Change is the law of life. And those who look only to the past or present are certain to miss the future

John F. Kennedy
We have no choice but to get this right

<table>
<thead>
<tr>
<th>+1H</th>
<th>$88B</th>
<th>70%</th>
<th>1.3M deaths</th>
<th>6 Gt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily commute time in Chicago’s low- vs. high-income areas</td>
<td>2019 congestion cost in the U.S.</td>
<td>Population that will live in urban areas by 2050, with more than 40 mega-cities globally</td>
<td>Road traffic deaths every year, 7th leading cause of death in lower-income countries</td>
<td>CO2 emitted from light duty vehicles on road per year, representing 12% of total global emissions</td>
</tr>
</tbody>
</table>

... limiting access to jobs & contributing to economic inequality

Source: INRIX 2019 & 2020 Global Traffic Scorecard; TomTom Traffic Index 2020; European Environment Agency (EEA); IEA; WHO; World Bank; BCG Inclusivity Quotient Project
Five key forces converging to unlock opportunity never-before possible

1. AI / Machine Learning
2. Tech Maturity (Cost ↓)
3. Connectivity
4. Attitudinal Shifts
5. Regulatory Pressures

NEW MOBILITY
<table>
<thead>
<tr>
<th>What will this new world look like?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas guzzlers to electrified vehicles</td>
</tr>
<tr>
<td>Hardware to software</td>
</tr>
<tr>
<td>Product to service</td>
</tr>
<tr>
<td>Single-use to circular</td>
</tr>
<tr>
<td>Active safety from luxury to common good</td>
</tr>
<tr>
<td>Privately owned to sharing</td>
</tr>
</tbody>
</table>

Deeper dive on following pages
By 2025, EV will be advantaged on total cost of ownership (TCO) relative to traditional ICE in most key markets.

**Regulations**
- Tightening further in many markets
- Concrete steps toward net-zero; ICE bans starting as early as 2025

**Battery costs**
- Declining faster than anticipated
- Purchase cost parity vs ICE; Less than $75 / kWh pack price by 2030

**OEM competition**
- Intensifying though broader offerings
- 400 models by 2025; Availability across all vehicle segments
Nearly 70% of new vehicles sold will be full hybrid or cleaner by 2035

US volume projections

EU volume projections

China volume projections

Note: Forecast includes all light vehicles, except HVAN. 'Zero-emission' is BEV + FCEV, 'Full hybrid' is PHEV + HEV, 'Gas/Diesel' includes MHEV
Source: BCG analysis
Dozens of new players will emerge, but most new EV players will face significant hurdles carving out meaningful positions.

EXAMPLE: U.S. PICKUP TRUCKS

Slow growth, mature market w/ 90% sales concentrated among 5 brands, each of which is taking steps to electrify and evolve business models.

Success requires more than just the product; landscape littered with failed entrants.
Dramatic improvements in technology ushering in a new era of connectivity and software defined vehicles

... from metal to bits at scale

- **2010**: OBD
- **2015**: Infotainment: Initial connectivity to cloud
- **2020**: 2GB/day
- **2025**: 50GB/day
- **2030**: 2+TB/day

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Data Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>OBD</td>
<td>2KB/day</td>
</tr>
<tr>
<td>2015</td>
<td>Infotainment: Initial connectivity to cloud</td>
<td>2MB/day</td>
</tr>
<tr>
<td>2020</td>
<td>ADAS: Hundreds of data points + cameras</td>
<td>2GB/day</td>
</tr>
<tr>
<td>2025</td>
<td>ADAS: Hundreds of data points + cameras</td>
<td>50GB/day</td>
</tr>
<tr>
<td>2030</td>
<td>AV: Radar, lidar, ultrasonic</td>
<td>2+TB/day</td>
</tr>
</tbody>
</table>

Note: Only small share of (post-processed) data leaves the vehicle

Source: BCG analysis
A software-defined car completely reshapes where value is realized

"If we want to remain independent, we have to develop car software ourselves"

Herbert Diess, VW

"The critical role of software [...] cannot be overstated"

Mark Reuss, GM

<table>
<thead>
<tr>
<th>90%</th>
<th>of future differentiating car features to be software-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>$26B</td>
<td>annual software R&amp;D spend by suppliers and vehicle manufacturers</td>
</tr>
<tr>
<td>$500-1,000</td>
<td>per car BoM reduction opportunity from standards/commoditization/re-use</td>
</tr>
<tr>
<td>$150B</td>
<td>annual car software market size with competition between OEMs &amp; suppliers</td>
</tr>
<tr>
<td>$1B+</td>
<td>potential annual revenue for major OEMs through software-based services</td>
</tr>
</tbody>
</table>

Source: BCG analysis, Expert interviews, Bank of America, CapitalIQ
While euphoria has somewhat waned, compelling SAEV unit economics will spur longer-term adoption.

Adoption driven by favorable economics

**US**

- **Rideshare**: ~1.35
- **Private vehicle**: ~0.85
- **SAEV**: ~1.50

**Europe**

- **Rideshare**: ~4.00
- **Private vehicle**: ~2.50
- **SAEV**: ~1.00

**China**

- **Rideshare (today)**: ~0.60
- **Rideshare (future)**: ~1.50
- **Private vehicle**: 1.50
- **SAEV**: 0.75

Expect regulation to increase the current cost of ridesharing—favoring SAEV economics.

Cost per mile

Source: BCG analysis
SAEVs to account for over 30% of passenger miles by 2035 in large metro areas

3 elements needed:
Demand density
Low complexity environments (ODD)
Major mobility pain points

SAEV penetration to be largely concentrated in dense urban areas — e.g., Chicago

<table>
<thead>
<tr>
<th>Region</th>
<th>% of total new vehicle sales</th>
<th>SAEV + Rideshare</th>
<th>Public transit</th>
<th>Private car</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>8%</td>
<td>36%</td>
<td>6%</td>
<td>58%</td>
</tr>
<tr>
<td>Europe</td>
<td>5%</td>
<td>31%</td>
<td>20%</td>
<td>49%</td>
</tr>
<tr>
<td>China</td>
<td>5%</td>
<td>40%</td>
<td>25%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Passenger mile index' in largest metro areas

1. Indexed to current annual passenger miles in each region
Note: Passenger miles calculated on the basis of modal breakdowns, average trip distances, and number of trips (weighted by metro area population)
Source: BCG analysis

Source: BCG analysis
Today, ride-sharing players capture value by controlling a key choke point

Ride-sharing firms operate a two-sided marketplace connecting drivers & riders and take advantage of arbitrage between buyer and seller “willingness to pay”.

In the future, AVs will change the nature of the competitive game

In urban areas, shared AV fleets will emerge as a major form of transportation. Traditional ride-sharing capabilities will become less relevant as drivers are no longer needed and fleets are owned.

Future basis of competition is uncertain, winners depend on how industry evolves

Advantaged players will be determined by where chokepoint emerges - AV mobility marketplace, AV tech stack or AV fleet operations - and who controls it. Jockeying for positions already well underway.

But radical industry disruption is never easy - five key challenges our industry most navigate in years ahead

- Capital intensive Business models
- Increasingly complex supply chains
- Insufficient infrastructure
- Ill-Equipped regulatory frameworks
- Mis-aligned public / private incentives

Source: BCG analysis
Traditional auto players have long-relied on capital intensive business models which have historically destroyed capital.
As we move forward, OEMs must break free from these constraints and industry dogmas, fundamentally changing how cars are...

<table>
<thead>
<tr>
<th>...Designed</th>
<th>Reducing need for scale, unbundling HW from SW, shifting from metal to bits at scale, reducing time-to-market, leveraging recycled content</th>
</tr>
</thead>
<tbody>
<tr>
<td>...Built</td>
<td>Decoupling product from production, unlocking operational efficiencies, reducing need for scale, achieving net-zero emissions</td>
</tr>
<tr>
<td>...Sold</td>
<td>Introducing innovative sales models, abandoning traditional dealerships in favor of fully-online / city-center owned stores</td>
</tr>
<tr>
<td>...Used</td>
<td>Introducing vehicles designed for a specific purpose, integrated in multiple ecosystems</td>
</tr>
</tbody>
</table>

### New flexible cell layout:
Fully automated assembly of different vehicles

**KEY BENEFITS**
- Eliminated stamping and painting shops
- Operational in 6 months, w. lower CapEx / smaller footprint
- Decentralized production, w. limited floorspace required
- Reduced break-even point, enabling low volume production
Supply chains are increasingly long and complex, necessitating that the industry finally place value on resiliency.

**Silica** (semiconductors)
A semiconductor can have a 6-month/15,000 km journey from mine to finished vehicle.

**Lithium** (battery)
Typical supply chain for battery.

- More (trade) roads leading through China
- $75B in vehicle and part exports (from $16B in '05)
- 70% of world's battery manufacturing capacity
- >50% of world's supply of rare earth metals

Source: OEC, BCG analysis
Regulators have yet to establish clarity on a critical dimensions required for full potential of new mobility to be realized - e.g., Autonomous Vehicles

### Open topics for regulators

- **Data**: Who ultimately owns data collected by AVs, and who is allowed to analyze and commercialize it?
- **Operation**: How does the law need to be adjusted to allow Level 4 AV operation? (e.g., steering wheel requirement, driver responsibilities)
- **Safety**: How are the large array of AV players kept in line with safety standards? What’s the “driver’s license” equivalent?
- **Ethics**: Can a system consider ethical implications of potential actions—especially in an emergency? What is “good enough”?
- **Liability**: Who bears responsibility in an accident with a Level 4 vehicle?

Significant infrastructure investments required to support EV ambition; critical coordination with utilities, property owners, & permitting organizations needed.

Large public charging network needed to support EV adoption

- High-powered (150+ kW)
- Fast (22-149 kW)
- Slow (<22 kW)

Total public EV charging points in EU by type ('000s)

- 2020: 211, 84%
- 2030: 1,819, 73%

+24% p.a.

Los Angeles, near airport (2021)

... but significant constraints to grid (transmission, distribution) could risk rapid build out

Source: BCG analysis
Lastly, a note of caution…

The threat of unintended consequences is massive.

Successfully navigating the change before us will require a level of public/private collaboration rarely before seen.
Way forward …
For companies to thrive in this increasingly complex world they must:

<table>
<thead>
<tr>
<th>Focus</th>
<th>Challenge everything</th>
<th>Secure scale</th>
<th>Master data</th>
<th>Win the war for talent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure laser like clarity on what you stand for and how you will create sustained value</td>
<td>Shake up the status quo and ruthlessly re-invent for advantage (e.g., business model, operating model, path to net zero, etc.)</td>
<td>Gain an advantaged scale position (cost, talent access, ability to reinvest)… either owned or thru broader partnership ecosystem</td>
<td>Ingrain throughout the org the ability to access, integrate, and manipulate data at scale (and quickly)</td>
<td>Break free from traditional talent models / cultural constraints and accelerate move to new skills and new ways of working</td>
</tr>
</tbody>
</table>
The task before us is immense, but when we get this right, we will change the world

- A safer, far cleaner world
- Equitable mobility access & reliability
- Engine for economic growth