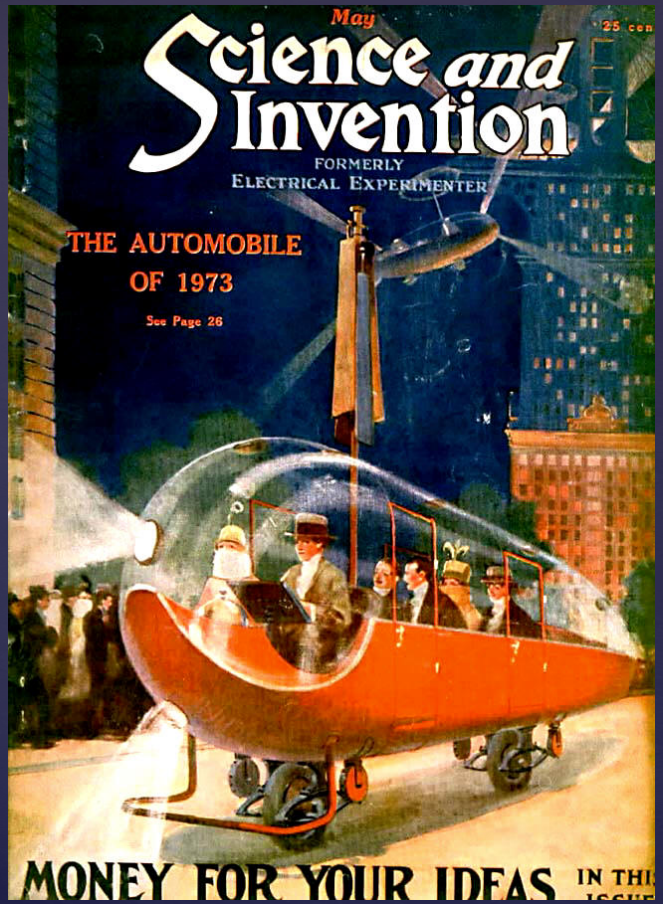
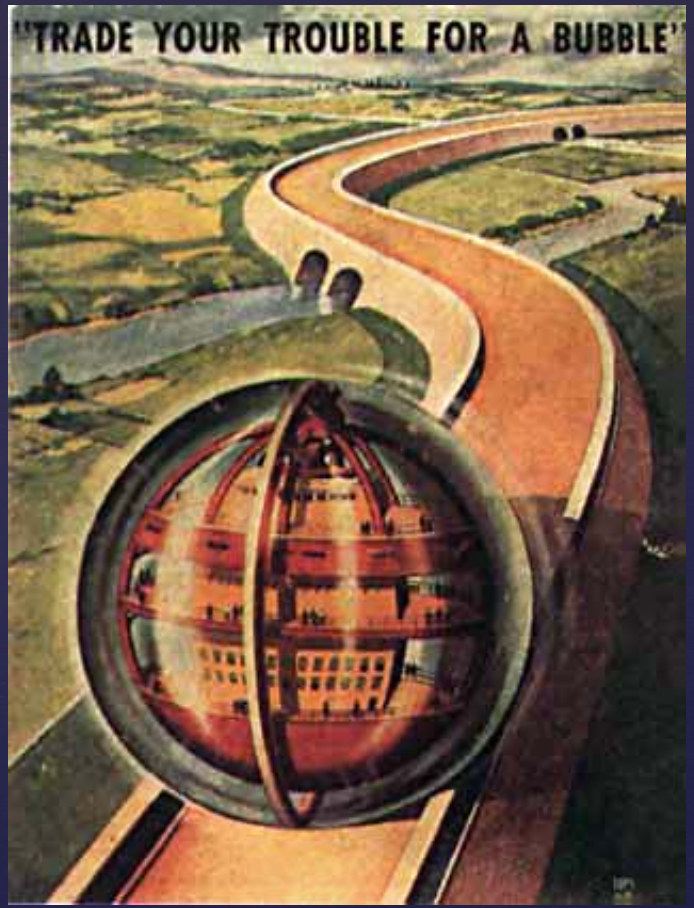
Planning for Autonomous Vehicles

What, when and the implications for transportation planning



Science & Invention, May 1923



Amazing Stories, February 1946.

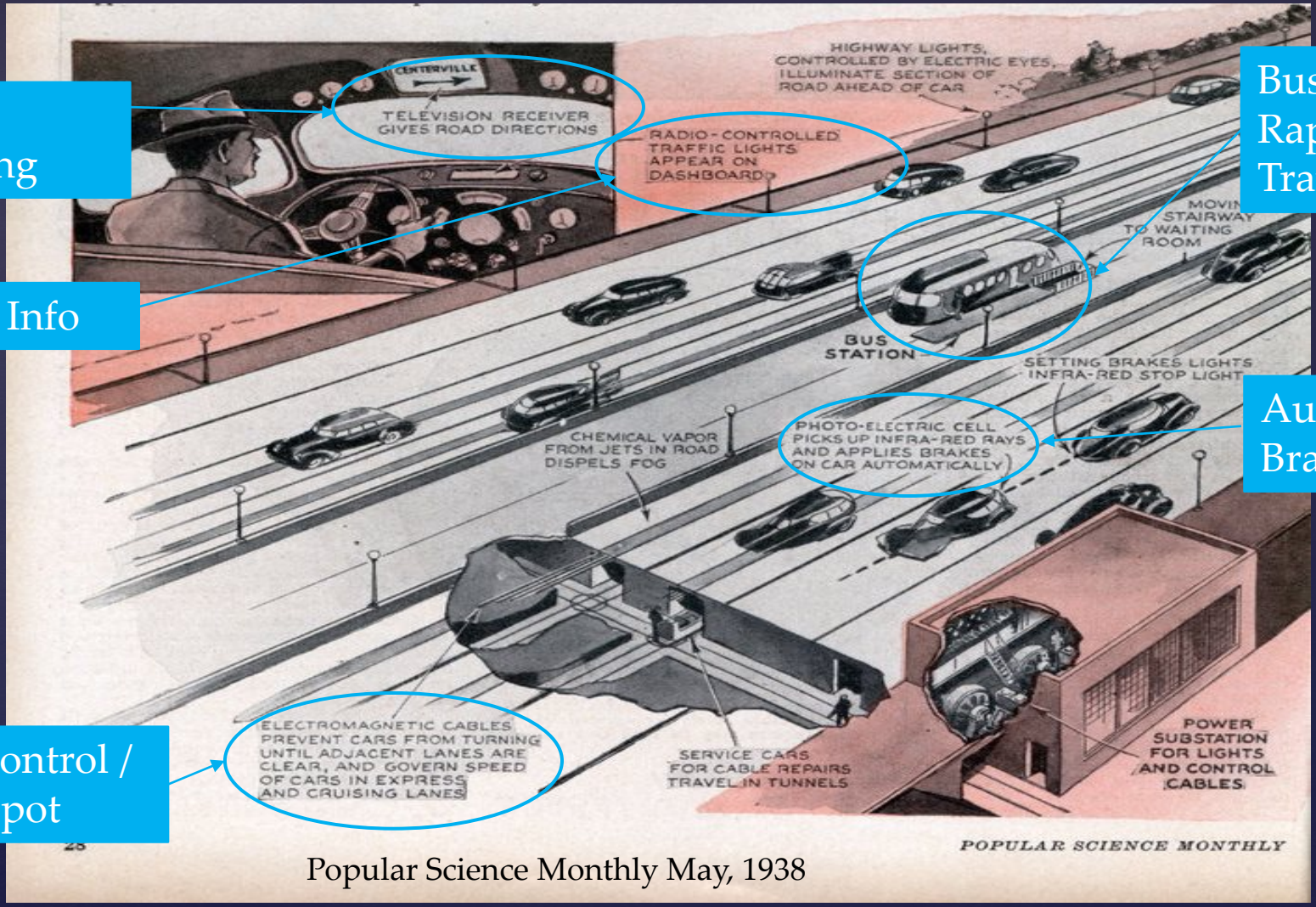
GPS / Mapping

Traffic Info

Lane Control / Blind Spot

Bus Rapid Transit

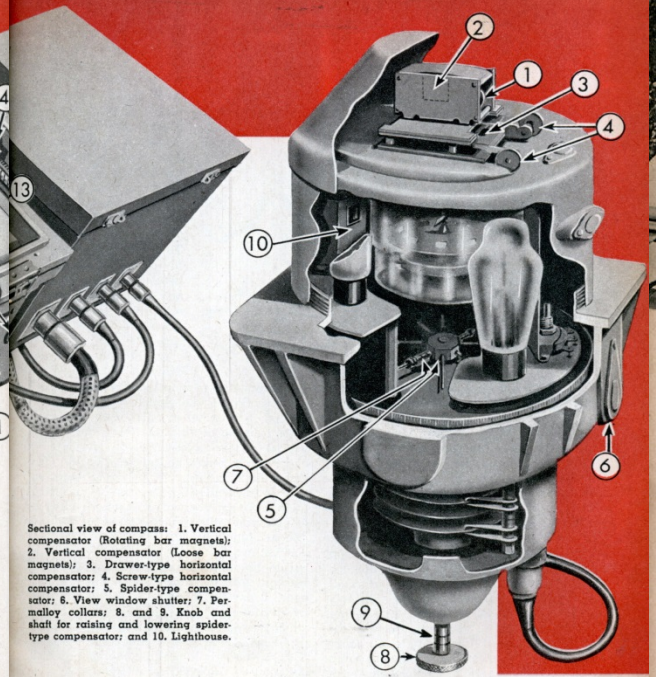
Automatic Braking



Popular Science Monthly May, 1938

HIGHWAY "BEAM" FOR MOTORISTS

Key to parts of plotting unit: 1. Main map scale adjustor knob; 2. Intermediate map scale adjustor knob; 3. Pencil; 4. Pencil adjustment clamp; 5. Pencil adjustment knobs; 6. Azimuth dial; 7. Pointer swing control knob; 8. Total miles counter; 9. Coordinate miles counter; 10. Individual coordinate miles-counting preset keys; 11. Coordinate miles-counting master key; 12. Coordinate miles-counting shutter reversing keys; 13. Crosswise lead screw; 14. Map scale dials.



Sectional view of compass: 1. Vertical compensator (Rotating bar magnets); 2. Vertical compensator (Loose bar magnets); 3. Drawer-type horizontal compensator; 4. Screw-type horizontal compensator; 5. Spider-type compensator; 6. View window shutter; 7. Permalloy collars; 8. and 9. Knob and shaft for raising and lowering spider-type compensator; and 10. Lighthouse.

War-born device will guide peacetime motorists unerringly to their destinations —or plot their course as they go along.

EARLY one morning last year, just before sunrise, two men in a jeep found themselves lost in Washington. That is a horrible fate which can happen to anyone and often does, but in this case it was serious. In the back seat of the jeep was installed the first model of a secret new device which was being delivered under cover of darkness to the Army Engineer Board at Fort Belvoir, Virginia. It had to be there at 8:00 a. m. to be inspected by a full board of high Army officers. But the two men in the jeep, newcomers to Washington, were stymied.

At last they came upon a gas station that was open and pulled in to get directions. The attendant gave them the information they wanted and a road map—and the road map gave them a bright idea. Turning to the device in the back seat, they made some calculations, slipped the road map into the device, and drove without hesitation straight to Fort Belvoir.

The wonder machine which made that possible was the Odograph, an instrument which automatically plots the course of a moving vehicle or guides it to a given point. It's the first successful device for instantaneous map-making in the field, and therefore a major contribution to the winning of the war. It draws a map that all can understand while the vehicle is in motion.

The Odograph consists of three principal parts: an electronic magnetic compass, a power pack, and a plotting desk on which a moveable pencil actually draws the maps. All

E. F. Britten, Jr., of the Monroe Company, points out the plotting desk of the Odograph to Brig. General J. W. N. Schulz of Army's Engineer Board.

three parts are interconnected by means of electrical cables and flexible shafts. In addition to its use as a map-maker it can be operated to plot the position of objectives relative to a given base, such as the location of guns to field headquarters. It can also be used for land navigation, locating a rendezvous for combat and supply units; field artillery surveys; engineer reconnaissance and the tactical control of movements.

Until very recently it was on the restricted list, but now its story can be told. Two facts are necessary in plotting a course, the distance to be covered and the direction of travel. The Odograph determines the distance traveled by means of a speedometer attached by a flexible cable to the transmission of the vehicle on which it is mounted. Direction is determined by means of a magnetic compass, properly corrected by a special electronic unit so that the iron and steel in the vehicle will not affect the delicate compass. These two factors, distance and direction, are fed automatically into the mechanical brain of the plotting unit, a maze of wheels, wires, and cogs that actuates the plotting pencil which draws a map of the route traveled on a sheet of graph paper placed on the map table. The electrical power needed to operate the Odograph comes from the battery of the vehicle, and a special power pack raises the battery voltage to the values required in the electrical circuits.

The Odograph can plot to any scale from 1 to 20,000 to 1 to 500,000, making it possible to draw a route map showing all the roads in a specified area to the same scale as a topographic map, which shows no roads. By placing the Odograph over the topographic map, field commanders can get a complete road and topographic map—just what is needed to carry out operations against an enemy. The margin of error in the device is negligible—between one and three per cent. In terms of miles that usually means not more than a stone's throw.

In addition to its map drawing equipment, the Odograph has an azimuth dial which indicates the direction of the vehicle at any moment. Special counters tell at a glance the number of miles traveled north, south, east, and west, as well as the total miles traveled. Thus a trip of eleven miles might be indicated on the Odograph as six miles north, two miles west, one mile south, and two miles east. The instrument is built so ruggedly that it will take a lot of pounding and jouncing while in the field and still function.

After months of continued production research involving many firms, the Odograph was put into mass production about a year ago. Today the machine is built exclusively by the Monroe Calculating Machine Company, which solved many of the difficult production problems which arose. Monroe's president, E. F. Britten, Jr., himself an engineer, worked out some of the knottiest difficulties.

It was two Monroe experts who became lost in Washington while delivering the Odograph to the Engineer Board. Their use of it to get them to Fort Belvoir points the way to how it can be used by postwar motorists. Following a road map will be a cinch with the Odograph. Just slip the map into the plotting desk, adjust the scale of the device to that of the map, and keep the moving pencil on your route. It will tell you when you've taken a wrong turning.

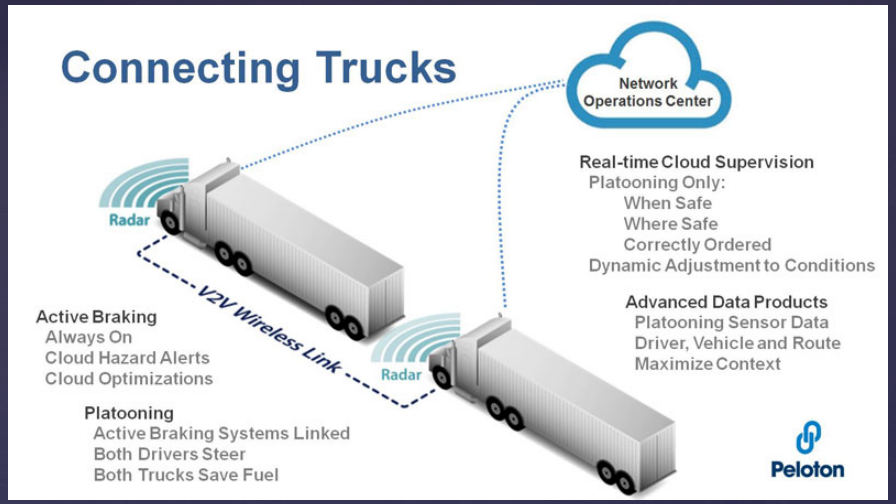
The Odograph is not only a contribution to the war effort—it's also a boon to every family in America. Think of all the arguments over which road to take that will be done away!

Advertisement from 1957 for "America's Independent Electric Light and Power Companies" (art by H. Miller).


LOCAL MOTORS
PHOENIX
olli


Google
DESERT DOPPLER
HAPPENING NOW
GOOGLE BRINGS SELF-DRIVING CARS TO THE VALLEY
COMPANY WILL SEE IF CARS CAN WITHSTAND ARIZONA SUMMERS
abc 15
ARIZONA
6:10
87°


513


Connecting Trucks
Network Operations Center
Real-time Cloud Supervision
Platooning Only:
When Safe
Where Safe
Correctly Ordered
Dynamic Adjustment to Conditions
Advanced Data Products
Platooning Sensor Data
Driver, Vehicle and Route
Maximize Context
Radar
V2V Wireless Link
Radar
Active Braking
Always On
Cloud Hazard Alerts
Cloud Optimizations
Platooning
Active Braking Systems Linked
Both Drivers Steer
Both Trucks Save Fuel
Peloton

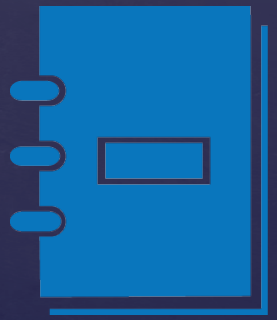

Walmart

- IEEE survey of 2000 experts in autonomous vehicles
  - ✓ Biggest obstacles are legal liability, policymaker and consumer acceptance.
  - ✓ By 2030, new cars will not have rear view mirrors, horns & emergency brakes.
  - ✓ By 2035, steering wheels and gas / brake pedals will be gone.

UNRESOLVED ISSUES FOR PUBLIC AGENCIES

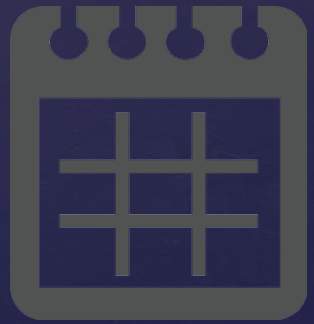
- **Over 100 research questions**

Policy



Infrastructure

Planning



Modal Apps

What does this mean?

PLANNING FOR CONNECTED AND AUTONOMOUS VEHICLES

Engineering

- Traffic Engineering.
- Roadway Design.
- Speed Limits.
- Parking.
- Freight Operations.
- Safety.

Planning and Policy

- Long Range Transportation Plans.
- Land Use and Urban/Rural Form.
- Impact Assessment.
- Driver Education and Licensing.
- Vehicle Regulation.
- Insurance and Liability.
- Safety.

LEVELS OF AUTOMATION

0 NO AUTOMATION
Forward collision warning, lane departure warning, blind spot monitoring

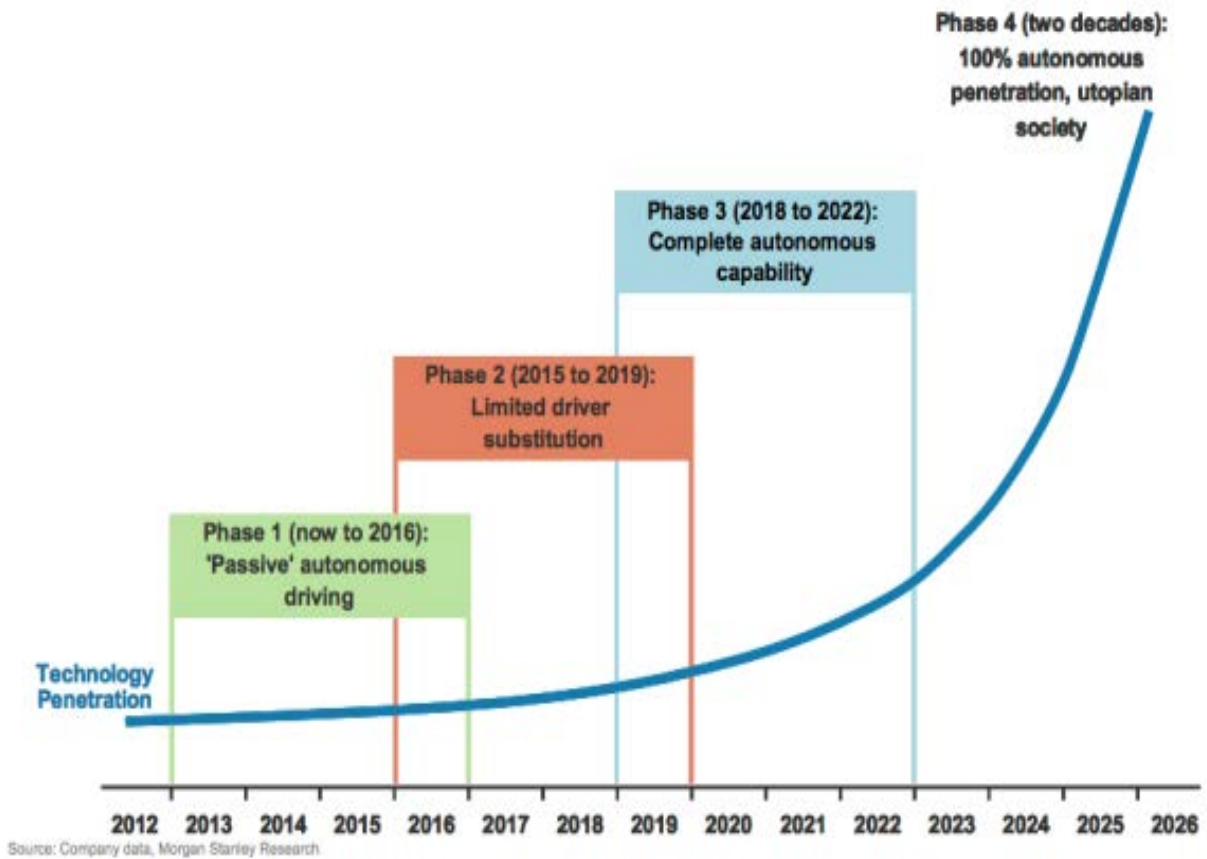
1 FUNCTION SPECIFIC AUTOMATION
Temporarily cedes control of either forward (speed) or lateral (side-to-side) movements, but not at the same time
Dynamic brake support, electronic stability control, adaptive cruise control

2 COMBINED FUNCTION AUTOMATION
At least two primary control functions designed to work in unison
Adaptive cruise control in combination with lane centering

3 LIMITED SELF-DRIVING AUTOMATION
Enables the driver to cede full control of all safety-critical functions
Designed so that the driver is not expected to constantly monitor the roadway while driving

4 FULL SELF-DRIVING AUTOMATION
Designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip

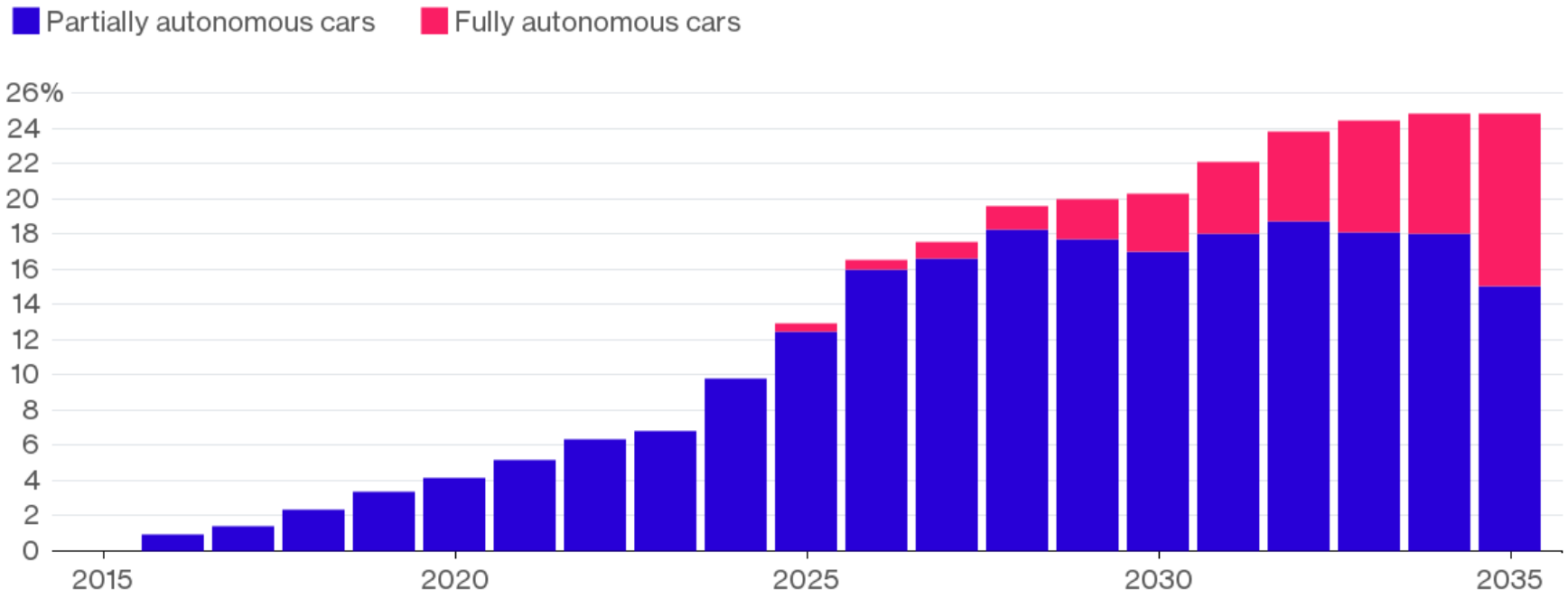
Exhibit 20
Timeline for Adoption



Source: Company data, Morgan Stanley Research

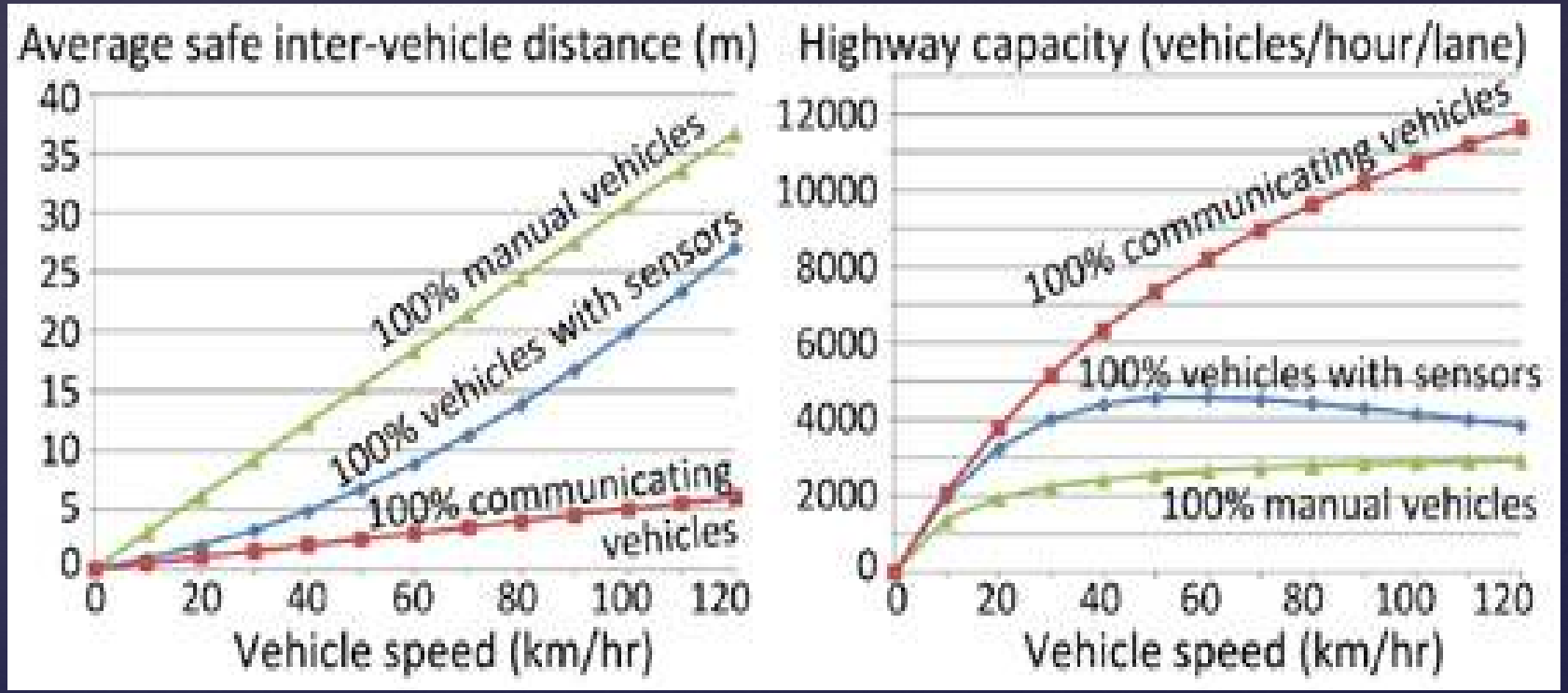
Autonomous Car Sales Will Surge By 2035

The cars will represent 25 percent of the global market

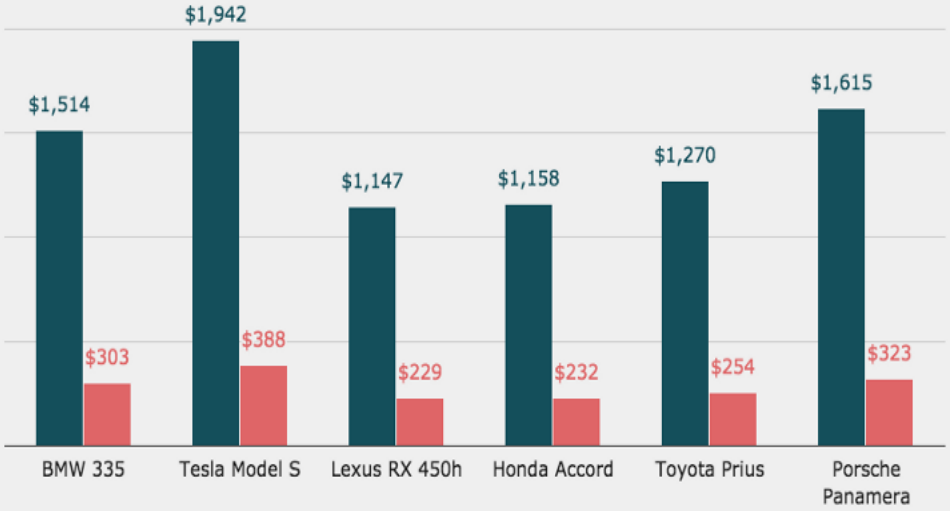


Source: The Boston Consulting Group
Note: 2015 data

Bloomberg

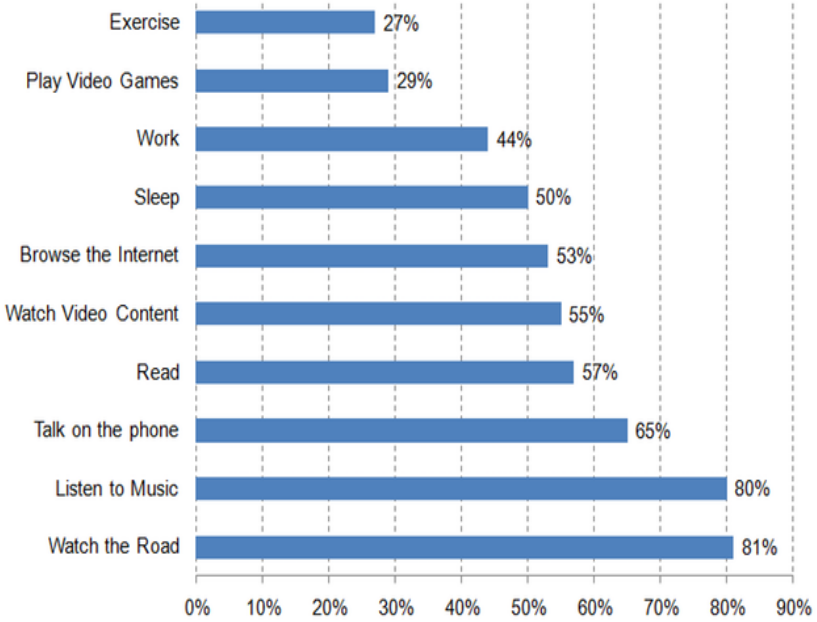

Average safe inter-vehicle distance (m)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
Vehicle speed (km/hr)
100% manual vehicles
100% vehicles with sensors
100% communicating vehicles
Highway capacity (vehicles/hour/lane)
12000
10000
8000
6000
4000
2000
0
0
20
40
60
80
100
120
Vehicle speed (km/hr)
100% communicating vehicles
100% vehicles with sensors
100% manual vehicles

Estimated Auto Insurance Costs: Self-Driving Vs. Human-Driven Cars Of Same Model (Self-Driving Price In Red)



(Credit: Ferenstein Wire / Source: Metro Mile)

Preferred Passenger Activities in Self-Driving Cars



Market Realist

Source: Goldman Sachs, CEA Survey, Quartz