buyer /Investor	→	Target /Recipient
October 2015	Audi, BMW, M-B	3B	HERE
November 2015	Toyota	1B	Toyota Research Institute
January 2016	GM	500M	LYFT
March 2016	GM	1B (600M?)	Cruise Automation
May 2016	VW	300M	GETT
May 2016	Apple	1B	DiDi Chuxing
May 2016	Toyota	N/A	UBER
August 2016	DiDi Chuxing	8B	UBER China

A Global Drive for AV and EV

Some Highest-Valued Companies (as of 09/16) in Asia have direct investments in AV and EV



Major Themes of Recent Investments

- **Evaluation of High-Tech investments much higher than traditional values in auto industry**
- **Shared mobility (ride hailing) services attracting significant investments**
- **High interest in self-driving technologies**
- **Software content a major focus**
- **(Deep) Machine Learning an active field**

How Big is the Pie (in the Sky)?

- **Driverless vehicles are poised to threaten the $570 billions that Americans spend each year on new cars.**
- **Auto industry revenue at $2.3 trillions a year globally.**
- **At stake is a transportation services market (ride sharing and bus services) that is worth $5.4 trillion, per estimate by one report.**
- **Now carmakers (feel that they) must be in the businesses of ride-hailing apps, shuttle buses, 3D maps, and computation / machine learning.**

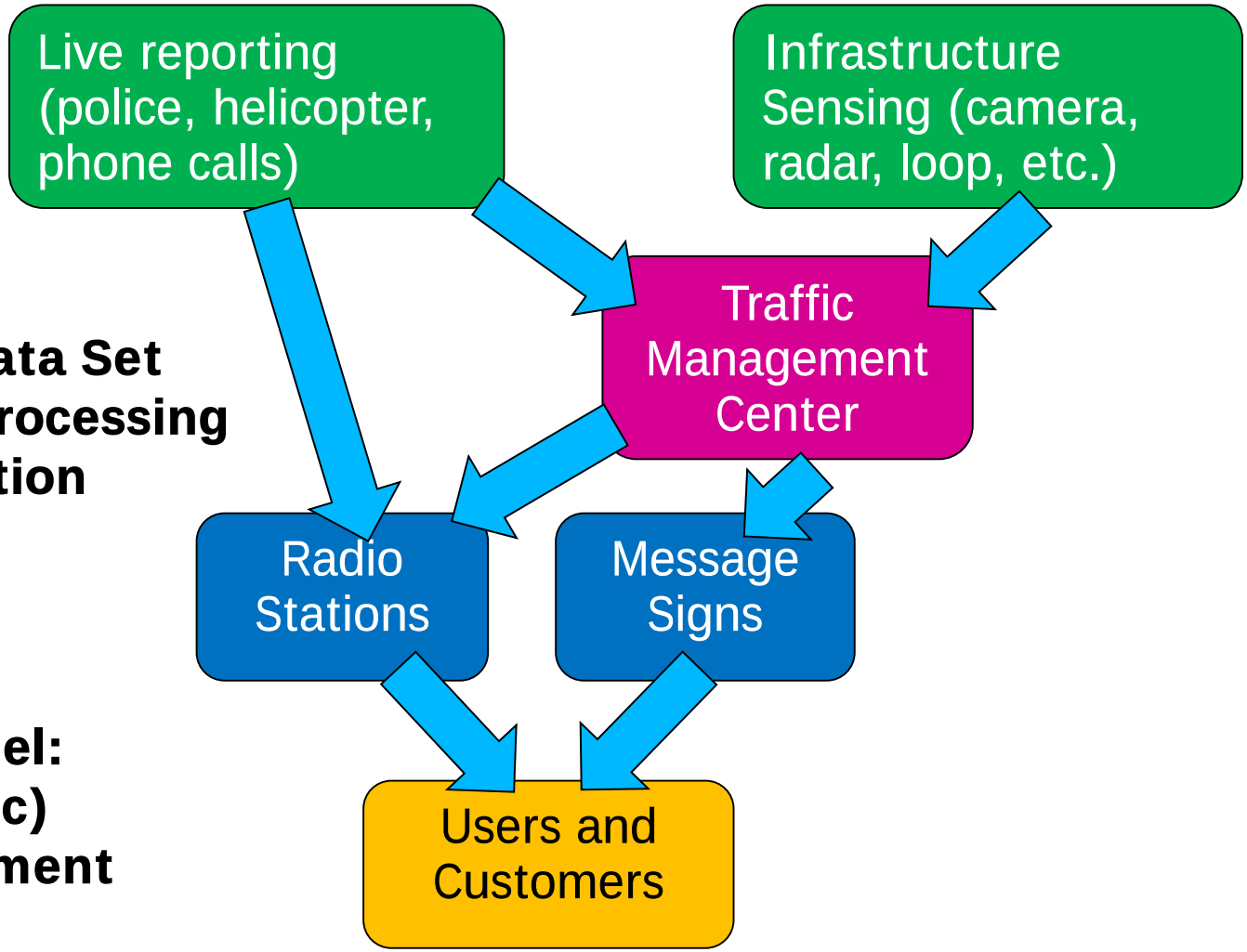
Transformations and Disruptions in Transportation

Illustration by Case Studies

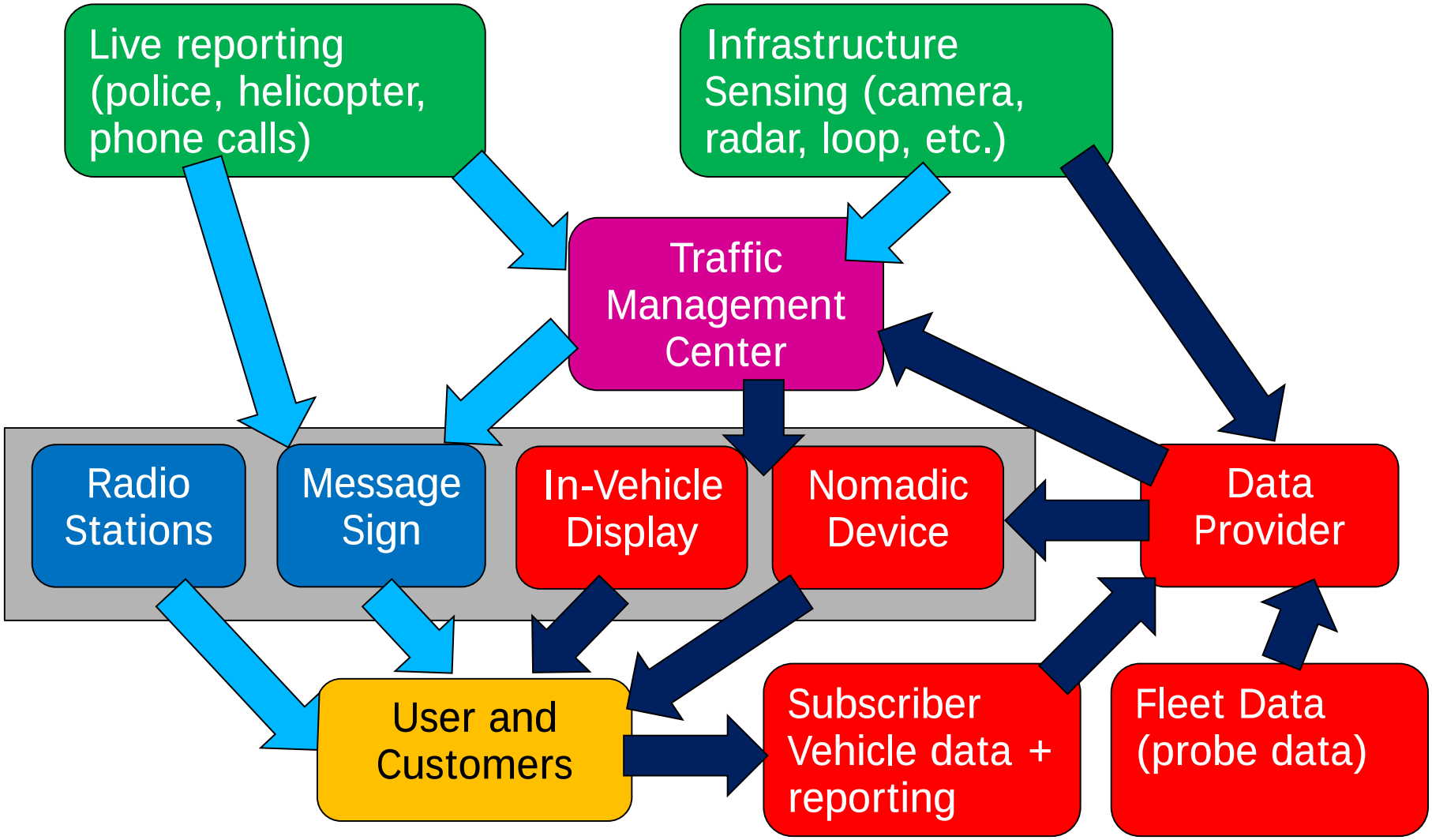
Traffic Data and Traveler Information (Older Model)

- **Data Model:**
  - **Limited Data Set**
  - **Minimal Processing & Integration**

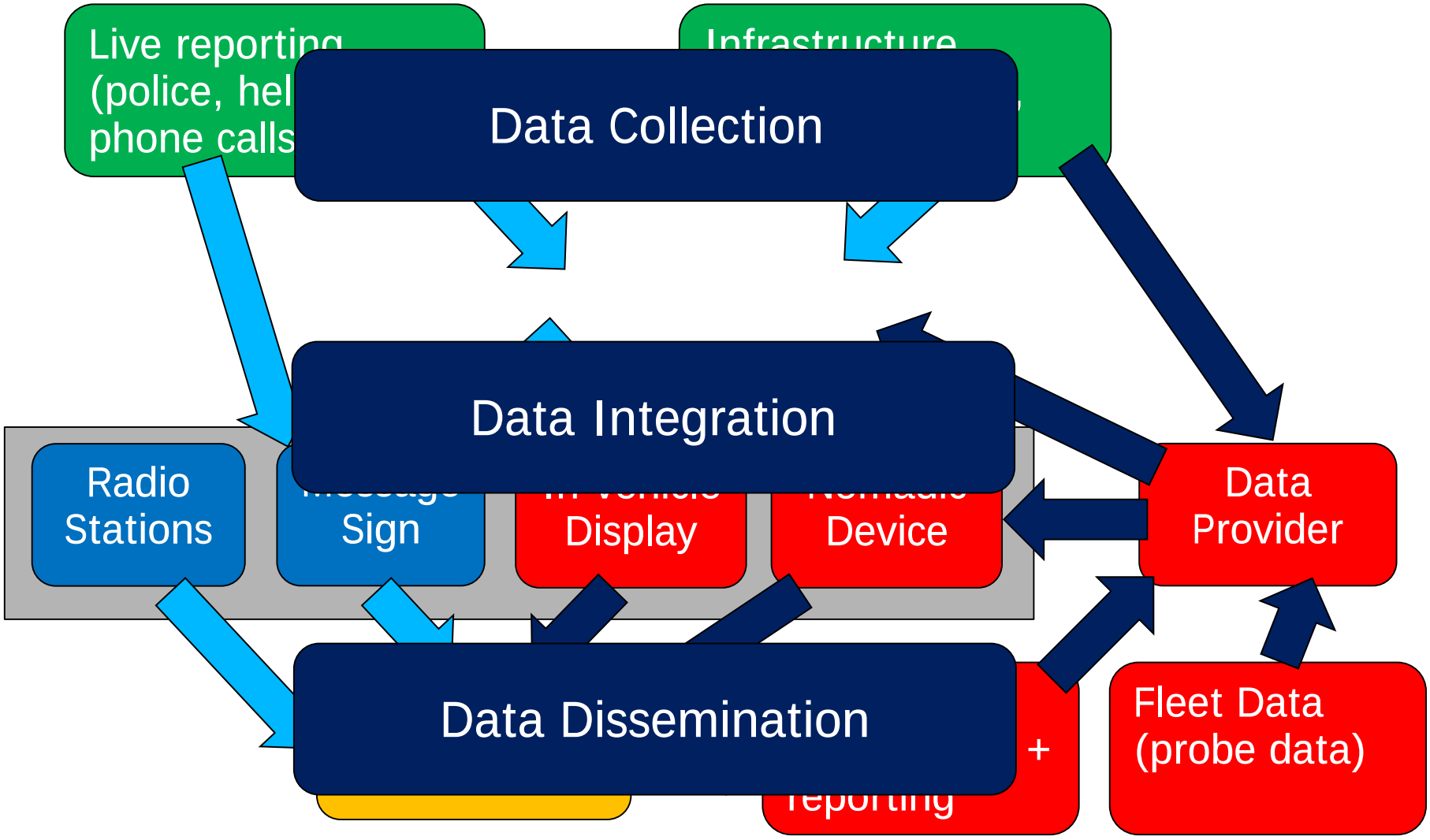
- **Business model:**
  - **Tax (public)**
  - **Advertisement (private)**



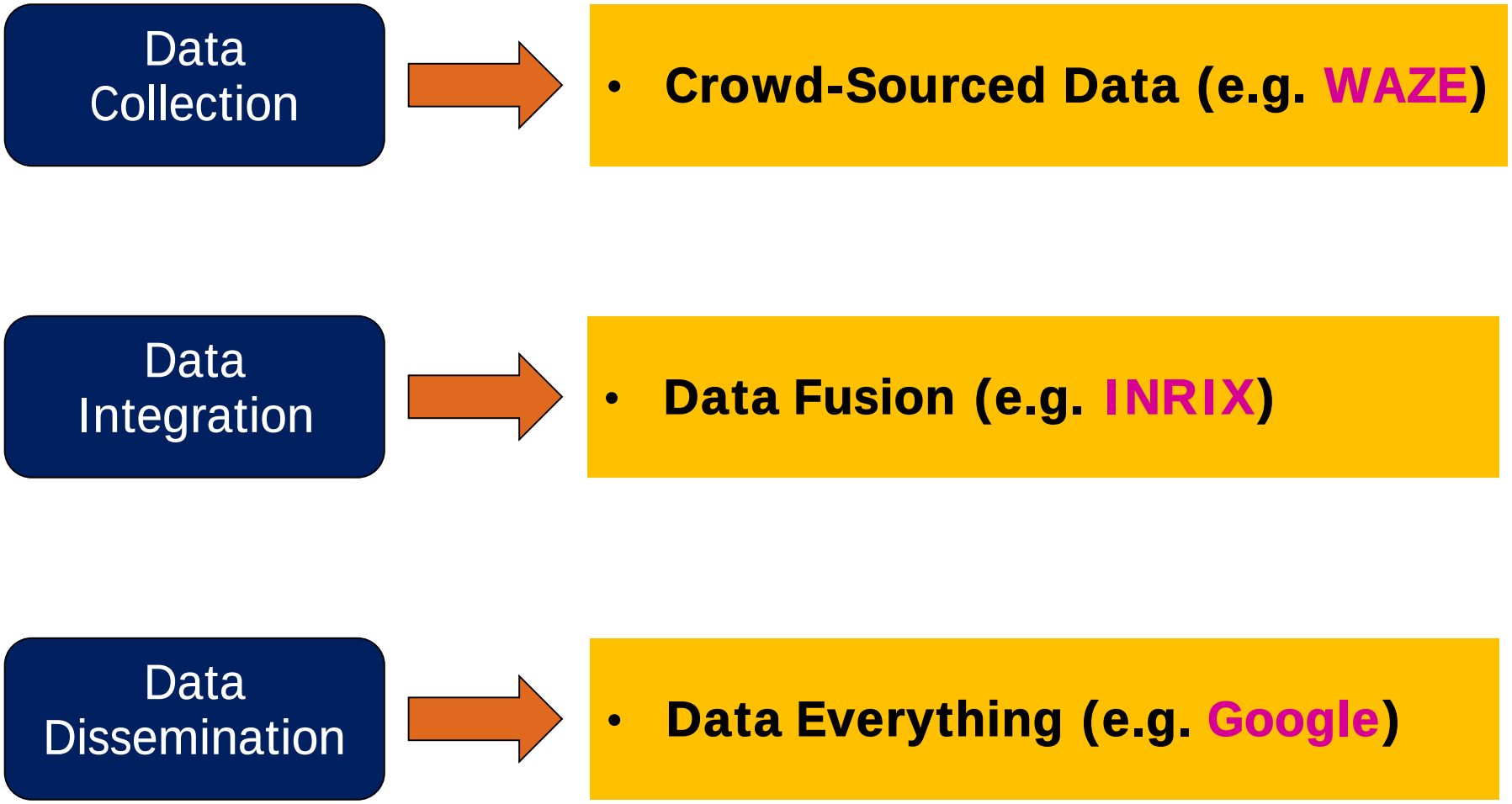
Traffic Data and Traveler Information (Newer Model)



Breakdown of Functional Needs (Newer Model)



Business Models and Exemplar Players (Newer Model)



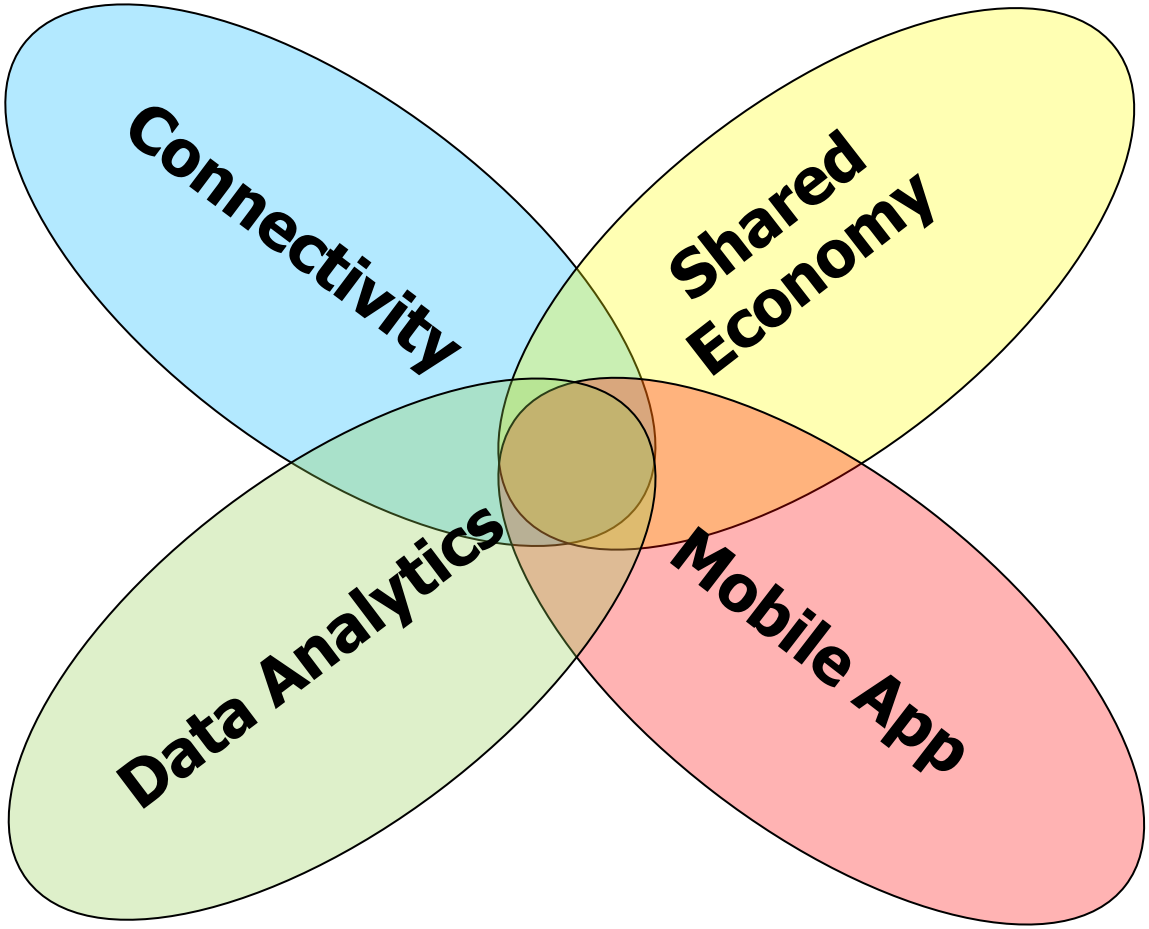
Transformations and Disruptions
Traffic Data and Traveler Information

- **What do customers gain?**
  - **Enhanced services with enriched content**
  - **Customized Delivery**

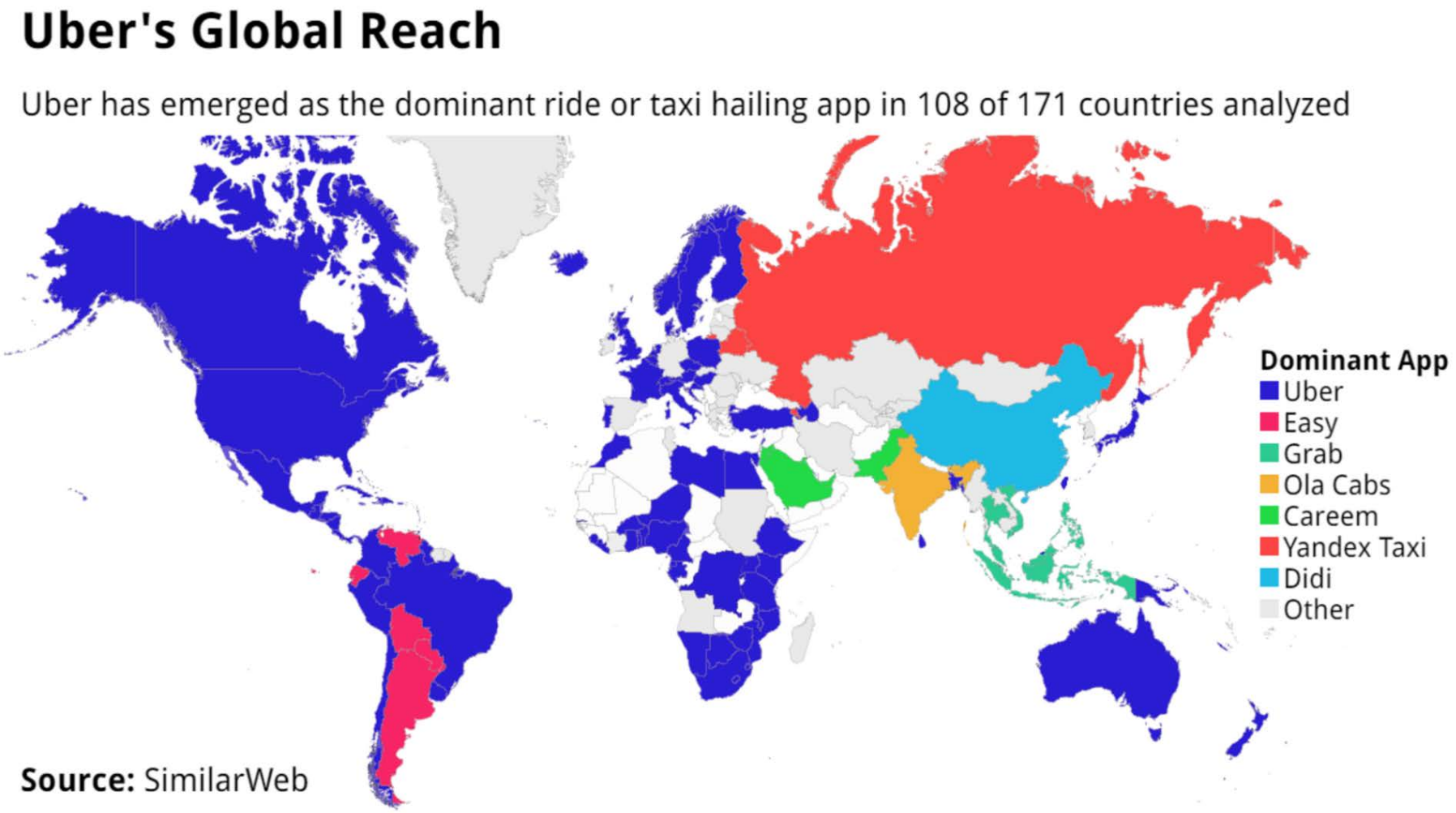
- **Transformations**
  - **Technology-centric with a strong link to ICT industry**
  - **User becomes an integral part of data structure**
  - **Data mining opportunities and enhanced services via cloud services**

- **Disruptions**
  - **Diminishing prospects for old providers**
  - **Emerging new data reseller & subscriber services**
  - **Realignment of public agencies' strategies (SF MTC as an example)**

Transformations in Mobility Services



UBER - A Trailblazer in Mobility Services



Emergence of the Largest Taxi Company in the World

- **UBER**
  - *A transportation network company*, leveraging smartphones for ride sharing and hailing
  - Founded in 2009
  - Official launch in SF in 2011

- **As of August 2016,**
  - Available in ~70 countries and ~500 cities
  - > 1M drivers
  - Reaching 2-Billionth ride milestone in 08/16
  - 2016 Revenue ~ $1B/quarter
  - Estimated market value >$60B with multiple rounds of funding by investors

Transformations and Disruptions

Mobility Service by UBER and LYFT and the like

- **What do customers gain?**
  - Door-to-door convenient ride service
  - Personalized account linked with family or business
  - Higher satisfaction
- **Transformations**
  - More timely and efficient services
  - General public involved as drivers and riders
  - Alternatives to substitute transit for travel needs (e.g. UBER collaboration with City of Summit NJ for commuter parking, 10/2016)
- **Disruptions**
  - Devastation of Taxi services
  - New York Taxi Cab Medallion Price cut in half, from $1M to $500k
  - SF Taxi trips drop ~70%; LA Taxi trips drop >30%

Disruptions to Automotive Industry
As a Result of New Mobility Services

- **Ride sharing at lower costs than owenership**
  - **High costs of ownerships, cars driven only 4% of time**
  - **Ride sharing can cut costs by 50%**

- **Ride-sharing threatens the business model of automakers**
  - **(Automated) ride-sharing will diminish or eliminate the needs of personally owned vehicles???**

→ **Automated Mobility Service will further impact auto industry significantly**

→ **Evidenced by investments by global automakers in ride sharing and self-driving cars?**

Connected and Automated Vehicles

Prevalent Trends in Transportation

- Telematics (In-Vehicle Services)
- Data Analytics and Cloud-Based Applications
- Driver Assistance Systems (ADAS)
- Mobility Service (+ or -AV)
- Environment Friendly/EV
- Car Sharing and Ride-Sharing

Prevalent Transportation Trends and Emerging Industrial Sectors

Industrial Sector	Selective Iconic Players

Connectivity + Automation
Two Enabling Pillars

Connectivity

Automation

Connectivity for Telematics Services

HERE as a Case Study

- **100,000s of vehicles from BMW, Daimler, VW are set to begin feeding visual data into the HERE system**

- **The new live traffic services are set to hit the road in the first half of 2017**

here

Maps for Life

- **Four services for drivers**
  - **video views of traffic jams or accidents**
  - **road hazards like fog or slippery streets**
  - **traffic signs including temporary speed limits**
  - **on-street parking**

- **Millions of vehicles expected to contribute live traffic feeds by the end of 2018**

Societal Growth of Connectivity

High-Tech Company Shuttle Buses

- **Commuting buses offered by Google, Facebook, Apple, and the like in the SF Bay Area**

→ **Productive employees with Wi-Fi access on board**

→ **~800 buses, 34,000 passengers daily, 9.6 millions boarding in 2014 (MTC report)**

→ **Elimination of some 2 million car trips a year from congested city streets, and estimated 12 million vehicle miles**

Leveraging Connectivity for Services

TESLA as a Case Study

- **Connectivity (4G links) essential for EV battery management**

→ **Enhanced infotainment and user interface utilizing the same 4G Link**

→ **Enriched user experience, customer relationship, and telematics contents**

→ **Over-the-Air software update to enable new function (Fall 2015 Auto-Pilot Activation)**

Leveraging Connectivity and Automation

TESLA as a Case Study

Connectivity

Connectivity for EV Battery & Infotainment

Backhaul Field Performance Data via Connectivity

Automation

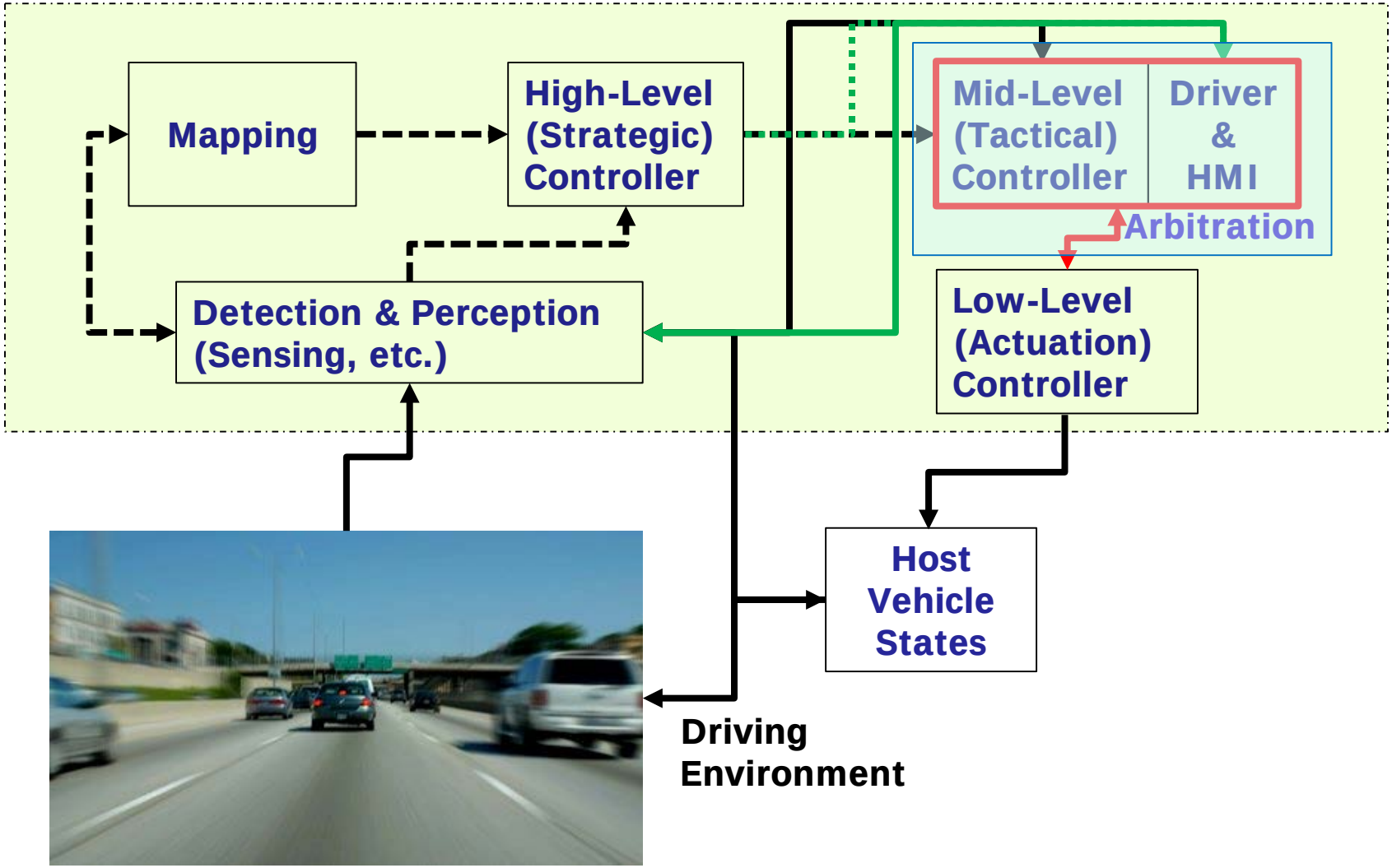
Over-the-Air Activation of Auto-Pilot

Enriched Data to Improve Automation

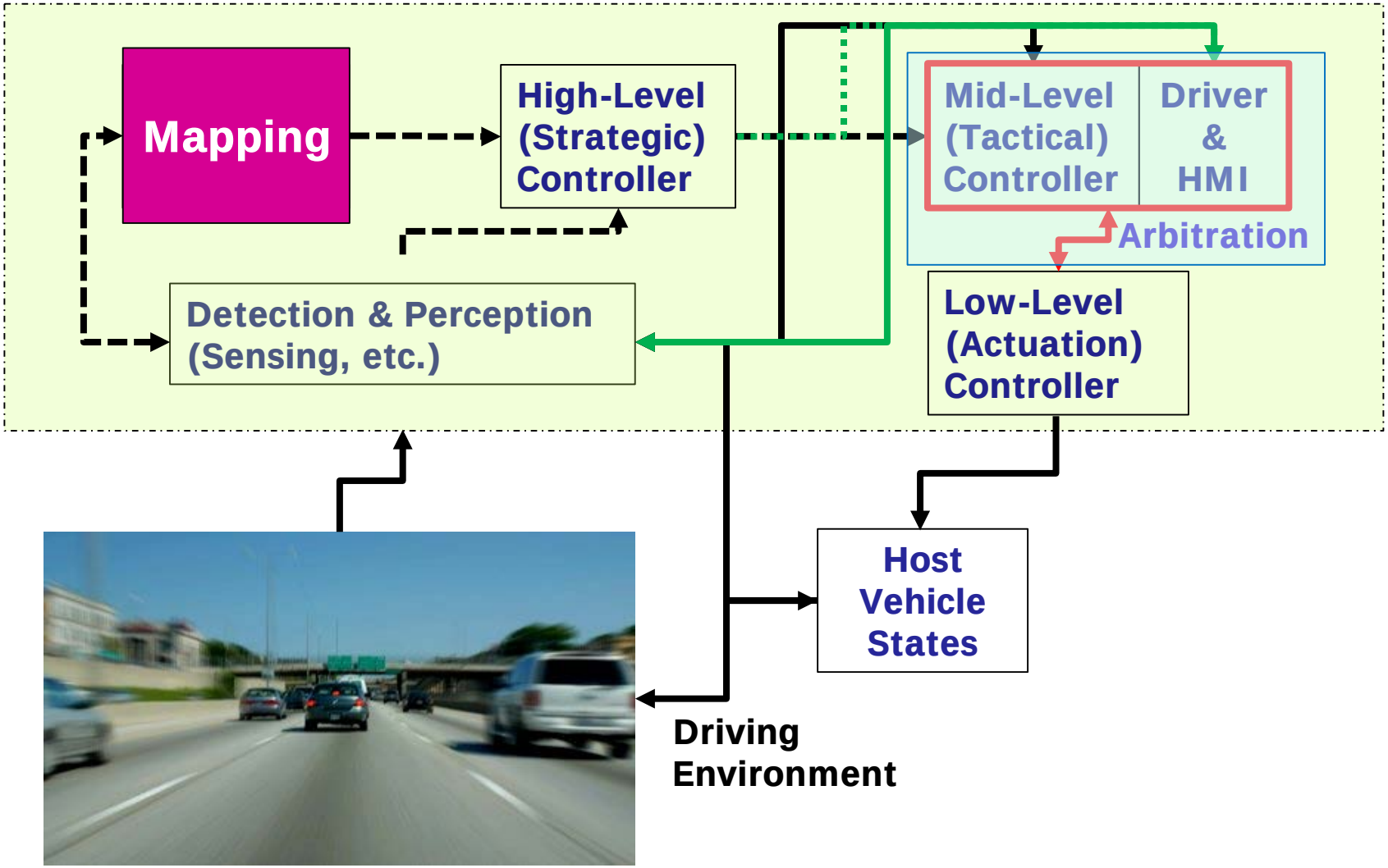
Dissecting Automated Driving Systems

Functional Blocks and Business Sectors

Automated Driving Systems (ADS)



Automated Driving Systems (ADS)



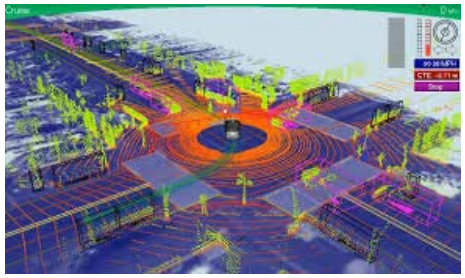
Renaissance of Mapping Sector

Mapping for Autonomous Vehicles

New Business Models for CVs and AVs

Mapping Sector as a Case Study

- **High-Definition and Data-Rich Map becomes a necessity for AVs**



→ Google

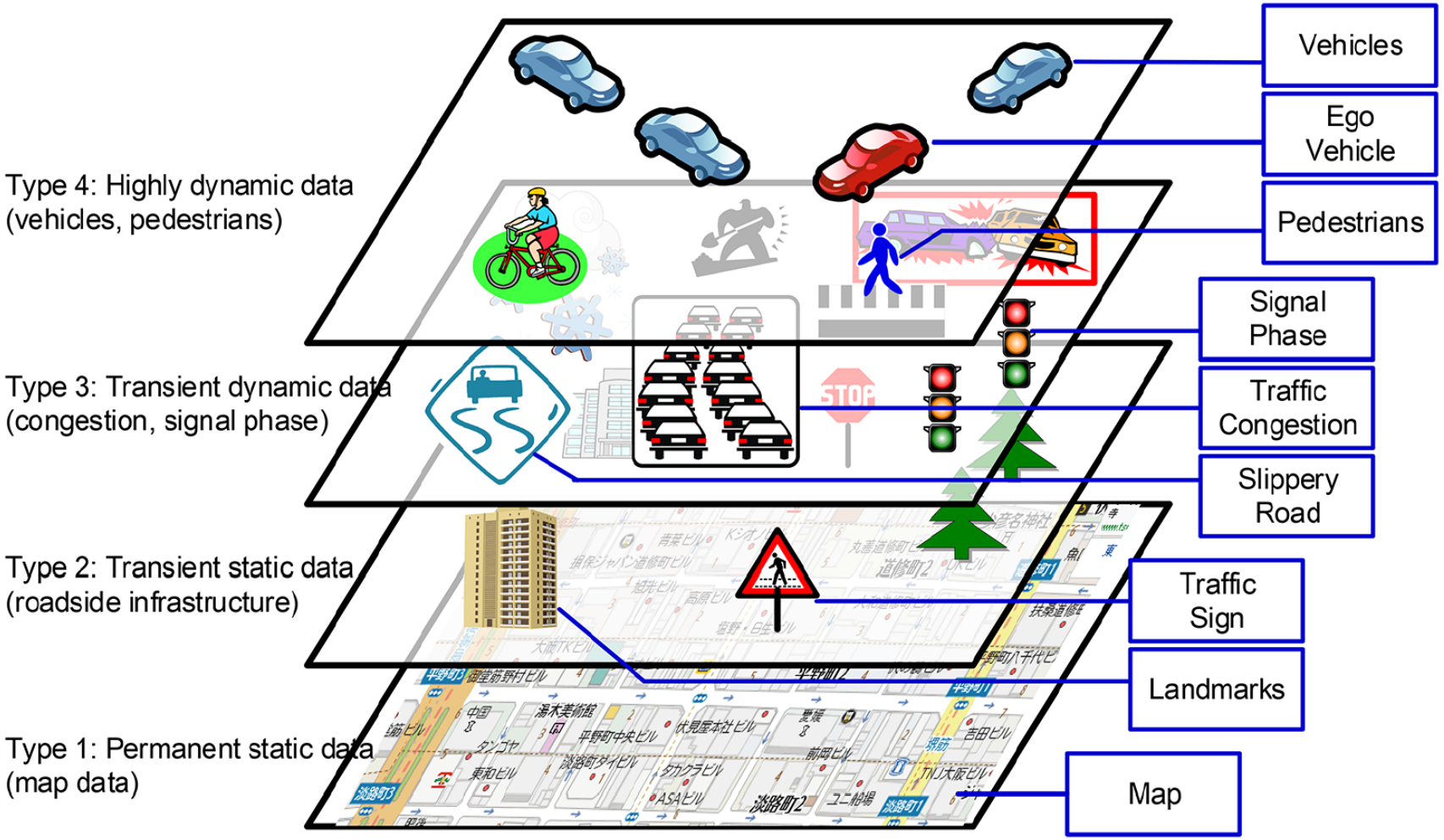
→ HERE (NAVTEQ) HD-LIVE

→ TomTom Roads DNA

→ Mobileye Road Experience Management (Roadbook)

→ Startups (e.g. Civil Map, Map Box)

Four Layers of Local Dynamic Map (LDM)

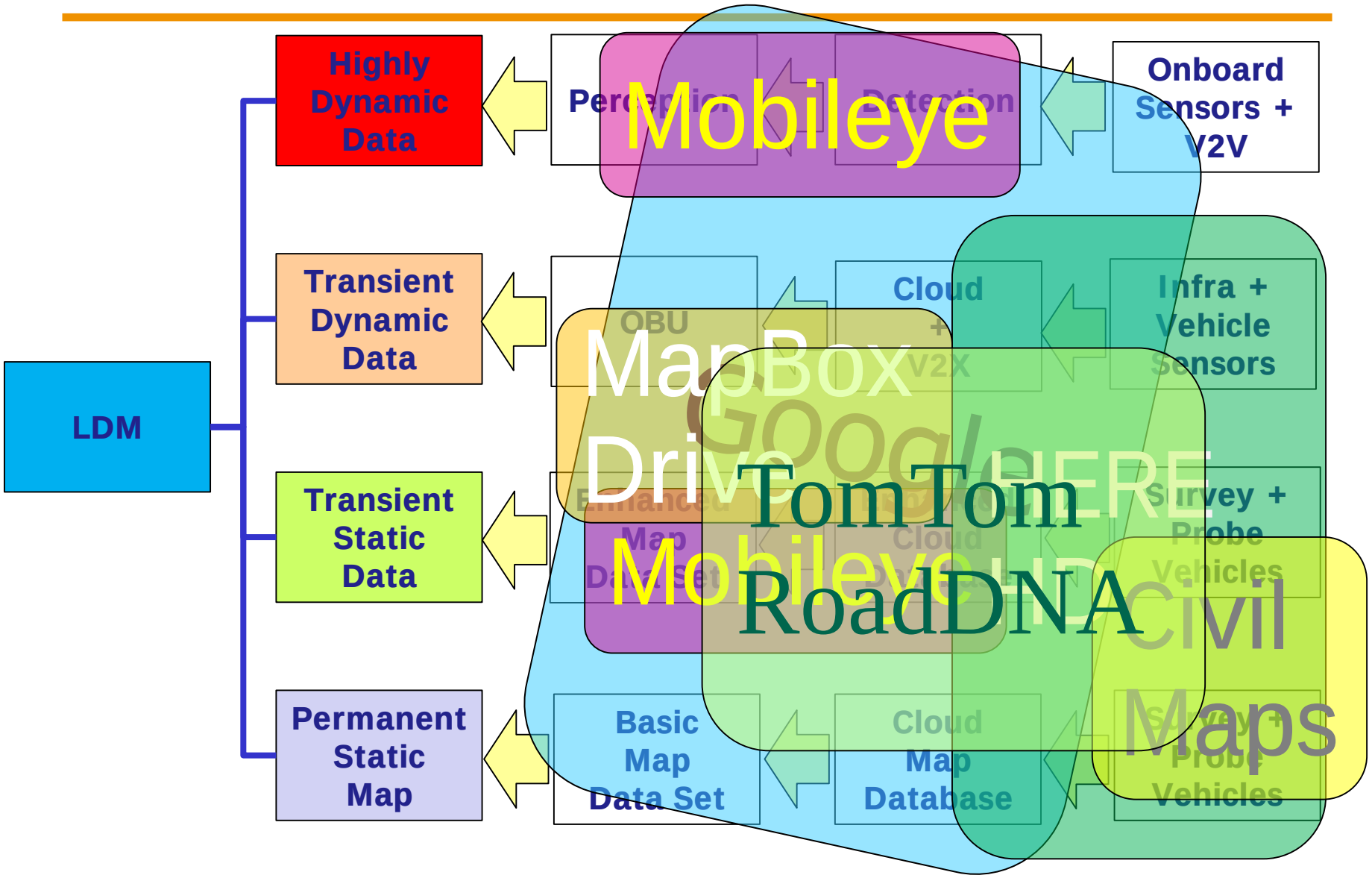


References:

1. Diagram Source: H. Shimada, A. Yamaguchi, H. Takada, K. Sato: 'Implementation and Evaluation of Local Dynamic Map in Safety Driving Systems'. ***Journal of Transportation Technologies,*** **2015, 5, 102-112**

2. CEN ISO EN 18750 Definition of a global concept for Local Dynamic Maps

Mapping (Exemplar Industrial Players)

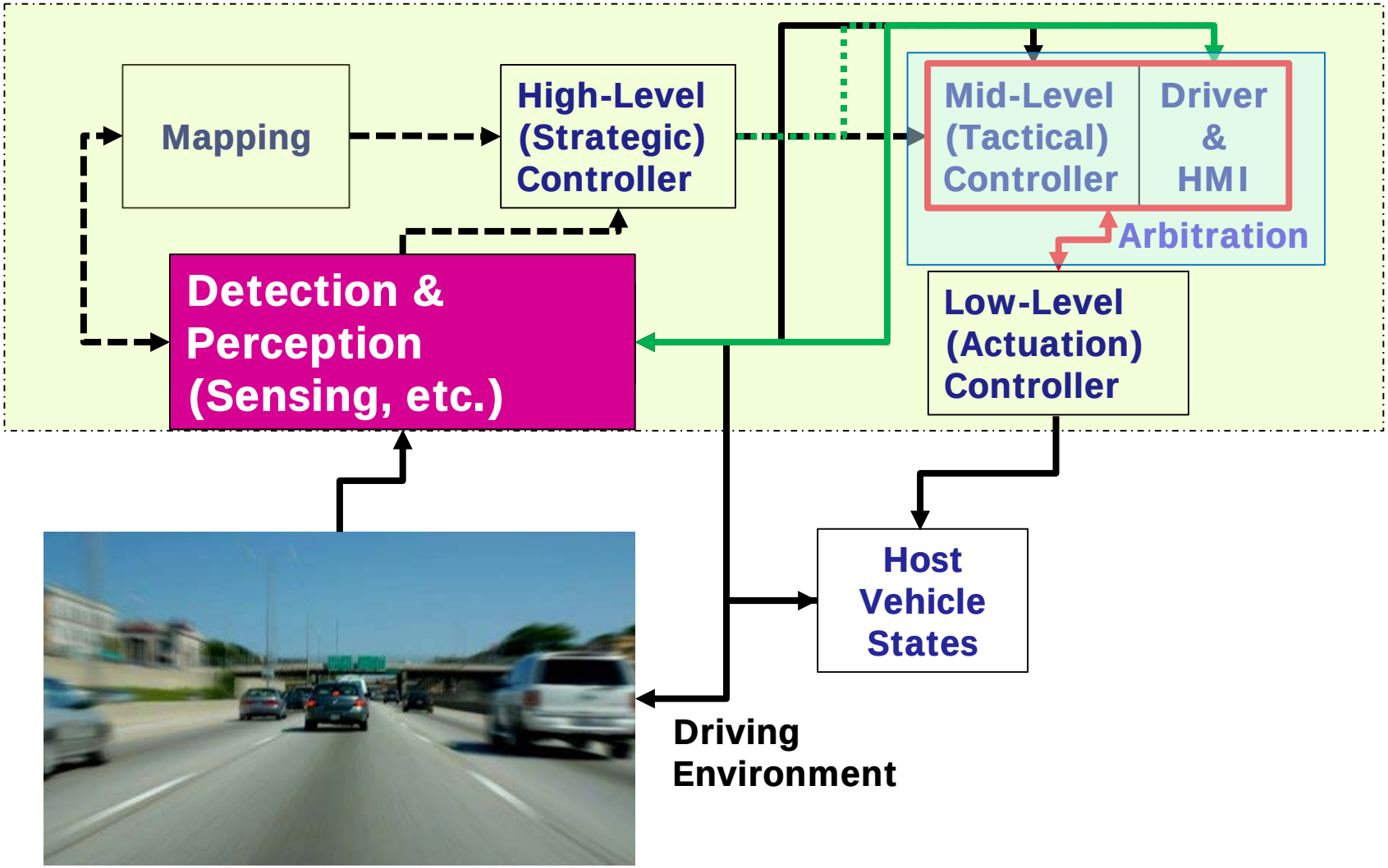


Putting Its Money Where Its Mouth Is

Recent Ford Motor Investments as a Case Study

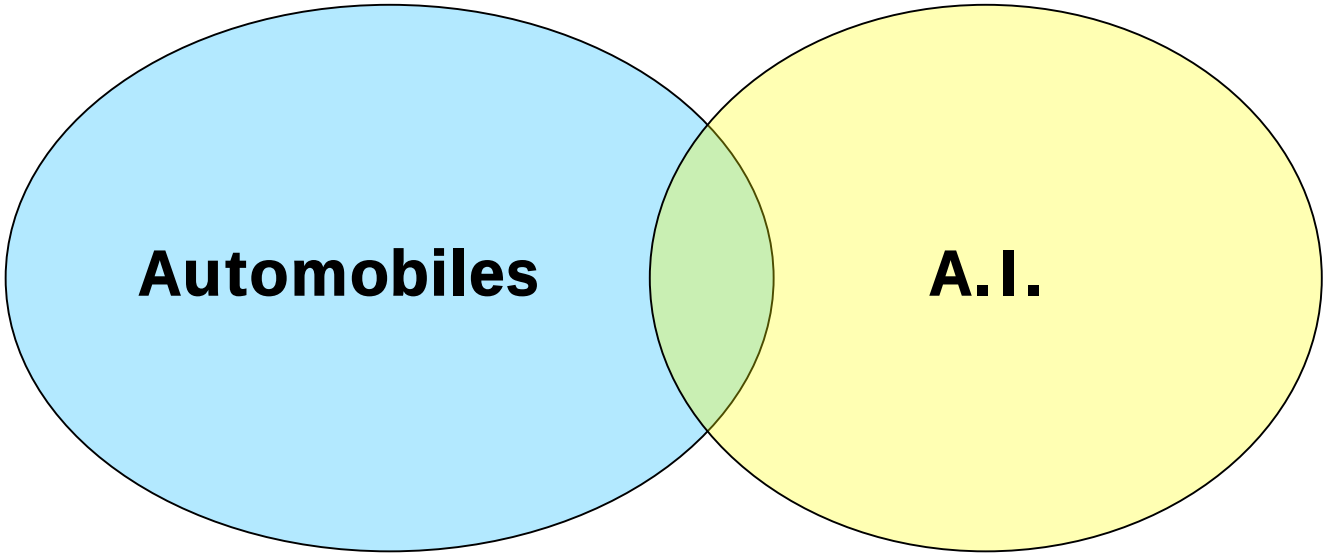
- **When Ford said (08/16) that it would have self-driving cars by 2021 for the market, it also announced four deals:**
  - **Investment in Civil Maps, for its high-resolution 3D mapping capabilities**
  - **Investment (along with China's Baidu) of $150 million in Velodyne for LIDAR systems;**
  - **Purchase (outright) of SAIPS, the Israeli company specializing in image and video processing algorithms;**
  - **License (exclusive) with Nirenberg Neuroscience LLC, focusing on machine vision algorithms**

Functional Blocks Critical for ADS



Detection and Perception

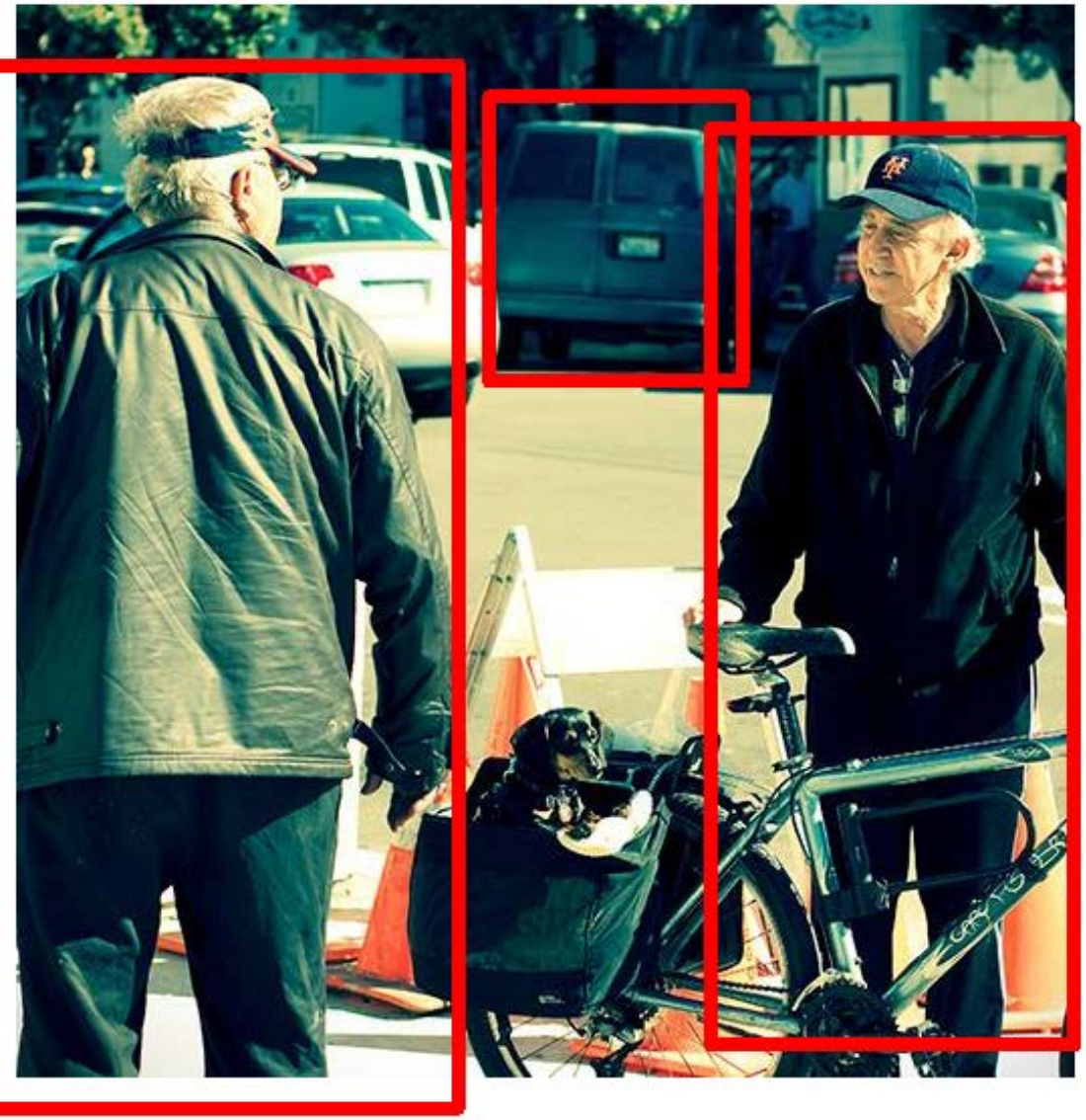
Can Machine Learning (AI) Help (Self-Driving) Cars?



A.I. (Artificial Intelligence) & Machine Learning (Deep Learning)

- **Becoming a Buzzword**
  - **Alpha Go beats (Human) Chess Champion (03/2016)**
- **Already broadly adopted at many high-tech companies**
  - **Google, Facebook, Microsoft, etc.**
- **A flurry of investments in start-ups**
  - **Red Hot in Silicon Valley**
- **White House Charts AI Future**
  - **Preparing for the Future of AI, 10/12/2016**

Large-scale Semantic Description



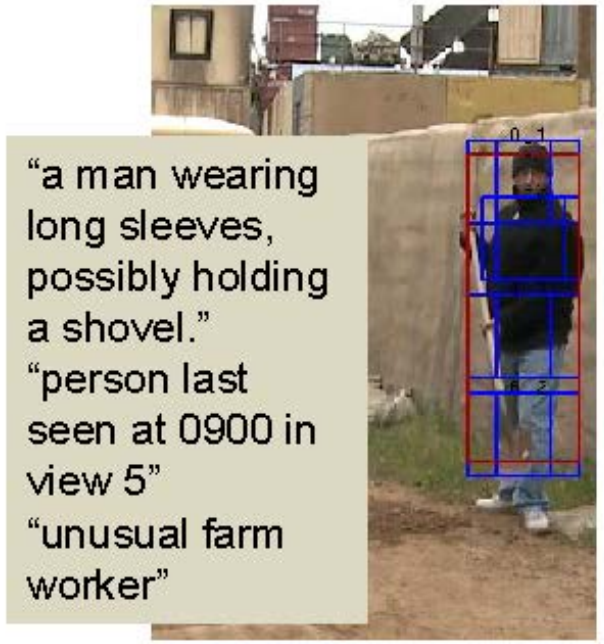
Object Detection

…

Source:
Trevor Darrell
presentation

Large-scale Semantic Description

Object Detection
Semantic Segmentation
Pose Estimation
Attribute Classification
Fine-Grained Recognition
Action Recognition
…



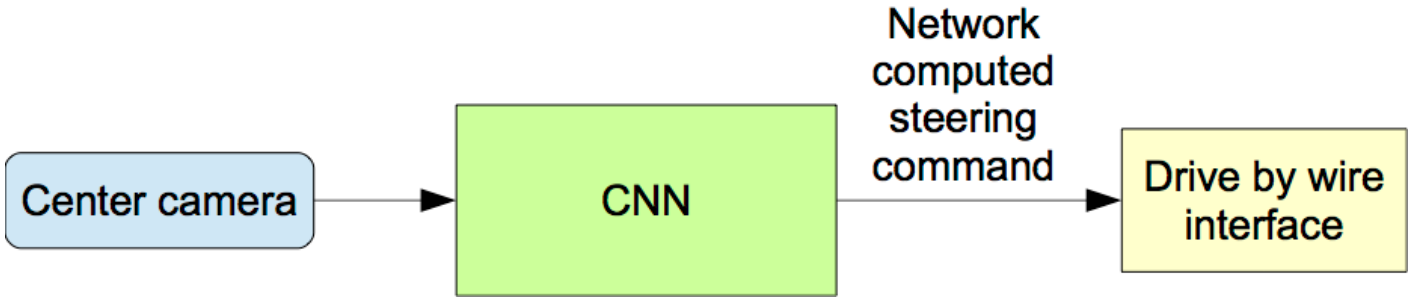
A Case in Point, Hypothetically,

- **Recent Tesla Incident (May 2016, Florida)**
  - **Supposedly, the Tesla (camera + radar) sensor did not recognize the "side of truck" versus the background sky;**
  - **(New Auto-Pilot software version from Tesla addressed the problem by improving radar signal processing)**
- **Can a "deep learning" system recognize an object that is "not the same" as a typical target?**

AI (Deep Learning) for Cars

Something out of Left Field?

- **Nvidia End to End Learning on Drive-PX2 for Self-Driving Cars (04/2016)**
  - **Trained a convolutional neural network (CNN) to map raw pixels from a single front-facing camera directly to steering commands**



- **Comma.ai will ship a $999 autonomous driving add-on by the end of this year (09/2016)**
  - **Tesla-like Auto-Pilot**

Self-Driving Cars

Where are they going?

State of the AV Industry

Organization	Confirmed and Predicted Product Introduction	Predictions of Readiness for Fully Autonomous Vehicles
Audi/VW	2016 – Piloted Driving	Available by 2021
BMW	2014 – traffic jam assist	Available by 2020
Bosch	2017 – Integrated Highway Assist 2020 - Highway Pilot	Auto Pilot by 2025
Continental		Available by 2020
Daimler-Benz	2014 – Intelligent Drive	Available by 2020
Ford	2015 – fully assisted parking	Fleets of AV in 2021
GM	2017 – Super cruise	
Google	2015 – Driverless Pod prototype	Available by 2018
Honda		Available by 2020
Hyundai		Available by 2030
Mobile Eye	2016 – technology ready for OEMs	
Nissan	2016 – traffic jam pilot 2018 – multiple lane control	Available by 2020
Tesla	2015 – Lane Assist + ACC 2016 – highly autonomous	Self-driving 2020-2025
Toyota	Mid 2010s – highly autonomous	
Volvo	2015 – traffic jam assist 2017 – Drive Me FOT in Sweden	Zero fatality cars by 2020

Autonomous Vehicles Getting Real in 2016?

- Google Inks Driverless Car Pact With Fiat Chrysler (04/2016)
- Mobileye signed with automakers for AV in 2019 (05/2016)
- BMW to provide autonomous driving in 2021 (06/2016)
- Baidu to mass produce driverless cars in 5 years (07/2016)
- Uber testing self-driving cars for rides in Pittsburg (08/2016)
- Ford to mass produce fully autonomous vehicles by 2021 (08/2016)
- VW aims at having fully autonomous vehicles by 2021 (08/2016)
- First “Drive Me” Volvo Car off production line and ready for launch for public FOT in early 2017 (09/2016)

Why Automation? Not just for Safety

This is boring and exhausting.

I know I shouldn't drive.

I am just so tired.

I like to chat with my friend.

I have a lot of work to do.

Can you take the kid to school?

Why Automation? Not just for Safety

This is boring and exhausting.

I know I shouldn't drive.

Driver Assistance

I am just so tired.

I like to chat with my friend.

Mobility Service

I have a lot of work to do.

Can you take the kid to school?

Not So Fast, You (Driverless) Cowboy!

- **A.I. guardian-angel vehicles will dominate auto industry, says Gil Pratt, CEO Toyota Research Institute**
  - **The vast majority of mainstream vehicles adopting autonomous driving features will be controlled by advanced driver assistance systems (ADAS) or "guardian angels" that learn over time**
  - **Your car will eventually learn your driving habits and correct you**

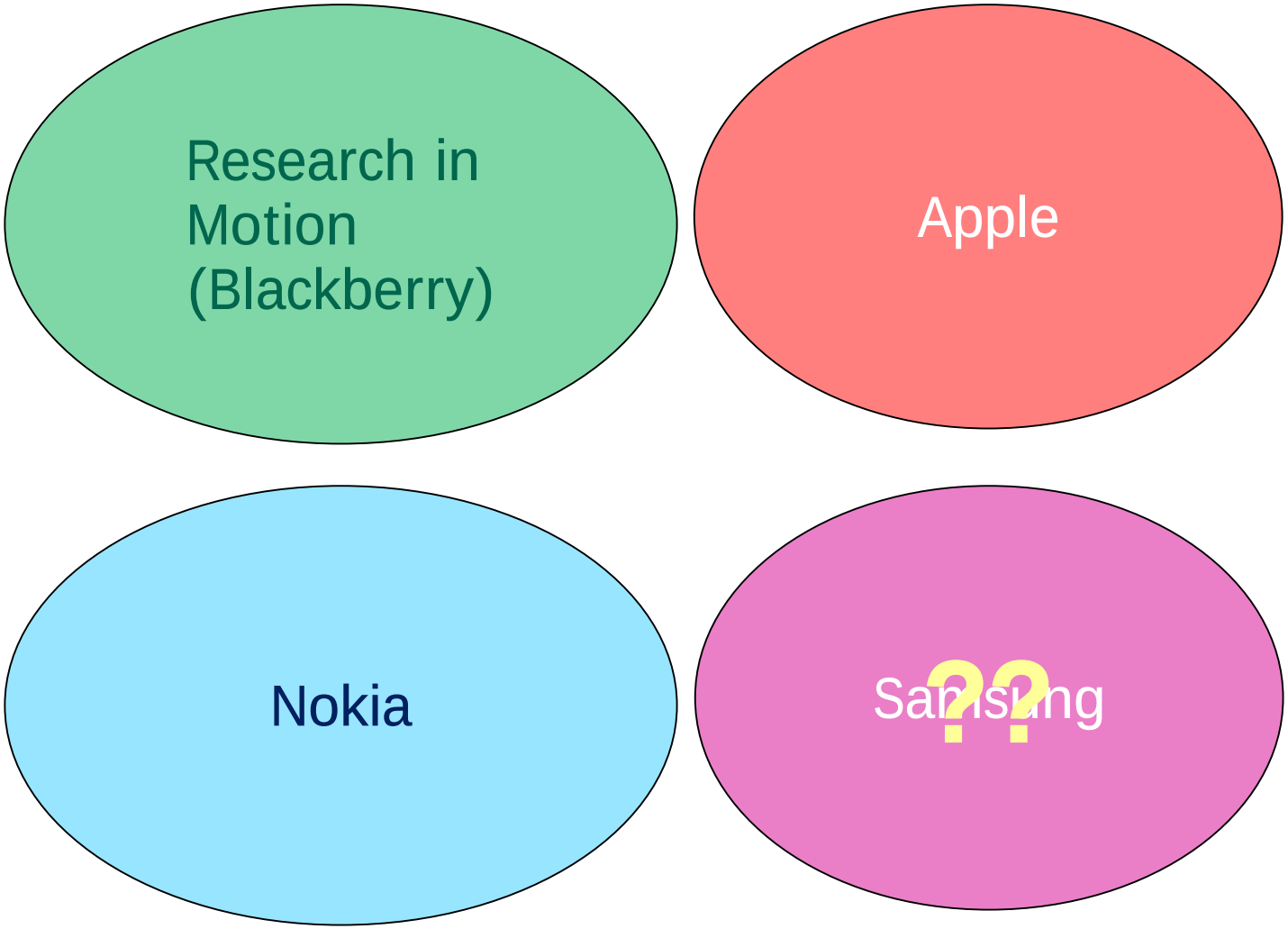
Why Buy a Cow when Milk is so Cheap?

- **Smart Mobility LLC established as a subsidiary of Ford Motor Company (company news, 03/2016)**
  - **Move comes as Ford expands its business model to be both an auto *and* a mobility company**
  - **Ford targets fully autonomous vehicles for ride-sharing in 2021 (company news, 08/2016)**

- **Ford design chief prepares for a driverless society (The Verge, 10/17/2016)**
  - **In the next five years, Ford says it will transform from a company that sells …Mustangs to … autonomous vehicles and … car-sharing ventures.**

A Look Toward the Future

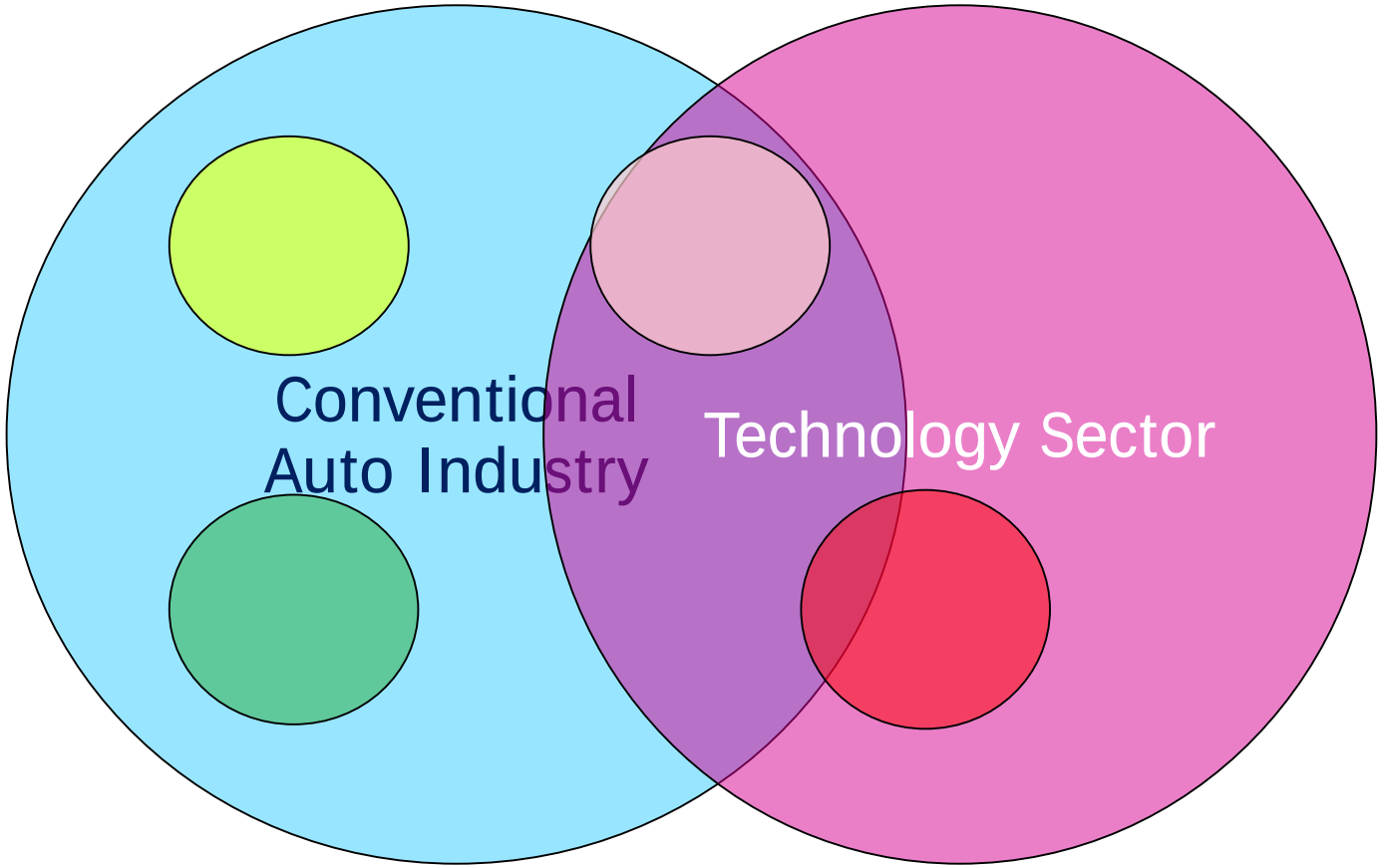
An All-too-Familiar Story



Landscape Shift in Auto and Tech Sectors

A sitting duck

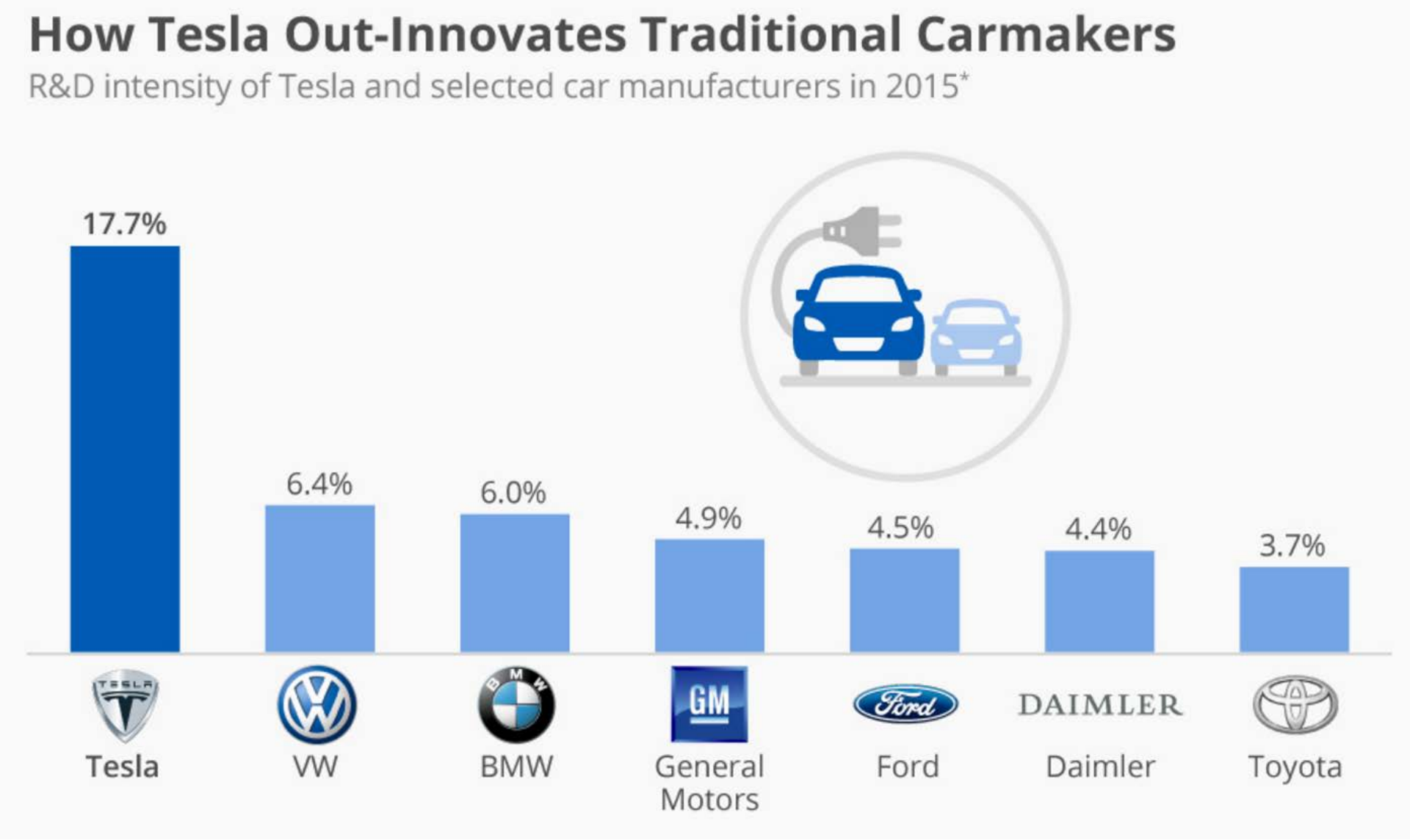
A newcomer



A nimble mover

An aggressor

Will Innovation Win?

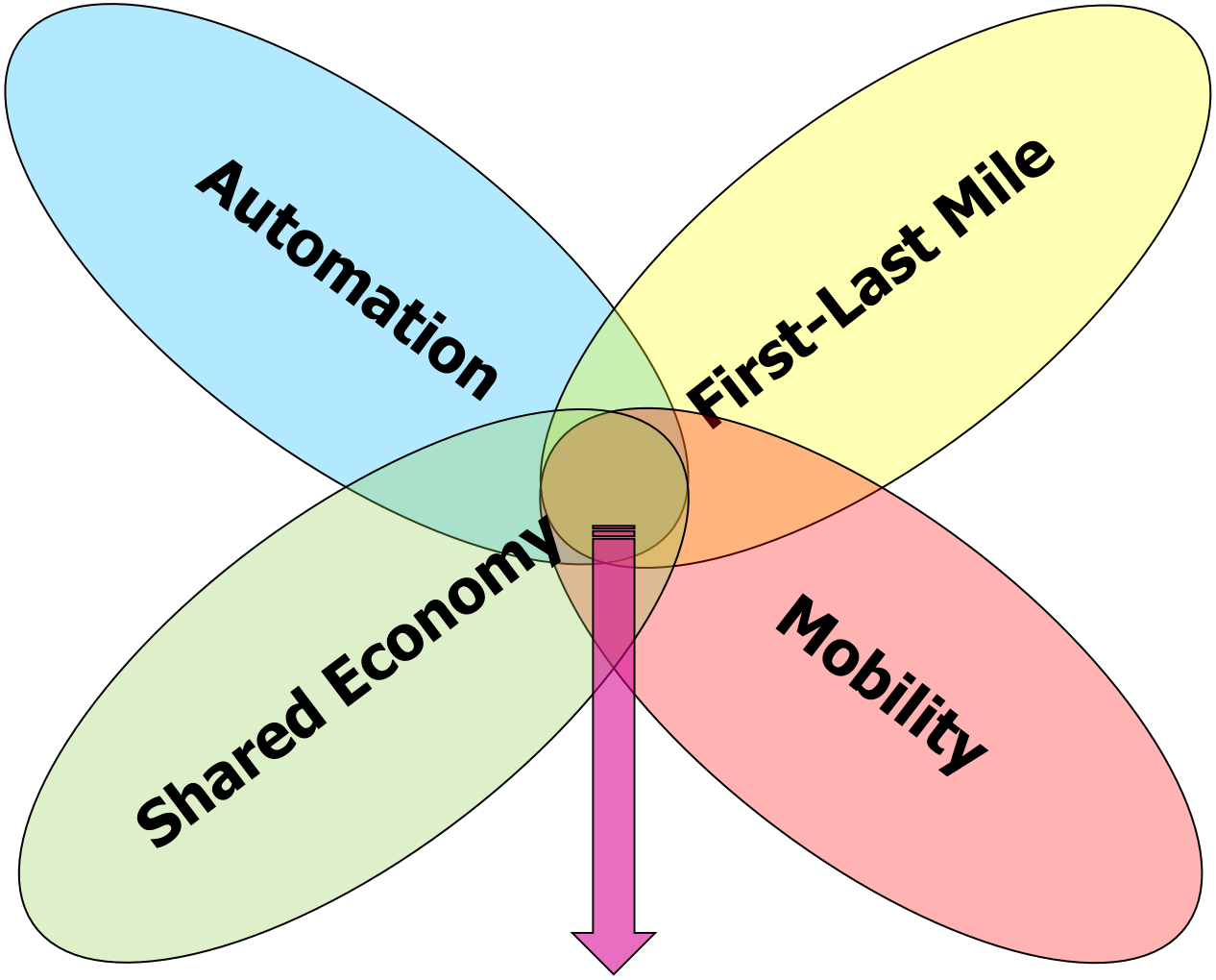


The Times They Are a-Changin'

"As the present now
Will later be past
The order is rapidly fading
And the first one now will later be last
Cause the times they are a-changing"

- *Bob Dylan, Nobel Laureate*

When Mobility Meets Automation



Automated Mobility Services

Disruptive Innovation in Transportation

Automated Mobility Service as a Case Study

- **Automation will enhance ride sharing**
  - **Reduction or elimination of labor costs**
  - **Increased use of car sharing**

- **Fallout, Things at Stake**
  - **Much lower numbers (?) of cars on the road**
  - **$?00B carmaker market at risks**
  - **$190B car insurance, $90B finance, $100B parking, $300B aftermarket**
  - **~4M people employed in auto industry**
  - **~6M professional drivers**

- **Benefits**
  - **$1T disposable income**
  - **?0,000 fatalities and ? millions of injuries**
  - **? hours of time saved on roads**
  - **? % reduction in green house gases**

Tesla Competing with UBER?

"Tesla Sets Price for Self-Driving Feature, Lays Groundwork for Ride-Hailing Service"

"Tesla Motors Inc. said it plans to charge buyers of its newest cars ***$8,000 to activate autonomous-driving technology***, hinting those who do would be ***able to offset the cost through a ride-hailing network*** similar to Uber Technologies Inc. and Lyft Inc."

(Washington Post, 10/21/2016)

Total A Paradigm Shift

What will happen to transportation?

- Demand
- Traffic

- Car ownership
- Business model

- Parking
- Urban Planning

- ....

“The Future is here.

It is just not very evenly distributed.”

-*William Ford Gibson, Novelist*