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Autonomous Vehicles, Connected Systems and Market Adoption Factors

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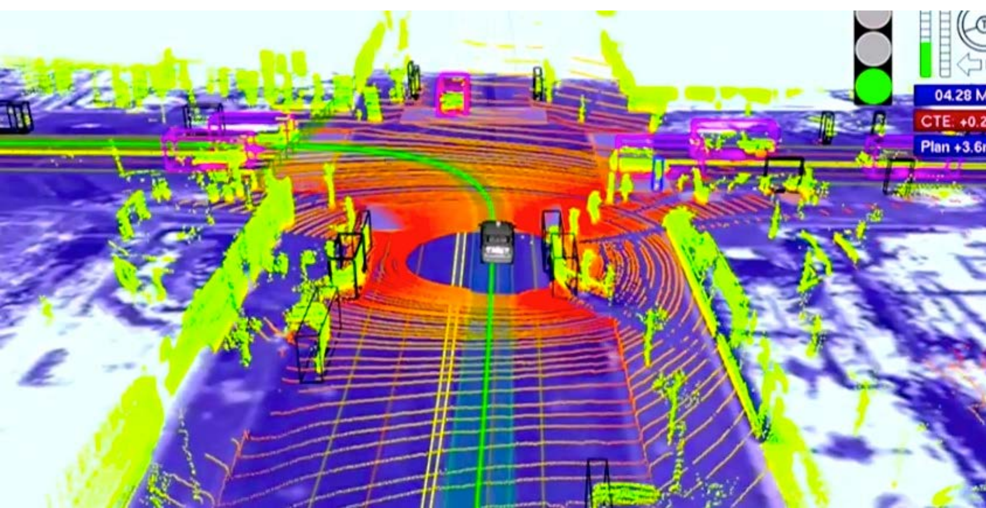


WHAT IS A DRIVERLESS CAR?
Four Levels of Automation

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Kornhauser, 2014

Preliminary Statement of Policy Concerning Automated Vehicles

SmartDrivingCars & Trucks

Level 0 (No automation)
The human is in complete and sole control of safety-critical functions (brake, throttle, steering) at all times.

Level 1 (Function-specific automation)
The human has complete authority, but cedes limited control of certain functions to the vehicle in certain normal driving or crash imminent situations. Example: electronic stability control

Level 2 (Combined function automation)
Automation of at least two control functions designed to work in harmony (e.g., adaptive cruise control and lane centering) in certain driving situations.
Enables hands-off-wheel and foot-off-pedal operation.
Driver still responsible for monitoring and safe operation and expected to be available at all times to resume control of the vehicle. Example: adaptive cruise control in conjunction with lane centering

Level 3 (Limited self-driving)
Vehicle controls all safety functions under certain traffic and environmental conditions.
Human can cede monitoring authority to vehicle, which must alert driver if conditions require transition to driver control.
Driver expected to be available for occasional control. Example: Google car

Level 4 (Full self-driving automation)
Vehicle controls all safety functions and monitors conditions for the entire trip.
The human provides destination or navigation input but is not expected to be available for control during the trip. ***Vehicle may operate while unoccupied.*** Responsibility for safe operation rests solely on the automated system

Implications of Each Level: User, Market and Society

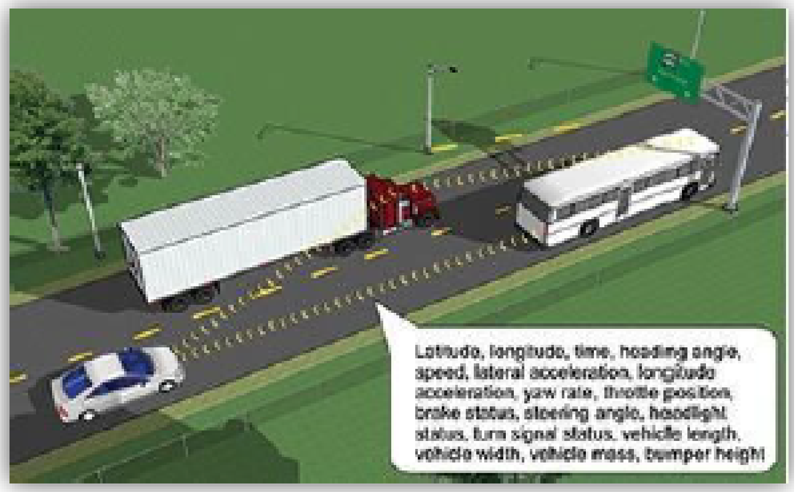
Kornhauser, 2014

Level	"Less"	Value Proposition	Market Force	Societal Implications
0 "55 Chevy"	Zero	Zero	Zero	Zero
1 "Cruise Control"	Infinitesimal	Some Comfort	Infinitesimal	Infinitesimal
2 "CC + Emergency Braking"	Infinitesimal	Some Safety	Small; Needs help From "Flo & the Gecko" (Insurance Industry)	"20+%" fewer accidents; less severity; fewer insurance claims
3 "Texting Machine"	Some	Liberation (some of the time/places) ; much more Safety	Consumers Pull, TravelTainment Industry Push	Increased car sales, many fewer insurance claims, Increased VMT
4 "aTaxi "	Always	Chauffeured, Buy Mobility "by the Drink" rather than "by the Bottle"	Profitable Business Opportunity for Utilities/Transit Companies	Personal Car becomes "Bling" not instrument of personal mobility, VMT ?; Comm. Design ? Energy, Congestion, Environment?

CONNECTED VEHICLE
Research Initiatives at US DOT

Connected vehicle research is a suite of technologies and applications that use wireless communications to provide connectivity:

- Among vehicles of all types
- Among vehicles and roadway infrastructure
- Among vehicles, infrastructure, and wireless consumer devices

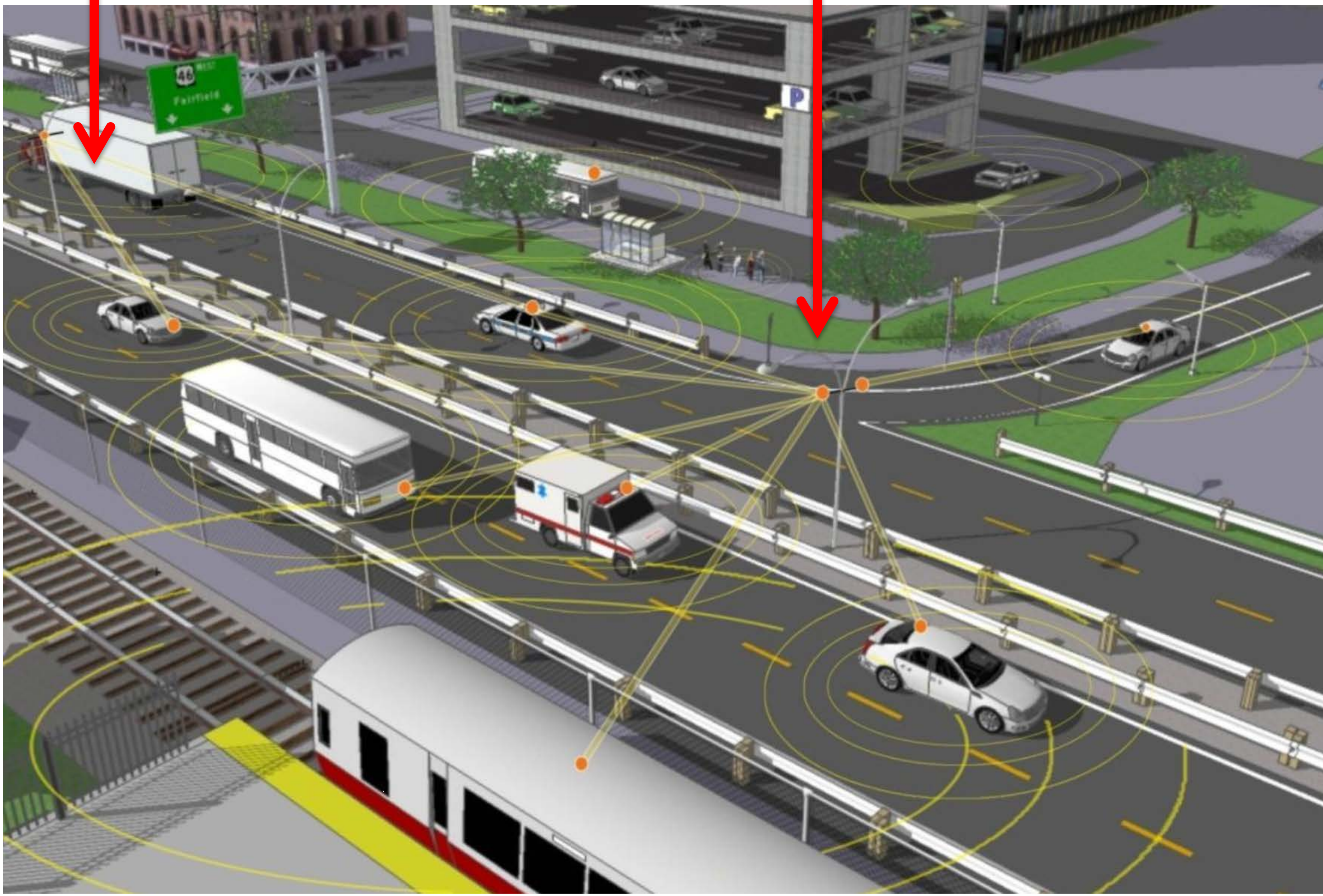


Connected SYSTEMS: Add
USERS (Travelers)
OPERATORS

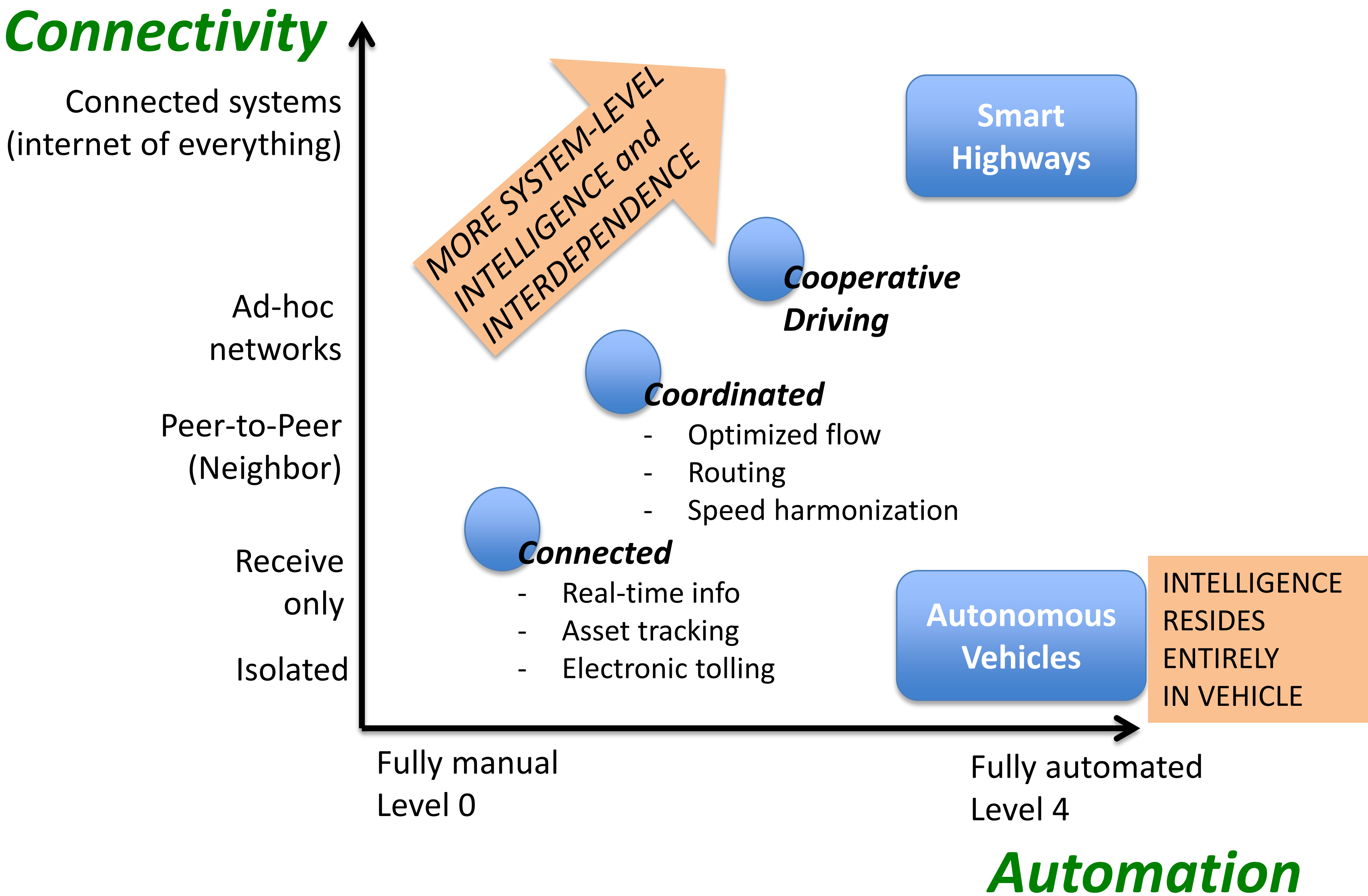
U.S. Department of Transportation

VEHICLE TO VEHICLE COMMUNICATION

VEHICLE TO INFRASTRUCTURE COMMUNICATION



U.S. Department of Transportation


Connectivity
Connected systems
(internet of everything)
Ad-hoc
networks
Peer-to-Peer
(Neighbor)
Receive
only
Isolated
MORE SYSTEM-LEVEL
INTELLIGENCE and
INTERDEPENDENCE
Smart
Highways
Cooperative
Driving
Coordinated
- Optimized flow
- Routing
- Speed harmonization
Connected
- Real-time info
- Asset tracking
- Electronic tolling
Autonomous
Vehicles
INTELLIGENCE
RESIDES
ENTIRELY
IN VEHICLE
Fully manual
Level 0
Fully automated
Level 4
Automation

INTELLIGENT *VEHICLE-HIGHWAY* SYSTEMS

ITS 0.9

Vehicles
Highway infrastructure

INTELLIGENT *TRANSPORTATION* SYSTEMS

ITS 1.0

Buses, trains, multimodal services
Urban mobility

ITS 2.0 = CS 2.0 *CONNECTED* SYSTEMS

FOCUS: THE USER

Mobility as an APP in seamless connected environment

NOT IF, BUT WHEN AND HOW

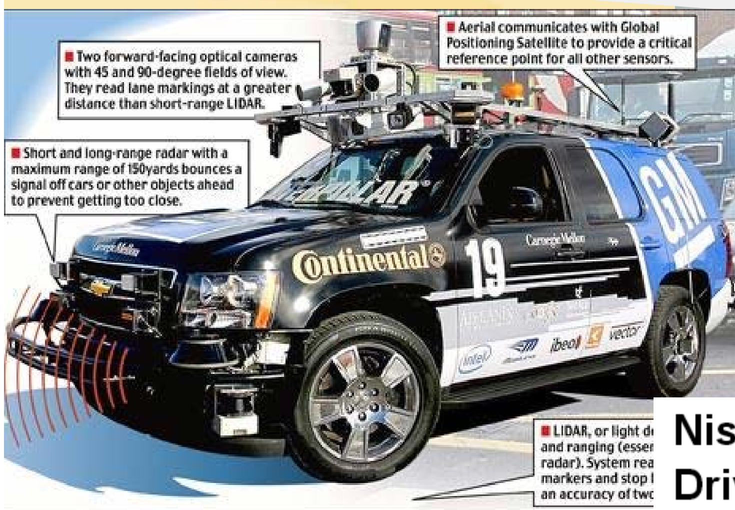
Compilation by Pendyala & Bhat, 2014

- ❖ Google cars have successfully driven 500,000 miles
- ❖ Set 2018 as expected release date for self-driving car

Elon Musk: Tesla's driverless car will be street-ready in three years

Tesla raises the stakes with a bold about driverless cars.

Volvo plans self-driving cars in 2014, envisions accident-free fleet by 2020



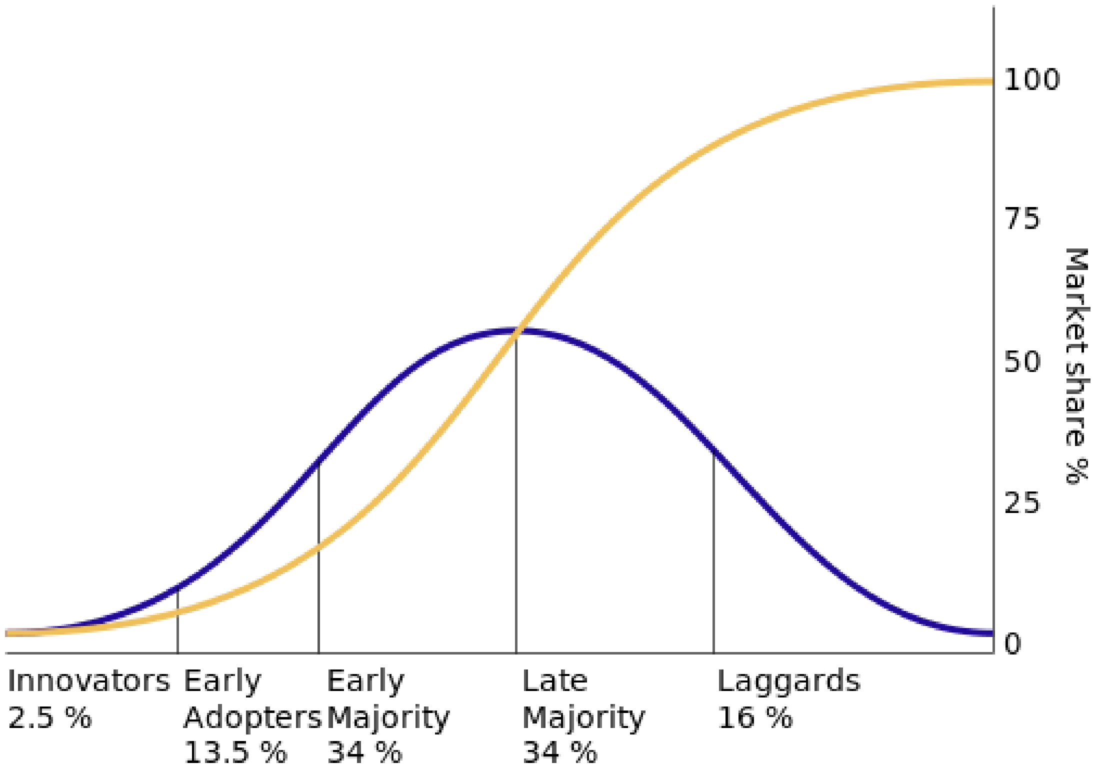
Nissan Sets Goal of Introducing First Self-Driving Cars by 2020

IS IT LEGAL TO "DRIVE" A DRIVERLESS VEHICLE?

- Several states in the US have passed enabling legislation to allow self-driving cars to use public roadways
  - California, Nevada, Florida
- National Highway Traffic and Safety Administration policy statement
  - Policy guidance on licensing, safety, testing
- Autopilot systems council in Japan
  - Safety
  - Mobility
  - Efficiency (time saving, constraint reduction)
- Citymobil2 initiative in Europe

Who will buy?

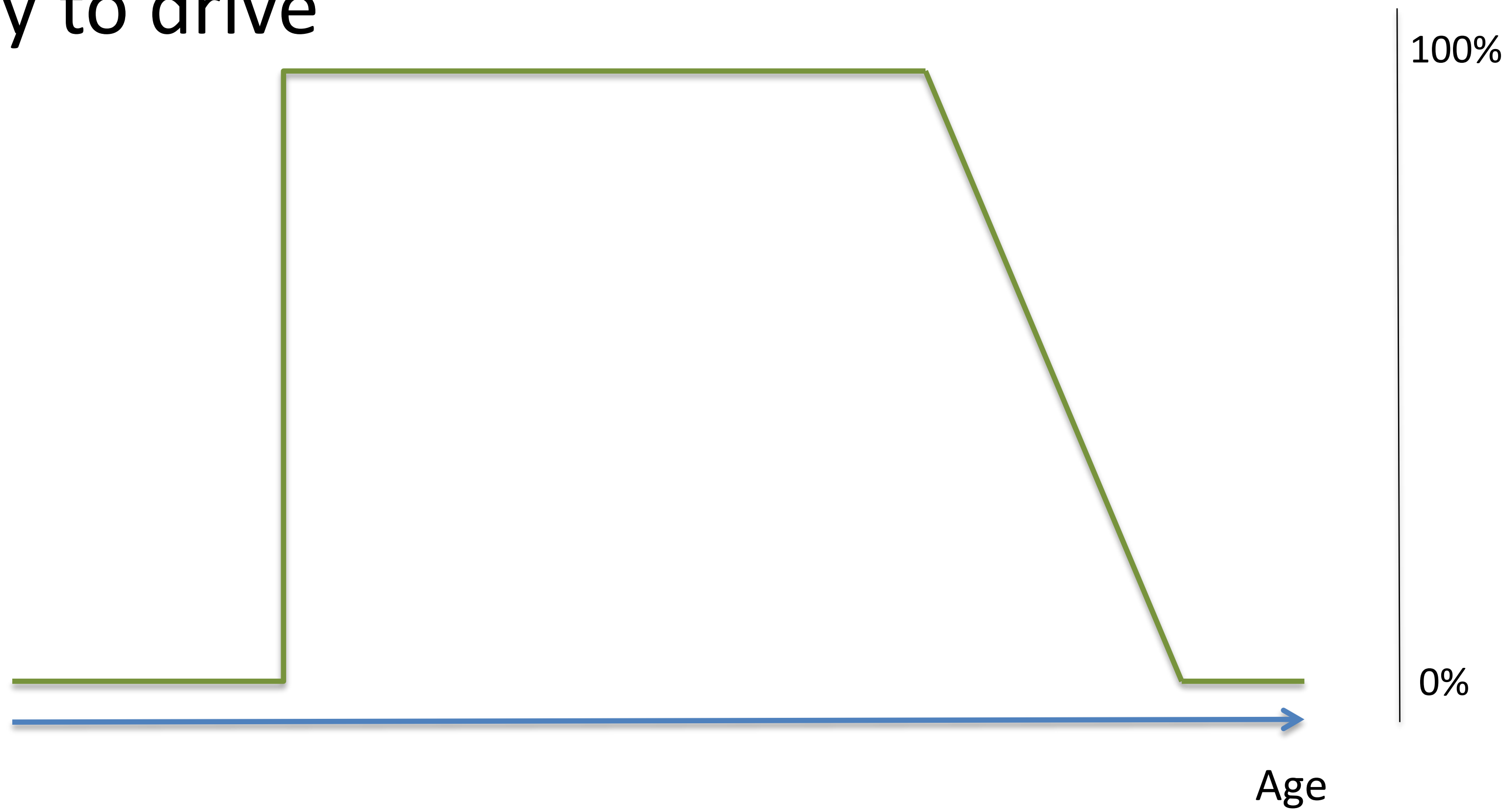
- WILL CLASSIC ROGERS' ADOPTION CURVE HOLD?



KEY ADOPTION FACTORS

- ABILITY TO DRIVE
- TRUST
- BENEFIT PERCEPTION
  - Safety
  - Mobility
  - Efficiency (time saving, constraint reduction)
- AFFORDABILITY

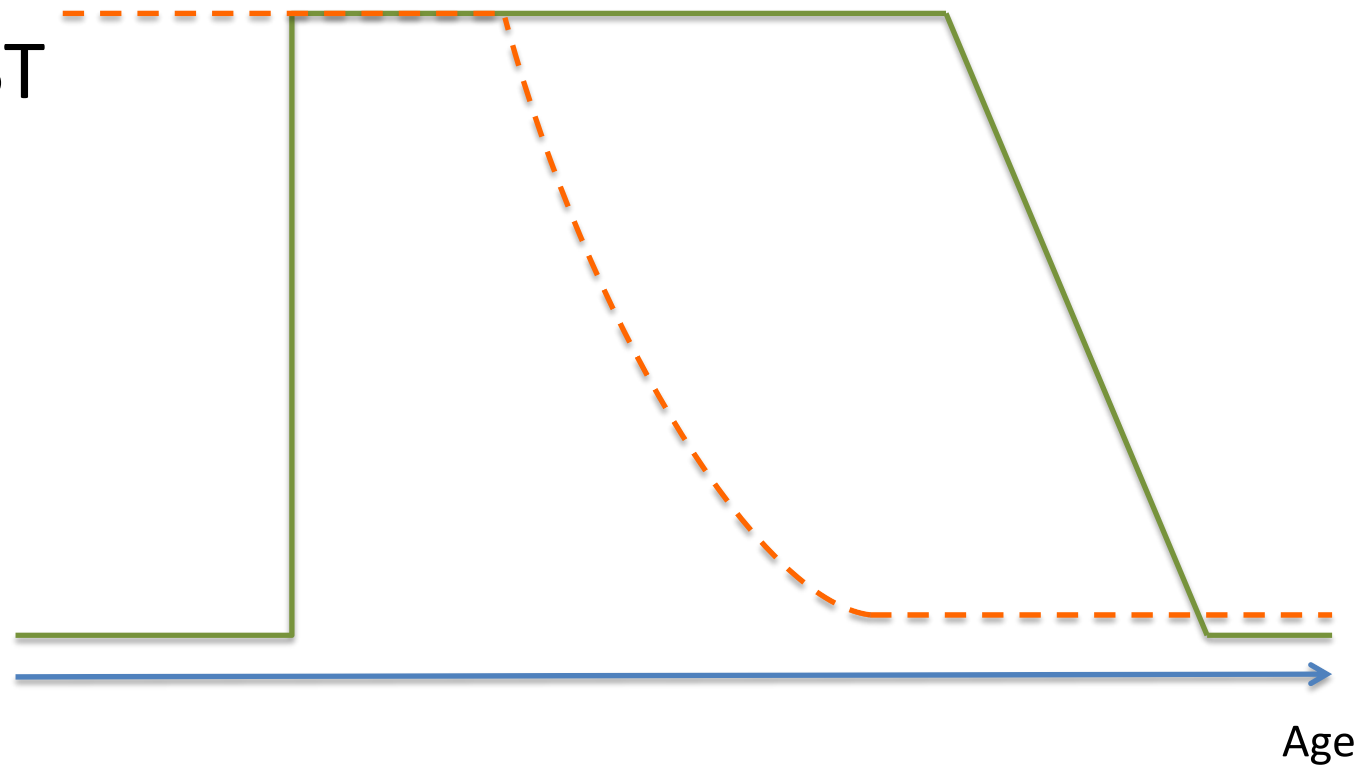
- Ability to drive



YOU and DRIVING

- THOSE WHO CANNOT DRIVE
- THOSE WHO PREFER NOT TO DRIVE
- THOSE WHO PREFER TO DRIVE
- THOSE WHO LOVE TO DRIVE

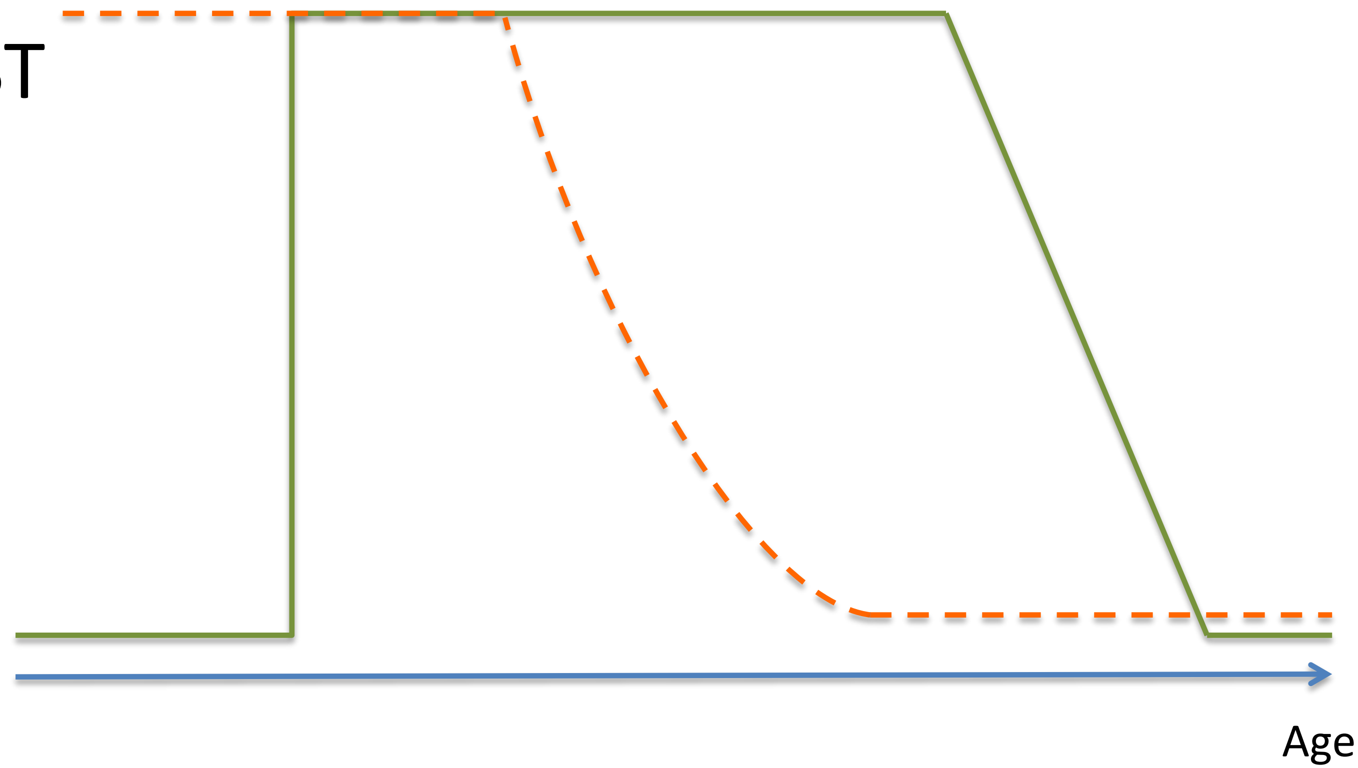
- Ability to drive
- TRUST

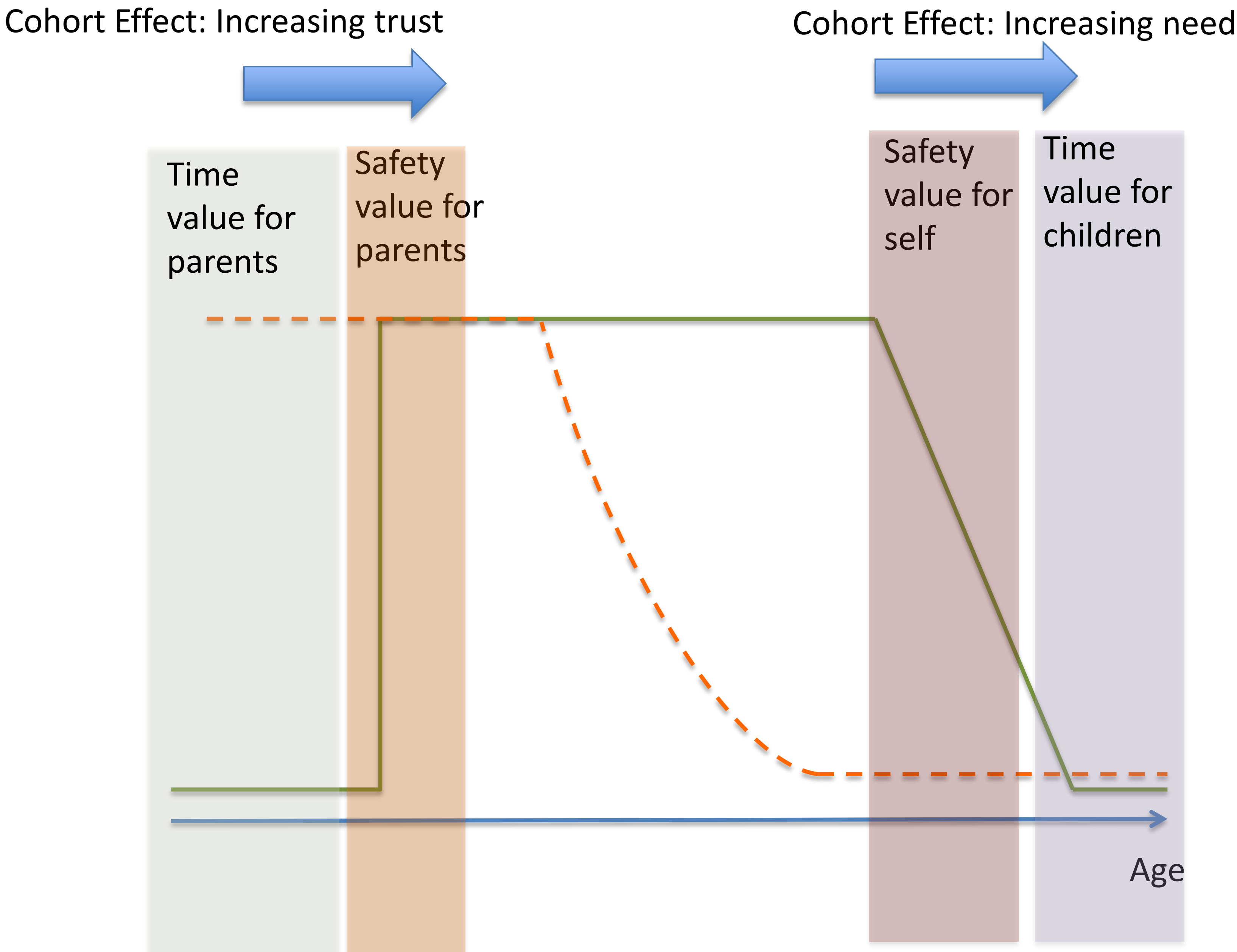


TRUST

- THOSE WHO TRUST
- THOSE WHO MAY TRUST FOR CERTAIN SITUATIONS
- THOSE WHO MAY REQUIRE CERTAIN GARANTEES
- THOSE WHO WILL NEVER TRUST

- Ability to drive
- TRUST

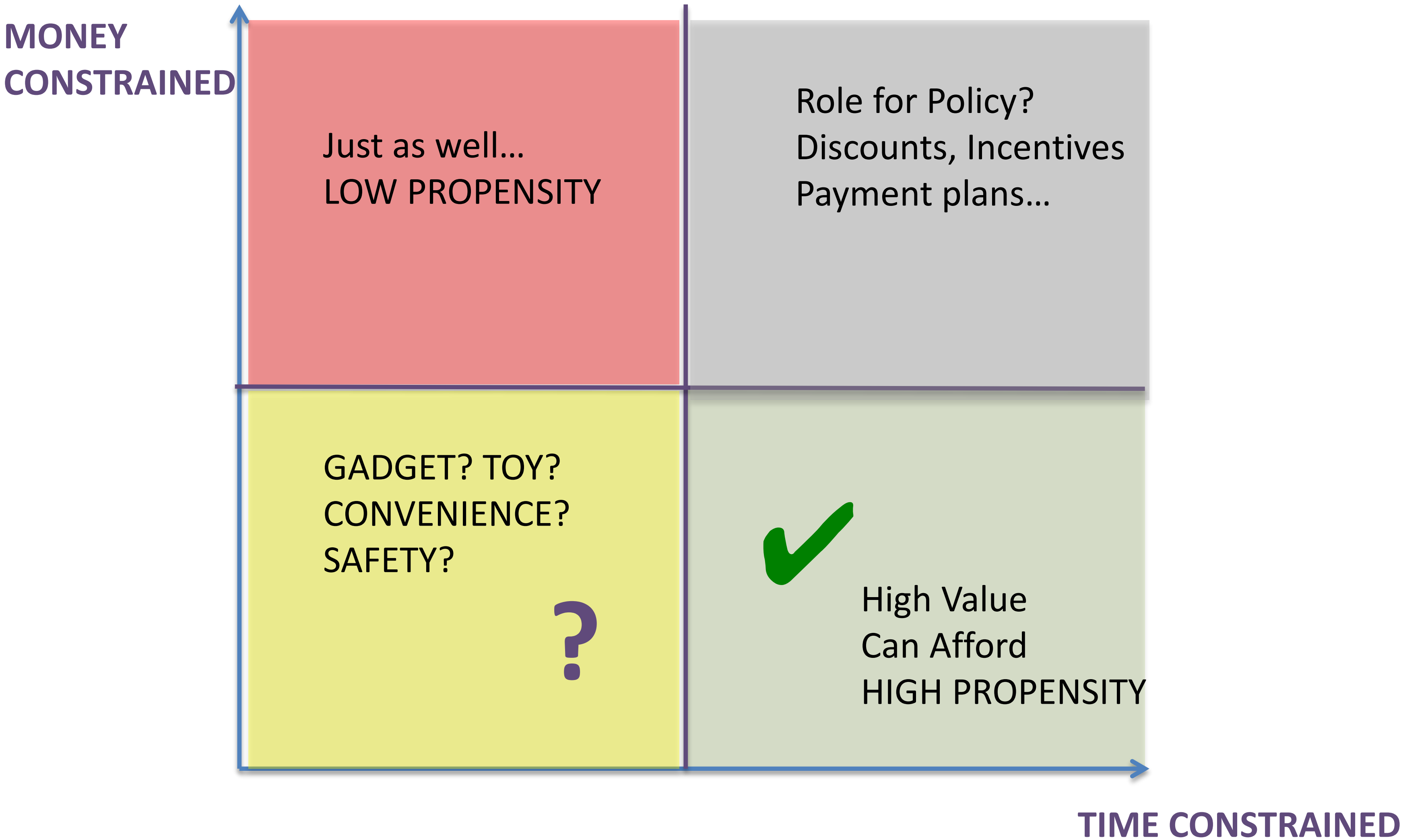



Cohort Effect: Increasing trust
Cohort Effect: Increasing need
Time value for parents
Safety value for parents
Safety value for self
Time value for children
Age

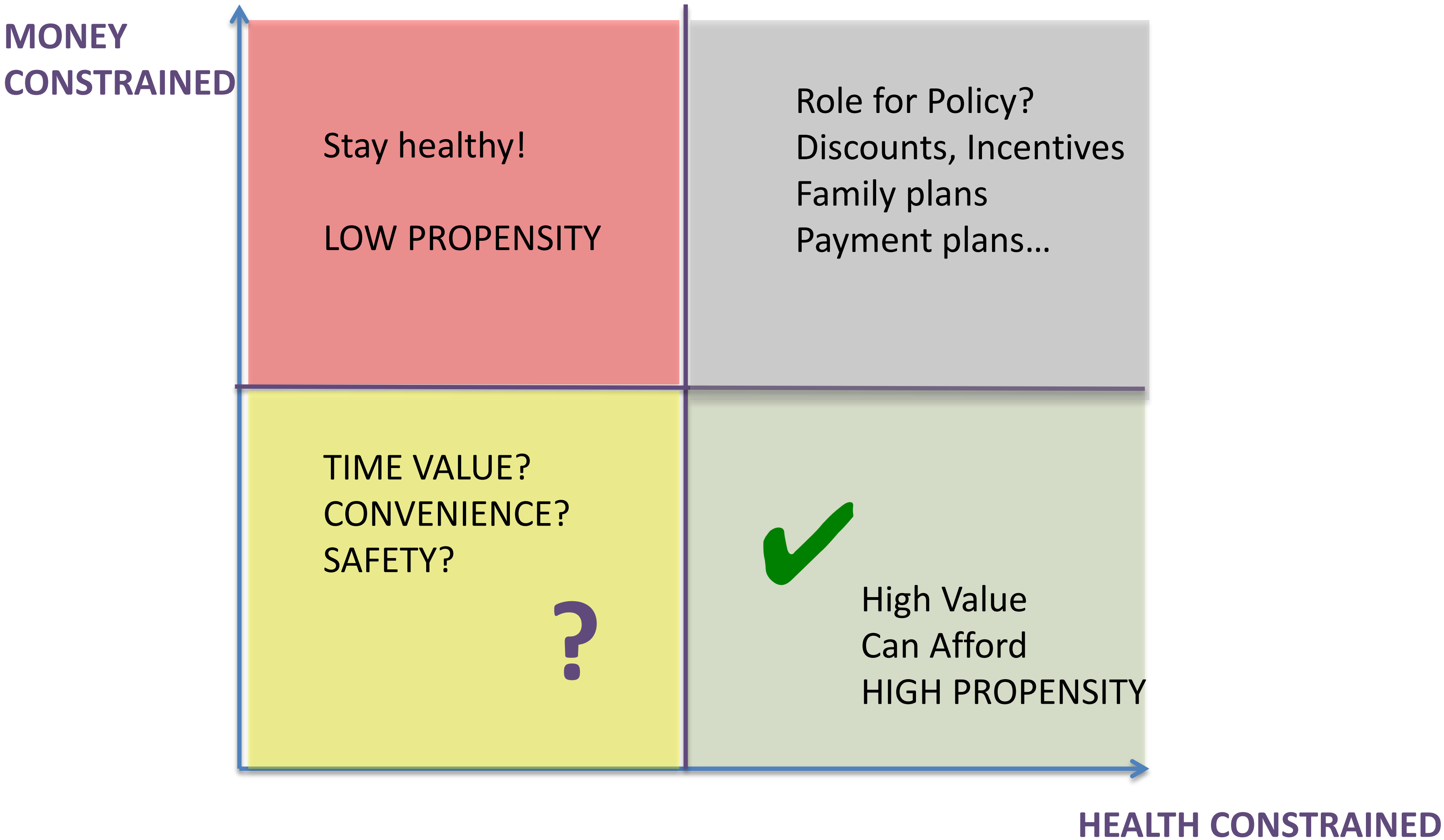
TWO KEY ASPECTS

- AUTONOMOUS CAR AS MOBILITY TOOL
  - Greater safety, efficiency, etc…
  - Enables multitasking, short vs. longer spans
- AS ROBOTIC ASSISTANT
  - Go shop, pick up kids– all mobility chores imposed by auto-centric suburban lifestyle
  - For small businesses– go deliver, pick up supplies…

ADOPTION PROPENSITY



ADOPTION PROPENSITY



SUBSTITUTION OR COMPLEMENTARITY?

Possible Hypotheses

- SUBSTITUTE, NO OTHER CHANGE
- SUBSTITUTE, FREE UP TIME, MONEY (individual level) and IMPROVE SAFETY AND CONGESTION (for society)
- START USING CAR FOR ACTIVITIES PREVIOUSLY EITHER NOT DONE, POSTPONED OR CHAINED
- NEW USES OF MOBILITY TOOLS, MAJOR REORGANIZATION OF ACTIVITY PATTERNS, ESPECIALLY for CAREGIVERS (of young people, elderly)

FINAL THOUGHTS

- DON’T FORGET FREIGHT and LOGISTICS
- IDEAL MARKET FOR INTRODUCING TECHNOLOGY AND ADOPTING ON WIDE SCALE
- INITIAL ROLE AS DRIVER-ASSISTANCE
  - Evident safety benefits
  - Potentially large fuel savings (just in driving mode, not including network aspects)
- LAST MILE DELIVERY STILL UP FOR GRABS, AND LIKELY TO BE BITTERLY FOUGHT