The Future of Transportation

Piero Scaruffi
Silicon Valley
September 2018
Piero Scaruffi

• 30+ years in Silicon Valley
• Written 20+ books
• Pioneered A.I. and Internet applications

• Founded international inter-university programs (LASERs, LAST Festival)
  Interdisciplinary research at Stanford, UC Berkeley. etc
What I am Going to Discuss

1. The new-energy vehicle (NEV) industry in the USA and innovative transportation vehicles
2. The smart-city infrastructure for the future of transportation
3. Designing the Future
1. The NEV industry in the USA
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
Rationale for Shared Mobility

- Cars are people’s second most expensive household expenditure…
- … but they sit unused 20+ hours a day
- When they are used, they also need to find parking
Shared Autonomous Mobility

- Mercedes (2016)
- NTU (2017)
- Drive.ai (Mountain View, 2018)
Ride-sharing Problem

- Schaller Consulting (2018): Ride-sharing increased traffic by 160% ("cities are likely to be overwhelmed with more automobility, more traffic and less transit")
Connected Mobility

• An "internet of cars": a system to share real-time data from vehicles, roads, traffic signals, etc
  – Infotainment
  – Diagnostics
  – Parking
  – Ride sharing
  – Driver behavior
  – …
GENIVI

Genivi: open-source alliance based in the Bay Area

GENIVI Alliance: An Open, Connected Car Community

- Nonprofit industry alliance
- More than 140 members from across global automotive ecosystem
- Delivering open software for the connected car to reduce costs and accelerate innovation
- 25+ products deployed on five continents
GENIVI

**GENIVI Alliance Membership**

### OEMs

- BMW Group
- DAIMLER
- LAND ROVER
- HONDA
- HYUNDAI
- NISSAN
- RENAULT
- PSA PEUGEOT CITROEN
- VOLVO

### First Tiers

- Aisin AW Co., Ltd.
- ALPINE Electronics
- ALPS Electric
- BOSCH
- Clarion
- Continental
- Delphi
- Denso
- Desay
- ESAB
- HSAE
- HARMAN
- Hyundai
- AUTRON
- LG
- Magneti Marelli
- Mobis
- Peiker
- Pioneer
- Visteon

### OSV, Middleware, Hardware, and Services Suppliers

- Abalta
- ACCESS
- Adera
- ACTIA
- Advanced Driver Information Technology
- Airbiquity (AllGo)
- Atera
- AppDirect
- ARGUS
- Aricent Group
- Arkamys
- audiokinetic
- CodeThink
- Collabora
- Cognite
- Cumulus
-Digia
- Digimarc
- Digital River
- Driveworks
- DRIVE SPOTTER
- DriveTime Metrics
- Element 13
- ENGIS
- EPM
- Ericsson
- Epic Systems
- Exceeda
- FireEye
- Fluendo
- Global Edge
- Garmin
- Global Logic
- Green Hills Software
- Heads-Up!
- HCL
- HERE
- Hero
- Karamba Security
- KIPT Cummins
- LT
- Linkmotion
- Livio
- Luxoft
- MapBox
- Mentor Automotive
- Movavi
- NXP
- Navis-AMS
- Neusoft
- NAVTEQ
- NGIN
- Nuvola
- Octan/e
- Open Systems
- Path Partner
- Polysync
- Quest
- Recognition Technologies, Inc.
- Rogue Wave Software
- Ranch To Road
- Renesas
- Rohm
- Texas Instruments
- Telemotive AG
- Tennos
- TomTom
- Trend Micro
- Tuxera
- Urban Systems
- Validated
- Workfront
- Windchill
- Xevo

### Silicon

- Analog Devices
- ARM
- Intel
- Marvell
- MediaTek
- NVIDIA
- NXP
- Qualcomm
- Renesas
- Rohm
- Telechips
- Texas Instruments
GENIVI

- Case study: Nevada Department of Transportation: connected cars for pedestrian safety (2017)
  - Bus Stop Warnings
  - High-Risk Warning Areas – using a
  - Speeding Warning
Self-driving Cars

• GM’s Chevy Bolt
• GM Cruise

GM unveils autonomous Bolt EV without steering wheel or pedal, aims to bring it to market next year
Fred Lambert - Jan. 12th 2018 8:14 am ET  
@FredericLambert

GM Cruise Prepping Launch Of Driverless Car Pilot In San Francisco: Emails

Ryan Felton  
6/05/18 2:57pm
Self-driving Cars

### Self-driving Cars

#### The Players

<table>
<thead>
<tr>
<th>Category</th>
<th>Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chipmakers</td>
<td>Intel, Nvidia, Qualcomm, Samsung</td>
</tr>
<tr>
<td>Component makers</td>
<td>Bosch, Valeo,</td>
</tr>
<tr>
<td>Software</td>
<td>Google/Waymo,</td>
</tr>
<tr>
<td>Automakers</td>
<td>GM, Ford, Toyota, BMW, Daimler,</td>
</tr>
<tr>
<td>Ride services</td>
<td>Uber, Lyft,</td>
</tr>
</tbody>
</table>
Self-driving Cars

- Las Vegas (2018) first fully autonomous electric shuttle
- Drive.ai (2018) taxi service in Texas
- Voyage (2018) service for gated community in San Jose
- California (2018) first license for fully-autonomous cars (Waymo)
Self-driving Cars

- Uber (San Francisco)
- Nutonomy (Boston)
- Zoox (Bay Area)
- Google (Bay Area)
Self-driving Cars

- Zoox (2014): an autonomous vehicle built “from the ground up”, not as an evolution of the traditional car.

Self-driving car startup Zoox is raising $500 million at a $3.2 billion valuation.

$3.2 Billion Autonomous Car Startup Zoox Suddenly Fired Its CEO and Won't Explain Why

Tim Kentley-Klay
Self-driving Cars

- Aurora (2016, former Google-Uber-Testa engineers)
- Nuro.ai (2016, former Google engineers)

California start-up Nuro unveils autonomous delivery van, raises $92 million

Our first step is a self-driving vehicle for local goods transportation

This is Sedric - Volkswagen's concept car that will integrate technology from new startup Aurora Innovations
Self-driving Cars

- Autox (2016): grocery delivery in San Jose in 2018

Autonomous vehicle startup AutoX has launched a grocery delivery and mobile store pilot.
Self-driving Cars

Google Autonomous Car Spinoff Waymo Builds Town As Test Track

San Francisco Chronicle
Waymo gets green light for robot cars in California; no humans needed
Oct. 30, 2018
Self-driving Cars

• Waymo launch commercial service in Arizona

"Waymo… we moved into very early days of commercialization. So, we do now have people paying for rides" (Ruth Porat)
Self-driving Cars

- Nvidia:
  - chips for autonomous driving
  - A.I. software for assisted driving
Self-driving Cars

- Nvidia: Audi, Volvo…
Self-driving Cars

- Nvidia’s competitors: AI hardware startups

<table>
<thead>
<tr>
<th>Startup</th>
<th>Founded</th>
<th>Number of Rounds</th>
<th>Total Funding Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave Computing (Campbell, Calif.)</td>
<td>2010</td>
<td>4</td>
<td>$117.3 million</td>
</tr>
<tr>
<td>Cerebras System (Los Altos, Calif.)</td>
<td>2016</td>
<td>3</td>
<td>$112 million</td>
</tr>
<tr>
<td>Graph core (Bristol, UK)</td>
<td>2016</td>
<td>3</td>
<td>$110 million</td>
</tr>
<tr>
<td>ThinCI (El Dorado Hills, Calif.)</td>
<td>2010</td>
<td>3</td>
<td>$85 million</td>
</tr>
<tr>
<td>Samba Nova Systems (Palo Alto, Calif.)</td>
<td>2017</td>
<td>1</td>
<td>$56 million</td>
</tr>
<tr>
<td>Mythic (Austin, Texas)</td>
<td>2012</td>
<td>5</td>
<td>$55.2 million</td>
</tr>
<tr>
<td>Groq (Palo Alto, Calif.)</td>
<td>--</td>
<td>1</td>
<td>$20 million</td>
</tr>
<tr>
<td>AlphaICs (Bengaluru, India)</td>
<td>2016</td>
<td>1</td>
<td>$2.4 million</td>
</tr>
</tbody>
</table>

(Source: Company filings, EE Times)
Self-driving Cars

- AI hardware startups

Forbes
AI Chip Boom: This Stealthy AI Hardware Startup Is Worth Almost A Billion

ThinCI raises $65 million to develop its processors for autonomous and connected vehicles

Groq, A Stealthy Startup Founded By Google’s TPU Team, Is Raising $60M
Self-driving Cars

- DeepMap (2018): centimeter-level real-time localization for various road types and driving conditions

Autonomous vehicle mapping startup DeepMap raises $60M+ on $450M valuation

The Funded: 10 Bay Area companies raise over $1.4B at week’s end

- View Inc., Milpitas, $1.1 billion: The SoftBank Vision Fund led the late-stage funding of this smart glass startup. Read more here.

- HashiCorp Inc., San Francisco, $100 million: Institutional Venture Partners led the Series D round for this cloud infrastructure automation company, which reportedly came at a valuation of $1.9 billion. It was joined by Bessemer Venture Partners, GGV Capital, Mayfield, Redpoint Ventures and True Ventures.

- Neo4j Inc., San Mateo, $80 million: One Peak Partners and Morgan Stanley Expansion Capital co-led the Series E round for this developer of graph databases. They were joined by Creandum, Eight Roads and Greenridge Partners. Read more here.

- DeepMap Inc., Palo Alto, $60 million: The Series B round for
Self-driving Cars

- Solid-state LIDAR (Quanergy, 2012)
  - Fisker EM 2019
Self-driving Cars

- Yes, we know about Pony.ai…
Self-driving Cars

Joshua Brown, the first person to die in a self-driving car accident (June 2016)

Waymo's cars with safety drivers have been involved in dozens of accidents in California,
Self-driving Cars

• 2018: Year of the Skepticism

Forbes
Robo-Car Skepticism Rises

REUTERS
OCTOBER 24, 2018 / 1:12 PM / 13 DAYS AGO

GM's driverless car bet faces long road ahead

MotorTrend
TAPPING THE BRAKES: WHY THE AUTONOMOUS-CAR SOCIETY IS STILL DECADES AWAY

The Wall Street Journal
Driverless Hype Collides With Merciless Reality

Sept. 13, 2018
Self-driving Cars

- Investment:
  - While big automotive and technology companies are investing billions, Silicon Valley investors have spent very little money in autonomous vehicle startups

Sergio Marchionne, CEO of Fiat Chrysler: “You can destroy a lot of value by investing… in autonomous driving.”
Self-driving Cars

Largest 2018 investment rounds:

1. WeWork (New York): $1B
2. **Lucid Motors (Newark, CA):** $1B
4. **Zoox (Menlo Park, CA):** $500M
5. Letgo (New York): $500M
6. Uber (San Francisco): $500M
7. Samumed (San Diego, CA): $438M
8. Slack Technologies (San Francisco): $427M
9. AppLovin (Palo Alto, CA): $400M
10. OpenDoor Labs (San Francisco): $400M
NEV industry

• Software (shared, connected, autonomous mobility)
• Hyper-transportation
• New energy
• Wireless charging
• Lightweight materials
• 3D Printing
Hyper-transportation

- Elon Musk’s white paper (2013): the hyperloop

Hyperloop Preliminary Design Study
Technical Section

Elon Musk (2013)

1. Abstract

Existing conventional modes of transportation of people consists of four unique types: rail, road, water, and air. These modes of transport tend to be either relatively slow (e.g., road) or expensive (e.g., rail and air). The concept of relatively slow transport that is both inexpensive for people and efficient for design concept, similar to what we can help advance the concept of transportation.

Hyperloop consists of a low pressure tube with capsules both low and high speeds throughout the length of the tube, supported on a cushion of air, featuring pressurized. The capsules are accelerated via a magnetic linear actuator, moving at various stations on the low pressure tube with rotors and fans. Passengers enter and exit Hyperloop at stations along the tube length.

Figure 2. Hyperloop conceptual diagram.

Figure 4. Hyperloop passenger capsule subsystem notional locations (not to scale).
Hyper-transportation

- SpaceX (Elon Musk - Los Angeles)
- Hyperloop Tech/One (Shervin Pishevar - Los Angeles, 2014)
  - Test tube in Nevada (2017)
  - cargo in 2019
  - passengers in 2021
Hyper-transportation

- Hyperloop TT (Dirk Ahlborn - Los Angeles, 2014)

Hyperloop Transportation Technologies to Build China's First Hyperloop System

HyperloopTT to open Chinese entity and begin work on China's first Hyperloop starting with an initial 10 km commercial agreement at Tongren in Guizhou Province.

HTT signs agreement to develop a Hyperloop in India
Hyper-transportation

- SpaceX Hyperloop Pod Competition

2019 SpaceX Hyperloop Pod Competition

Rules and Requirements

August 23, 2018
VTOL

- VTOLs - Vertical Take Off and Landing vehicles
- EVTOLs - Electric VTOLs

AIAA Paper 2003-2646

PERSONAL AIR VEHICLES:
A RURAL/ REGIONAL AND INTRA-URBAN ON-DEMAND TRANSPORTATION SYSTEM

Mark D. Moore
NASA Langley Research Center
Hampton, VA 23681-2199
VTOL

• EVTOLs - Electric VTOLs
  – Kitty Hawk (California): flying car Flyer (unveiled in 2017) and autonomous flying taxi Cora (unveiled in March 2018)
  – Cora = electric power + self-piloting software + vertical take-off

Bloomberg

Hyperdrive
Welcome to Larry Page’s Secret Flying-Car Factories
With Zee.Aero and Kitty Hawk, the Google co-founder looks to the skies.

Kitty Hawk Conducts Flying Car Trials in Las Vegas

The flying car backed by Google's cofounder just got a big update, and people can pilot it with less than an hour's training
VTOL

- EVTOLs - Electric VTOLs
  - A³ (Airbus in Silicon Valley): Vahana (first tested in January 2018)
VTOL

- VTOLs - Vertical Take Off and Landing vehicles
  - Joby (California): air taxi ($100m in February 2018)

Air-Taxi Startup Has a Working Prototype and a Fresh $100 Million

- Joby Aviation hides its craft at a secretive private airfield.
Flying Car

- Flying cars
  - Boeing
  - Japan: Boeing, Airbus, Japan Airlines, NEC, ANA Holdings, Yamato Holdings, Toyota’s startup Cartivator, etc
Flying Car

- Flying cars
  - Uber

Bloomberg

February 6, 2017.

Technology

Uber Hires Veteran NASA Engineer to Develop Flying Cars

The man who inspired Google's co-founder

Bloomberg

May 24, 2018.

Uber Is Opening a Flying-Car Lab in Paris
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
Clean-tech

• Planet (founded by ex-NASA scientists in 2010) operates the world’s largest constellation of satellites in history
• Planet has launched over 150 Earth-imaging satellites
• State of California + Planet Labs to develop a satellite that will track climate change-causing pollutants
• Climate Data Partnership to serve as a common platform for reporting data from satellite systems studying climate variables
Clean-tech

- Powerhouse (Oakland, 2013): incubator for cleantech startups
Clean-tech

- Bloom (Sunnyvale, 2001): fuel cells that can produce electricity at costs that are competitive with grid power
Clean-tech

- Genability (San Francisco, 2010): new-energy use optimization
- Autogrid (Redwood City, 2011): new-energy use optimization
- Advanced Microgrid Solutions (San Francisco, 2012): software to ensuring electricity from generators, renewable energy, batteries and the grid itself will always perfectly match the needs of the buildings
Clean-tech

- Aclima (San Francisco, 2010): air-quality mapping platform - mobile sensing platform on Street View cars in collaboration with Google Earth Outreach (IoT of city-wide network of sensors)
Clean-tech

- DBL Partners - Double Bottom Line Venture Capital (San Francisco, 2016): the first venture capital fund specializing in “impact investment” to achieve significant financial returns to scale
Clean-tech

- The garbage industry has traditionally been low-tech
- How to disrupt the $60 billion garbage industry?
- Rubicon Global (Kentucky, 2008): a cloud-based “Uber for trash”
- $1 billion in 2017 (most valued cleantech startup in the US)
- Controversy: “a trash brokerage business masquerading as a tech company” (Fortune)
Clean-tech

• Aemetis Company (Cupertino, 2006): renewable fuels
• Alphabet Energy (Berkeley, 2009), spinoff of Lawrence Berkeley National Laboratory: generate power from waste heat
Clean-tech

- Problems: BrightSource leaves California after building the largest solar thermal power plant in the world at Ivanpah (2014)
Clean-tech

- No cleantech unicorn in the top 100

<table>
<thead>
<tr>
<th>Company</th>
<th>Valuation ($B)</th>
<th>Date Joined</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uber</td>
<td>$72</td>
<td>8/23/2013</td>
<td>United States</td>
</tr>
<tr>
<td>Didi Chuxing</td>
<td>$56</td>
<td>12/31/2014</td>
<td>China</td>
</tr>
<tr>
<td>Airbnb</td>
<td>$29.3</td>
<td>7/26/2011</td>
<td>United States</td>
</tr>
<tr>
<td>SpaceX</td>
<td>$21.5</td>
<td>12/1/2012</td>
<td>United States</td>
</tr>
<tr>
<td>Palantir Technologies</td>
<td>$20</td>
<td>5/5/2011</td>
<td>United States</td>
</tr>
<tr>
<td>WeWork</td>
<td>$20</td>
<td>2/3/2014</td>
<td>United States</td>
</tr>
<tr>
<td>Toutiao (Bytedance)</td>
<td>$20</td>
<td>4/7/2017</td>
<td>China</td>
</tr>
<tr>
<td>Stripe</td>
<td>$20</td>
<td>1/23/2014</td>
<td>United States</td>
</tr>
</tbody>
</table>

Cbinsight.com - August 2018

<table>
<thead>
<tr>
<th>Company</th>
<th>Valuation ($B)</th>
<th>Date Joined</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lu.com</td>
<td>$18.5</td>
<td>12/26/2014</td>
<td>China</td>
</tr>
<tr>
<td>JUUL Labs</td>
<td>$15</td>
<td>12/20/2017</td>
<td>United States</td>
</tr>
<tr>
<td>Pinterest</td>
<td>$12.3</td>
<td>5/19/2012</td>
<td>United States</td>
</tr>
<tr>
<td>Bitmain Technologies</td>
<td>$12</td>
<td>7/6/2018</td>
<td>China</td>
</tr>
<tr>
<td>Lyft</td>
<td>$11.5</td>
<td>3/12/2015</td>
<td>United States</td>
</tr>
<tr>
<td>GrabTaxi</td>
<td>$11</td>
<td>12/4/2014</td>
<td>Singapore</td>
</tr>
<tr>
<td>Global Switch</td>
<td>$11.08</td>
<td>12/22/2016</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Infor</td>
<td>$10</td>
<td>11/16/2016</td>
<td>United States</td>
</tr>
<tr>
<td>DJI Innovations</td>
<td>$10</td>
<td>5/6/2015</td>
<td>China</td>
</tr>
</tbody>
</table>
Electric Cars

Tesla Market Cap 2009-2018

From: 06/29/2010 To: 11/05/2018

Zoom: 3M 6M 1Y 2Y 3Y 5Y A
Tesla is now the highest valued automaker in the United States.

Tesla is the world's 4th largest automaker by value.

This is despite only delivering 76,230 vehicles in 2016.
New-Energy Vehicles

• National programs to ban internal combustion engine (ICE) vehicles in favor of electric ones: Norway by 2025, India and China by 2030, Britain and France by 2040, California by 2040
New-Energy Vehicles

• 2017:
  – Opening of Tesla’s largest charger station, halfway between Los Angeles and San Francisco
New-Energy Vehicles

• China rules!
  – 2017: China’s electric vehicle production is 50% of global production (EU 21%, USA 17%, Japan 8%, South Korea 3%)
  – 2017: China’s battery cell production for electric vehicles is 11 times that of the USA
  – 2017: Largest stock of electric vehicles in the world, with cumulative sales of more than 1.7 million units
Figure ES-1. Electric vehicle sales, electric vehicle production, and electric vehicle battery production by region through 2017.
New-Energy Vehicles

- US startups
  - Electric vehicle startups raised more than $2 billion in the U.S. over the first months of 2018 alone, a huge increase over the $650 million raised in 2017

<table>
<thead>
<tr>
<th>Stage</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angel/Seed</td>
<td>$18.99</td>
<td>$7.65</td>
<td>$60.40</td>
<td>$12.39</td>
<td>$84.39</td>
<td>$2,006.30</td>
</tr>
<tr>
<td>Early VC</td>
<td>$301.37</td>
<td>$29.68</td>
<td>$60.17</td>
<td>$375.65</td>
<td>$194.35</td>
<td>$49.10</td>
</tr>
<tr>
<td>Later VC</td>
<td>$274.30</td>
<td>$61.63</td>
<td>$234.83</td>
<td>$245.62</td>
<td>$402.36</td>
<td>$100.42</td>
</tr>
</tbody>
</table>

*Data as of 3/18/2018
New-Energy Vehicles

- California startups

**Table 1. Electric vehicle and general data for California and the United States.**

<table>
<thead>
<tr>
<th></th>
<th>U.S.</th>
<th>California</th>
<th>California as percent of U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>326 million</td>
<td>39.5 million</td>
<td>12%</td>
</tr>
<tr>
<td>Gross domestic product</td>
<td>$19.4 trillion</td>
<td>$2.75 trillion</td>
<td>14%</td>
</tr>
<tr>
<td>Light-duty vehicle sales in 2016</td>
<td>16.2 million</td>
<td>2.0 million</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Electric vehicles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New 2017 electric vehicles</td>
<td>193,000</td>
<td>96,000</td>
<td>50%</td>
</tr>
<tr>
<td>Cumulative 2010-2017 electric vehicles</td>
<td>749,000</td>
<td>366,000</td>
<td>49%</td>
</tr>
<tr>
<td><strong>Electric vehicle public charging</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2 charge points</td>
<td>38,100</td>
<td>12,000</td>
<td>32%</td>
</tr>
<tr>
<td>Fast charge points</td>
<td>6,200</td>
<td>1,600</td>
<td>25%</td>
</tr>
<tr>
<td>Total charge points</td>
<td>44,300</td>
<td>13,600</td>
<td>31%</td>
</tr>
</tbody>
</table>

Population data from U.S. Census; income data from U.S. Bureau of Economic Analysis; vehicle registrations from IHS Automotive; public charging data from Alternative Fuels Data Center.
New-Energy Vehicles

- California startups
New-Energy Vehicles

- Karma Automotive (2015, ex Fisker, owned by Wanxiang Group)
- Evelozcity (2017)
- Independent Electric Vehicles (2017, Steve Osorio)
New-Energy Vehicles

- SF Motors (2016, John Zhang) – with Tesla’s founder Martin Eberhard
- Lucid Motors (2017, Peter Rawlinson)
New-Energy Vehicles

• The problem: the range
  – Chevy Bolt EV (238 miles)
  – Tesla Model 3 (220 miles)
  – Nissan Leaf (150 miles)

• Solutions
  – Charging stations
  – New kind of batteries
  – Wireless charging
  – Lighter materials
New-Energy Vehicles

- Volta Charging (San Francisco, 2010): network of free charging stations
- FreeWire (San Leandro, 2014): portable electric vehicle charging stations
New-Energy Vehicles

- New-energy vehicles use… OLD energy!
- The lithium-ion battery was introduced in 1991
New-Energy Vehicles

Energy@Stanford & SLAC 2018

Energy Research for the 21st Century
Monday - Thursday, September 10 - 13
Friday, September 14 (optional half-day)

Stanford Precourt Institute for Energy
SIMES SLAC National Accelerator Laboratory

August 30, 2018
Chuntian Cao wins 2018 Klein Award for lithium-ion battery research

Using SLAC’s X-ray synchrotron SSRL, Cao improves fundamental knowledge about how a new lithium-ion battery material works
New-Energy Vehicles

• Cryo-electron microscopy (Cryo-EM) to study battery materials
  – 2016: Yi Cui at Stanford uses Cryo-EM for research on battery material: the first time ever that scientists can see atomic-level microscopic images of lithium metal
New-Energy Vehicles

- Cryo-electron microscopy (Cryo-EM)
  - 2017 Nobel prize in chemistry

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry 2017 to

Jacques Dubochet
University of Lausanne, Switzerland

Joachim Frank
Columbia University, New York, USA

Richard Henderson
MRC Laboratory of Molecular Biology, Cambridge, UK

“for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution”
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
New-Energy Vehicles

- Wireless Charging: Near-field WPT (wireless power transfer), inductive or capacitive
New-Energy Vehicles

- Wireless Charging: energy.gov/eere
New-Energy Vehicles

- Wireless Charging based on magnetic resonance technology
  - WiTriCity (Boston)
  - Qualcomm’s wireless charging system Halo
New-Energy Vehicles

- Wireless Charging of moving electric vehicles
  - Shanhui Fan (Stanford)

Robust wireless power transfer using a nonlinear parity-time-symmetric circuit

Sid Assawaworrarit, Xiaofang Yu & Shanhui Fan
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
• Carbon fiber instead of steel?
Materials

• Carbon fiber instead of steel?
Materials

- Ford+Novomer (Boston): make auto parts using durable plastics made from CO2 (inspired by plants that take in carbon dioxide and create complex sugars)
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
3-D Printed Cars

- Forcing a simplified design of cars (20-50 parts, not thousands)
- Divergent3D’s prototype Blade Supercar
- Local Motors’ Strati (first 3-D printed electric car)
- Local Motors’ OLLI, a self-driving electric vehicle built with 3-D printing technology and piloted by IBM Watson
3-D Printed Cars

• March 2017: Ford announces testing of large-scale 3-D printing
NEV industry

- Software (shared, connected, autonomous mobility)
- Hyper-transportation
- New energy
- Wireless charging
- Lightweight materials
- 3D Printing
Software (addendum!)

• The automobile as an environment for entertainment and socialization will create a new platform for the delivery of content and media
Software

• A typical application: the Personal Mobility App
  – The concept of the mobility network (car, subway, bus, train, airplane…)
  – Plan the best combination for your trip (car, subway, bus, train, airplane…)

Software

- Auto companies will transition from building and selling vehicles to “apps” such as data analysis, ride-sharing, fleet maintenance, …
- Passengers will think of the automated vehicle as a multi-purpose environment (socializing, relaxing, work…)
- Consumers will transition from owning to sharing, from capital investment to on-demand rent
- Mobility as a Service
Economics

- Summarizing: disruption at multiple levels
NEV industry in the USA

• Conclusions
  – The USA lags behind China in NEVs
  – Modest investment in flying cars
  – Strong research in new energy
  – Research on lighter materials
  – Shared connected autonomous vehicles are made mostly of software, not steel
  – The car industry will become a software industry
  – 3D-printing may force a simplified design of cars
  – Disruption at multiple levels
2. Smart-city Infrastructure
The Infrastructure

- Today’s cities are built around the car
- Tomorrow’s cities may not need roads and parking lots
Charter Cities

• Build completely new cities
  – Paul Romer’s “charter cities”
  – Y Combinator’s “New Cities”
  – NYU’s Urbanization Project”
  – Sidewalk Labs (Google)
City Planning

- City planners increasingly focus on creating environments for humans rather than for cars
- The “walkability” principle: A city is only as livable as it is walkable
- Design for cars is optional
City Planning

- San Francisco
  - Connected and collision avoidance technology
  - Shared, connected, autonomous vehicles
  - Wi-Fi
  - Charging
  - Smart signals
  - Sensors and beacons
  - Fleet operations
  - First-last mile
  - Transit shuttles
  - Open spaces
  - Delivery services
  - Parking management
City Planning

- San Francisco
  - Shifting from Ownership to Experience
  - Open Data strategy
  - Civic Innovation Lab (City Innovate)
3. Designing the Future
Designing the Future

- Industry Crossover and Technological Convergence
  - Software: shared connected autonomous mobility
  - Materials: new energy and new materials
  - Infrastructure: the “hackable” smart city
Designing the Future

The Future of Mobility = The Future Of Accessibility

- Identify points of interests to monitor for mobility activity (e.g. around train stations, tourist sites, public parks, shopping malls, …)
- Deploy sensors and beacons
- Collect, organize, analyze data
- Provide data-access dashboards to the public
- Encourage the public to build the “apps” that utilize those contextualized data analytics
Designing the Future

Urban planners should hack: "Hack the City"

- Provide the community with access to city data
- Gather: urban designers, neuroscientists, social scientists, architects, engineers, shop owners, home owners, commuters, tenants, landlords, …
- Hack: access data, explore ideas, design solutions
- Create collaborations, interest groups, laboratories, startups
- The economy of popular enthusiasm