Automated Vehicles: Challenges and Opportunities

IEEE-CNSV Meeting: 11 Oct 2016

Ioannis Kanellakopoulos, PhD
Principal, Oraton Consulting
IEEE Fellow

ioannis@oraton.co

ioannis@ieee.org

IEEE-CNSV
Consultants' Network of Silicon Valley

Outline

- Let’s Get our Terms Straight
- Why I Get to Talk About This
- When Things Go Wrong
- Whose Fault Is It?
- Where Are We Headed?

Let’s Get our Terms Straight

ADAS vs SDC

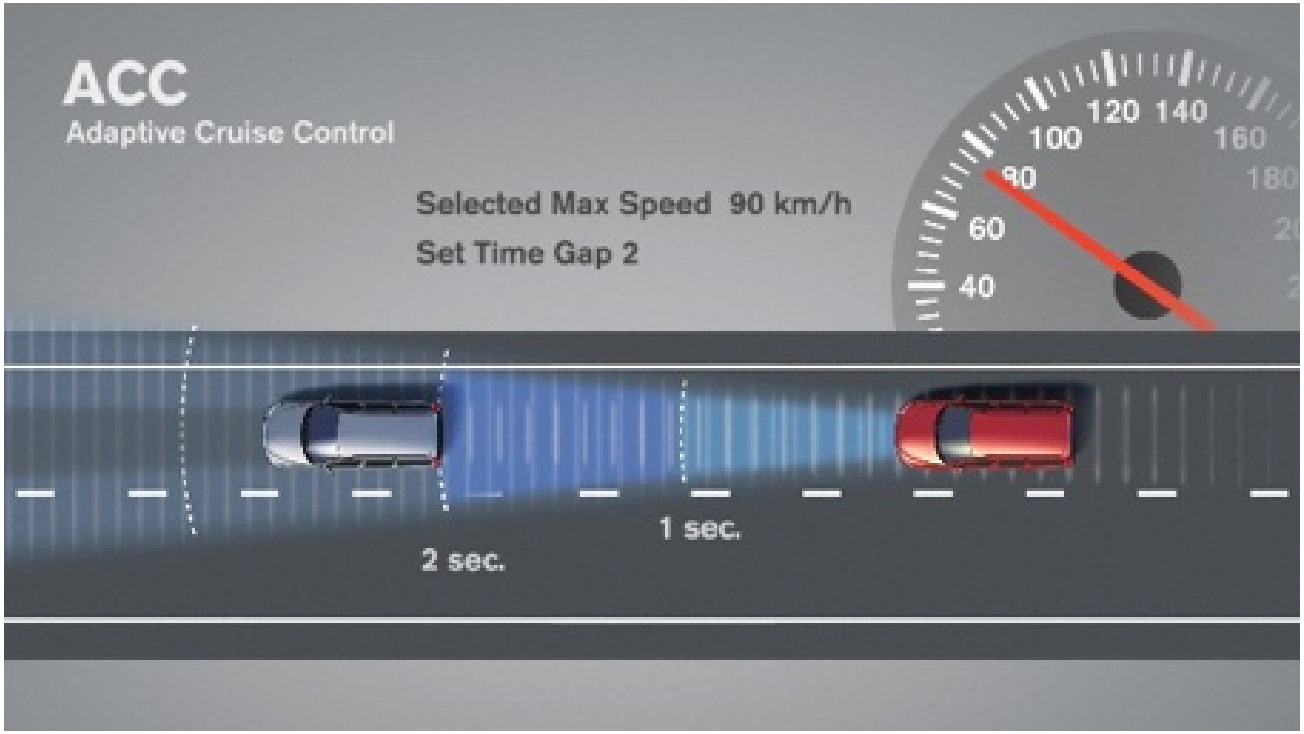
Source: *Last Man Standing*, ABC Television, 9/30/2016

ADAS vs SDC

- ADAS: Advanced Driver Assistance Systems
  - Adaptive Cruise Control
  - Emergency Braking (Front / Rear)
  - Blind Spot Monitoring
  - Lane Departure Warning
  - Lane Keeping Assist
  - Active Park Assist
  - Pedestrian Detection
  - Autopilot
  - Driver is required to monitor
- SDC: Self-Driving Cars
  - All of the above features and much more, all integrated
  - Driver is not required, at least in defined-use cases

Adaptive Cruise Control

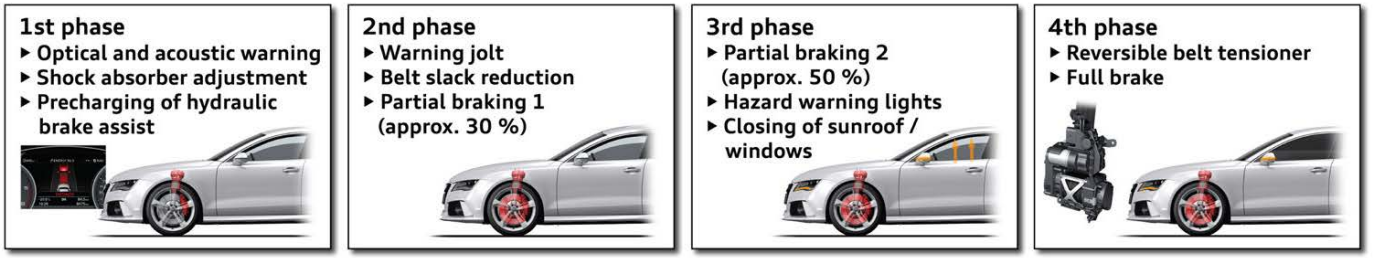
- Cruise Control that slows down to maintain Time Gap (Time Headway) from car in front

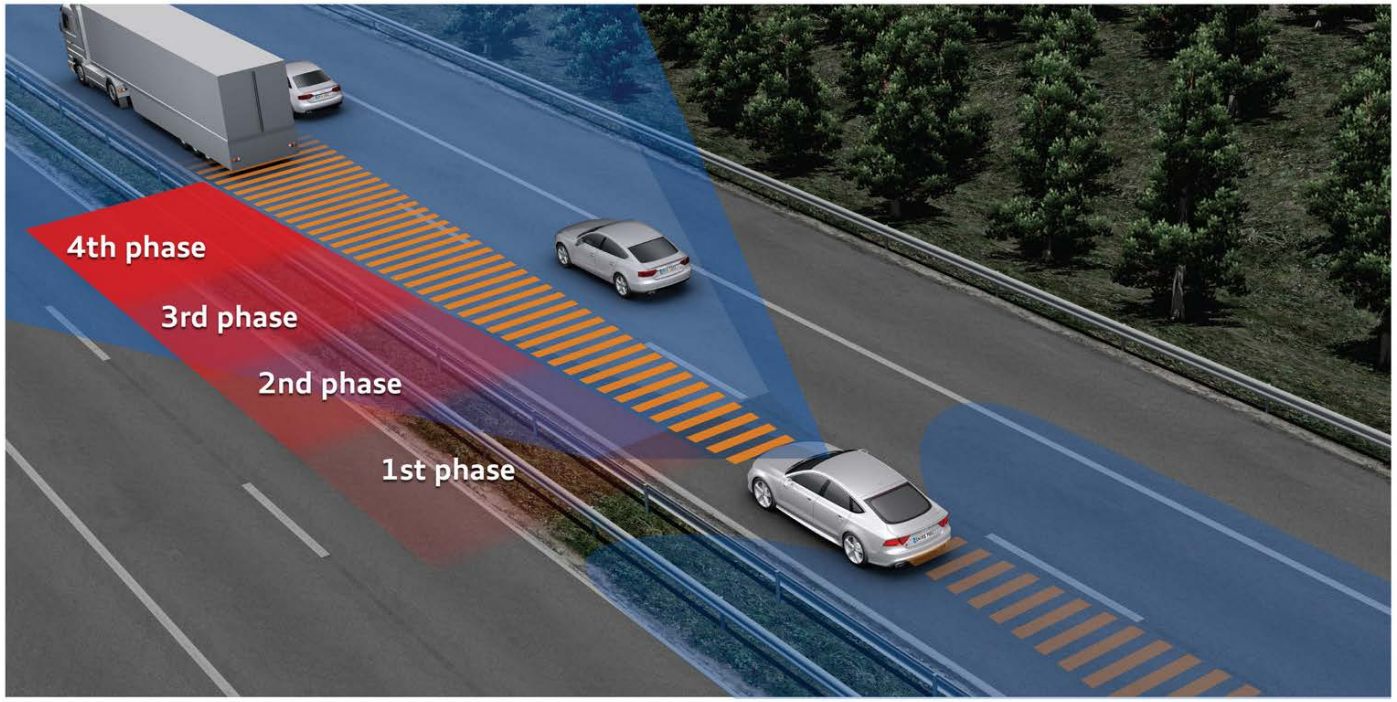


- Mercedes was first in 1998 (Distronic)

Emergency Braking

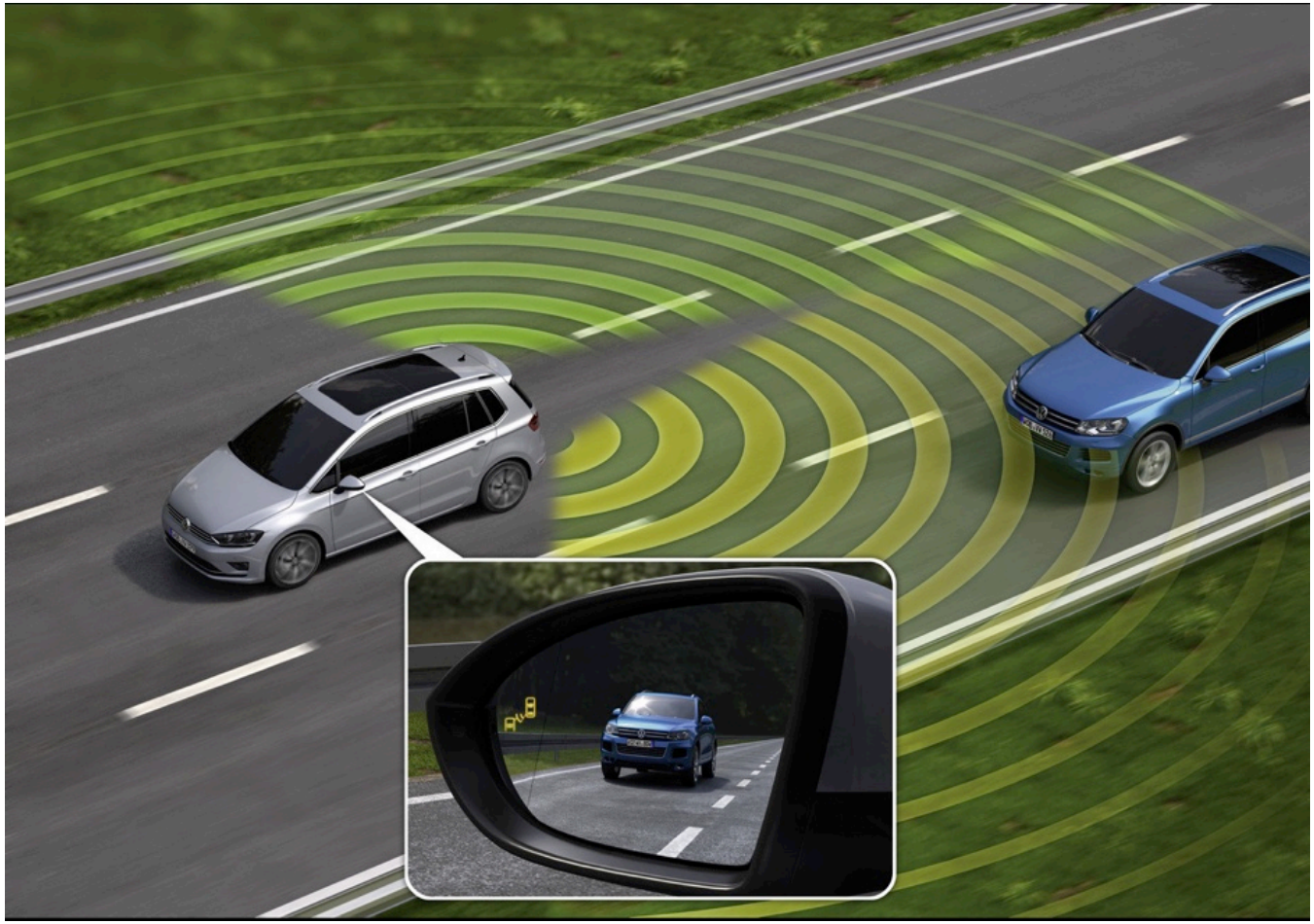
- Audi Pre-Sense





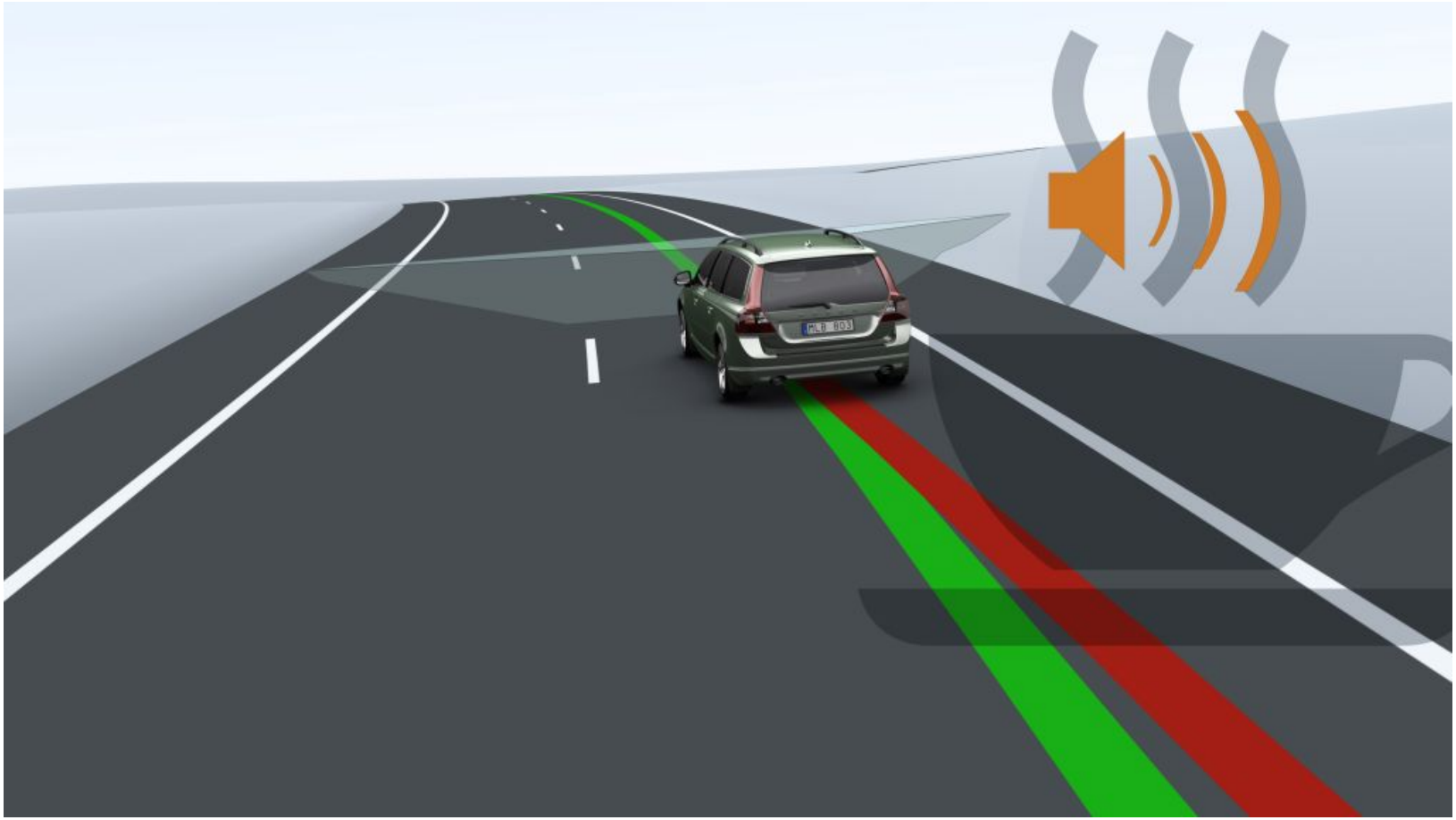
Blind-Spot Monitoring

- VW Blind Spot Monitor



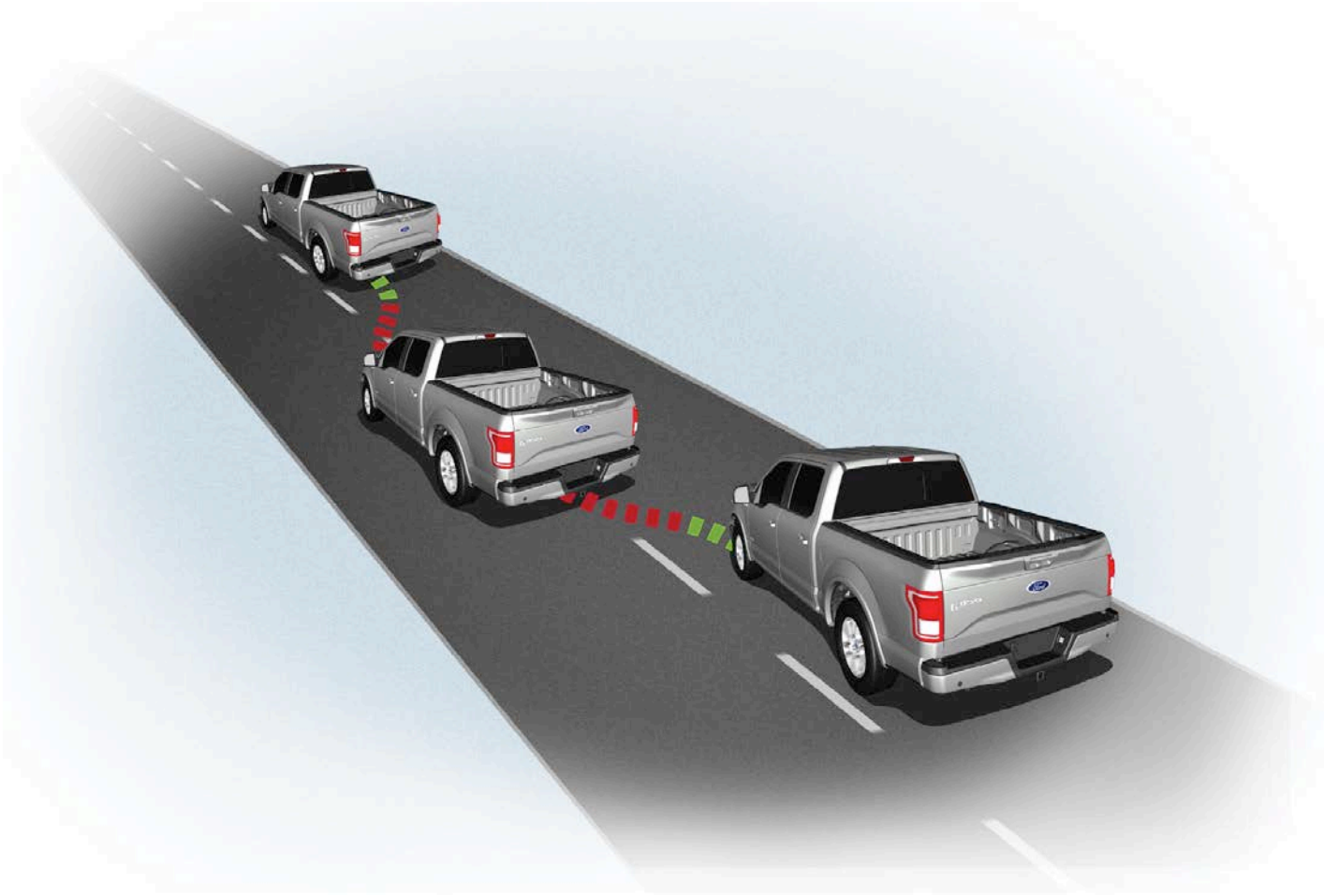
Lane Departure Warning

- Volvo LDWS



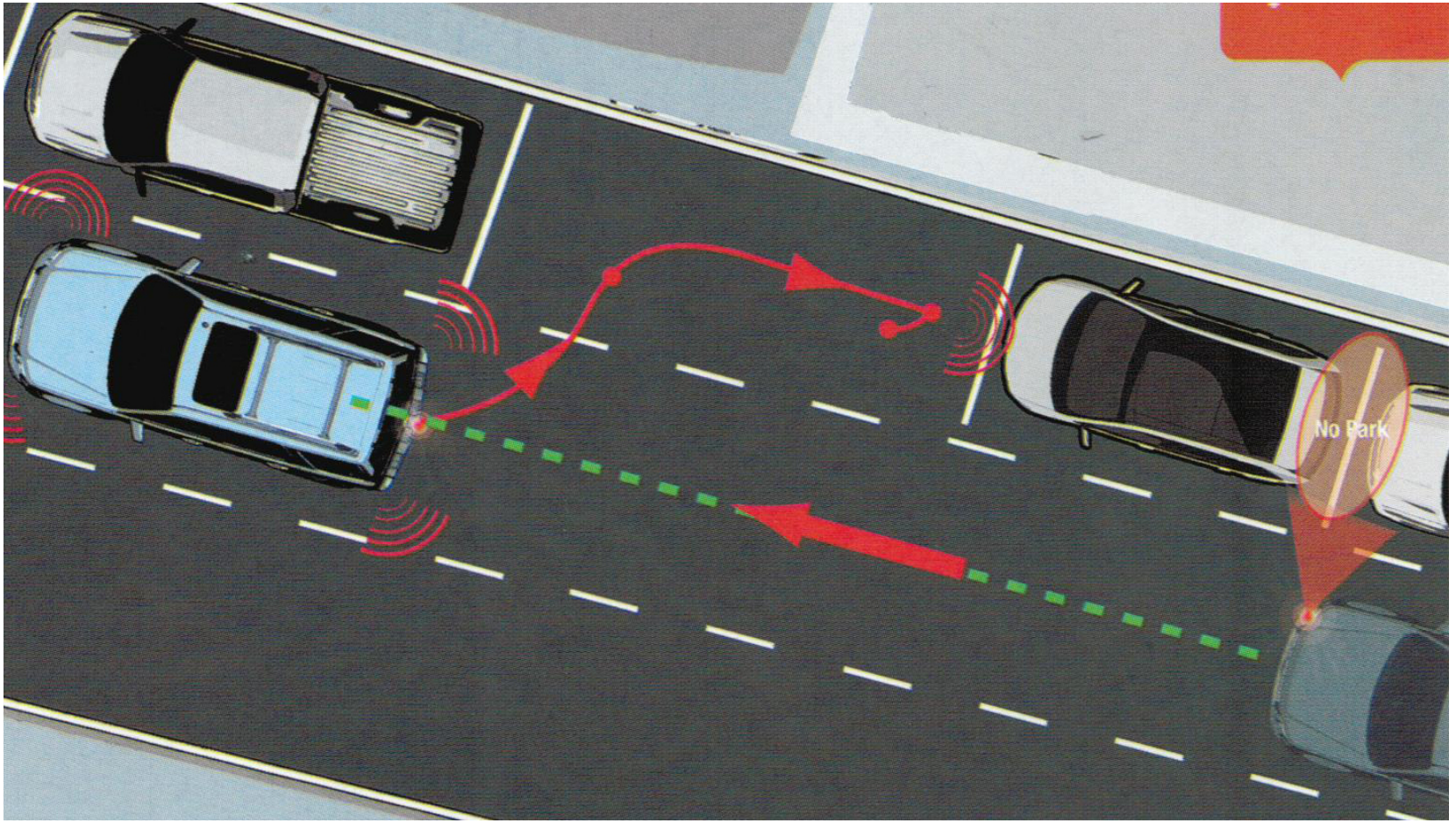
Lane-Keeping Assist

- Ford LKAS



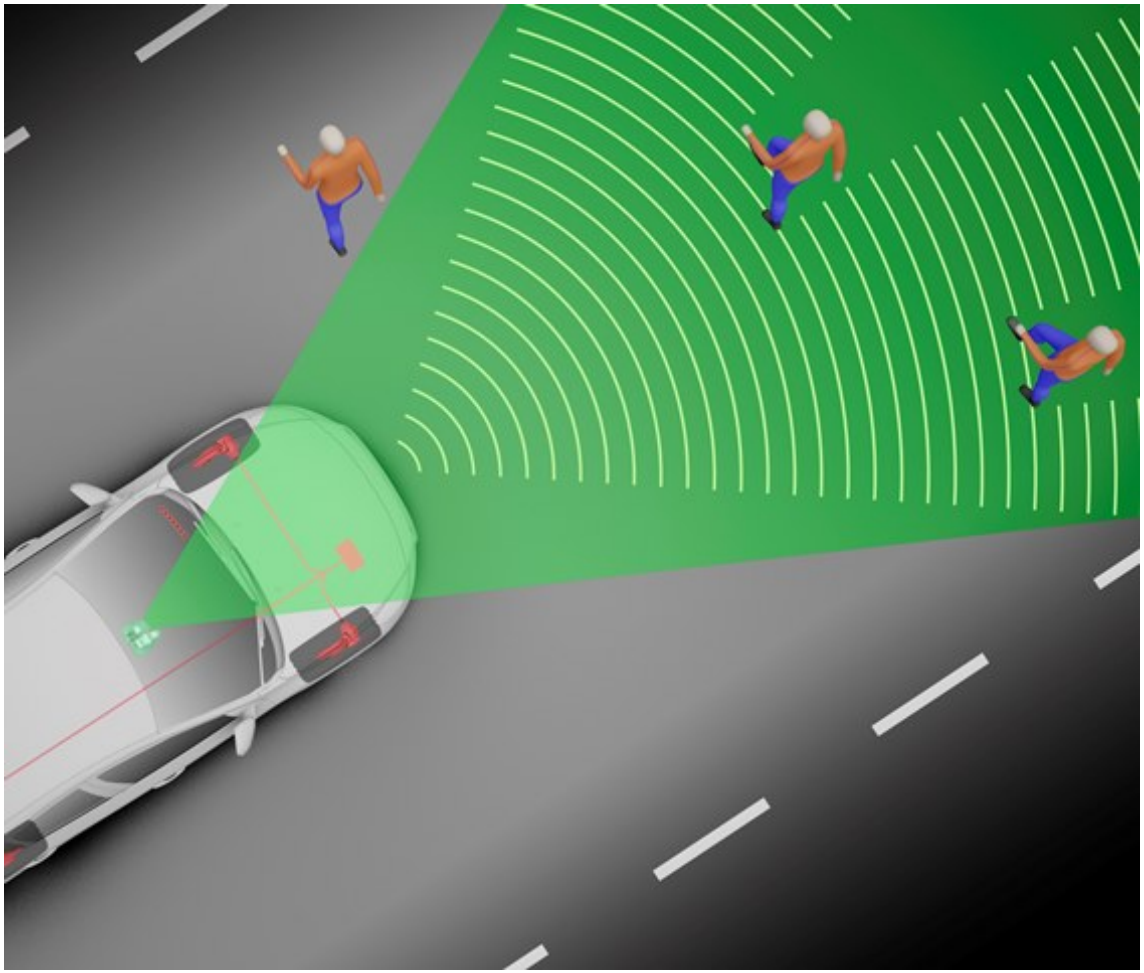
Active Park Assist

- Ford APA



Pedestrian Detection

- Volvo PDS



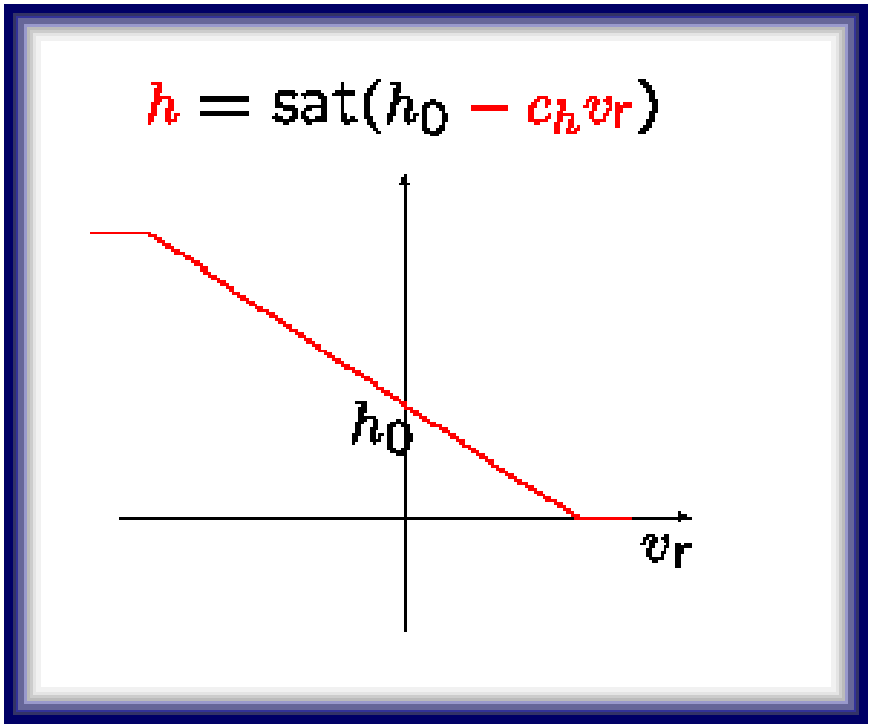
Why I Get to Talk About This

Variable Time-Headway (VTH)

- Adaptive Cruise Control (ACC) traditionally uses ***time headway*** spacing: follow x seconds behind the car in front (independent of speed)
- In the real world, sensor and actuator delays create instabilities that may lead to crashes in platoons of ACC-enabled vehicles
- While at UCLA in the ‘90s, my then-student Diana Yanakiev (now at Uber ATC) and I developed ***variable time headway*** spacing

Variable Time-Headway (VTH)

- **Reduce** time headway if the leading car is traveling **faster**, **increase** time headway if the leading car is traveling **slower**



VTH Simulation

Source: *UCLA Adaptive & Nonlinear Systems Lab*, 10/1996

VTH Experimental Test

Source: *California PATH / UCLA Adaptive & Nonlinear Systems Lab*, 08/1999

IRIS Sensor for ADAS

IR LED ON

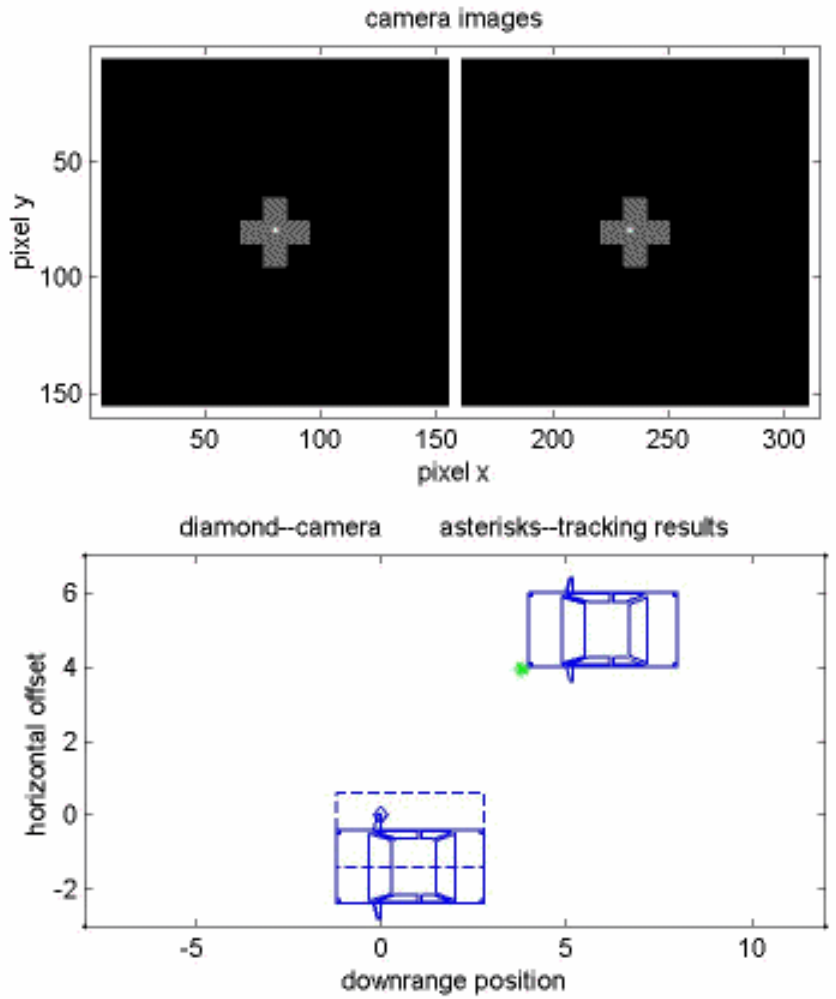
Regular scene

IR LED OFF

Subtracted image

Source: *UCLA EE Department*, 1996, with O. M. Stafsudd, P. R. Nelson, N. Bambos

Iperasys: An ADAS Startup



When Things Go Wrong

Main Concerns about ADAS/SDC

- Malfunction concerns
  - Ghost targets (false positives) may cause rear-end collisions
  - Missed targets (false negatives) are even worse
  - Unexpected swerving, braking, etc.
- Cyber-security concerns
  - If the car is a computer, it can be hacked

ACC False Negatives

- Typically seen with stationary objects
- Here is such a “dummy” object:

Source: YouTube, youtu.be/hl0LCOIW_SI

ACC False Negatives

- Amateur test using Audi A6

Source: YouTube: youtu.be/hl0LCOIW_SI

ACC False Negatives

- Professional test using Volvo S60

Source: YouTube, youtu.be/jClxcSBNwcw

What Happened There?

- The easy answer is to blame radar
- All the incidents involved stationary objects
- Radar has trouble “seeing” stationary objects because they blend into the background
- What can be done?
- Sensor fusion: Radar + Camera + Lidar + …
- But most cars today claim to use sensor fusion, and yet problems occur all the time
- So… is the radar really at fault?

Lane Keeping Assist Swerving

- Real-world mishap in Tesla Model S

Source: YouTube, youtu.be/MrwxEX8qOxA

Lane Keeping Assist Swerving

- Another real-world mishap in Tesla Model S

Source: YouTube, youtu.be/pw2mUhLtYBk

Pedestrian (Un?)Detection

- Volvo pedestrian detection “test”

Source: YouTube, youtu.be/w2pwxv8rFkU

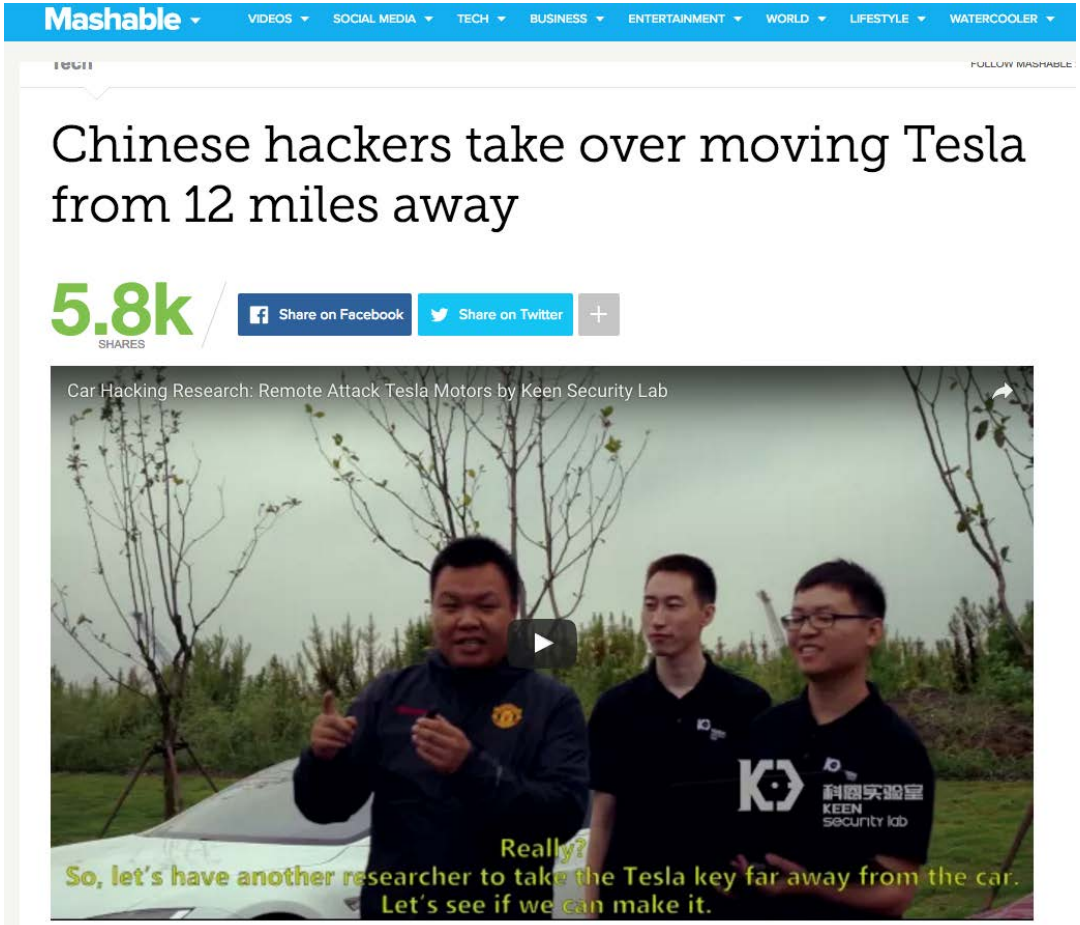
Car-jacking -> Car-hacking

- This is just fantasy, right?

Source: *Fast & Furious 6*, Universal Pictures, 2013

Car-jacking -> Car-hacking

- Nope! Reality is even worse!



Source: *Mashable,* 9/20/2016, mashable.com/2016/09/20/chinese-hackers-tesla/

Whose Fault Is It?

Assigning Responsibility

- Tests and demos are one thing; we can laugh them off
- But real-world accidents trigger insurance claims and lawsuits and recalls
- With today's ADAS, the standing assumption is that the driver is responsible
- Will insurance companies take on the risk of insuring SDC owners?
- And who will be blamed for SDC accidents?
  - Driver? Manufacturer? Hacker?

ACC False Negative

- Real-world mishap in Tesla Model S

Source: YouTube, youtu.be/qQkx-4pFjus

Active Park Assist Mishap

- Volvo self-parking fails to detect pedestrians

Source: YouTube, youtu.be/CQZKWAOYt0Y

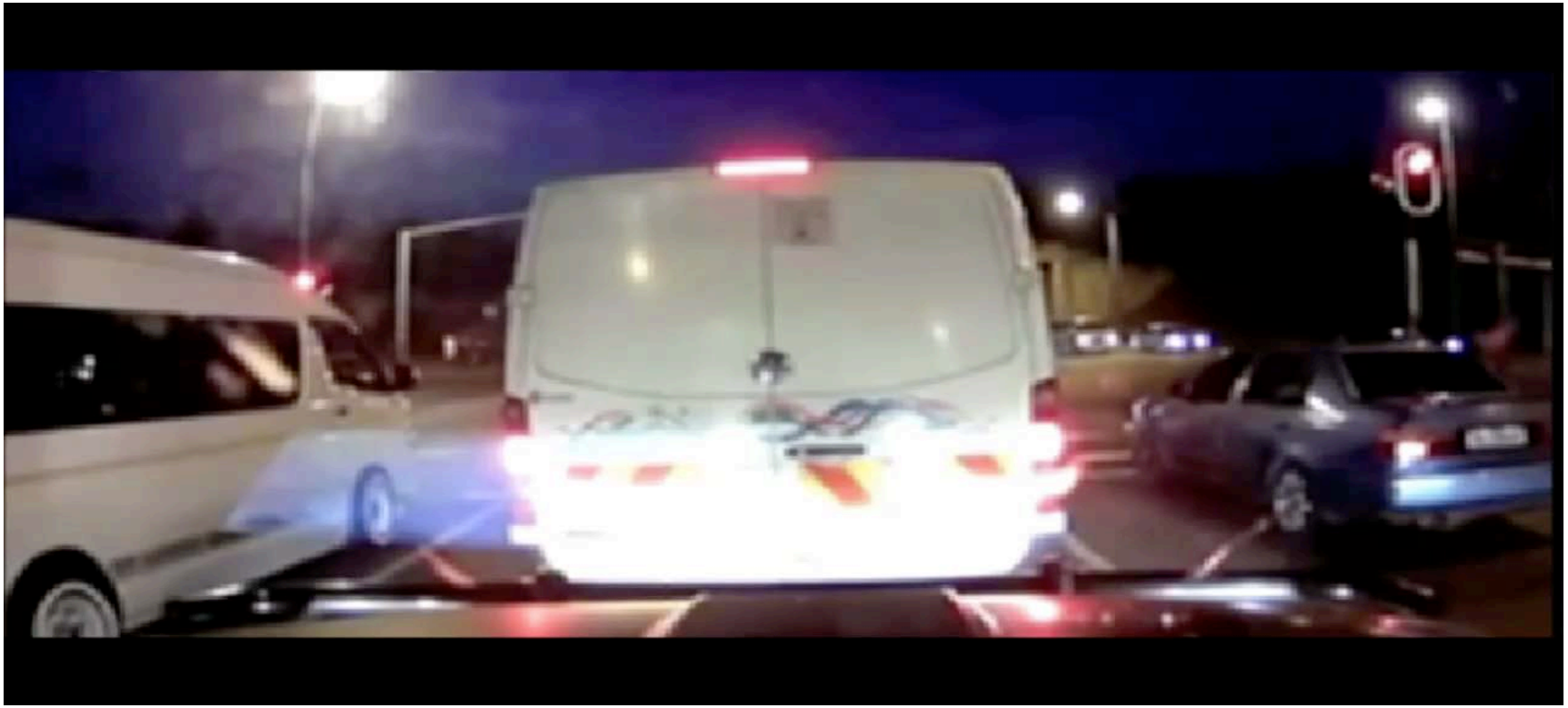
What if This Were an SDC?

- Please don't freak out – wait for the end

Source: YouTube, youtu.be/Khuie6_axRg

And What if THIS Were an SDC?

- OK, you can freak out here

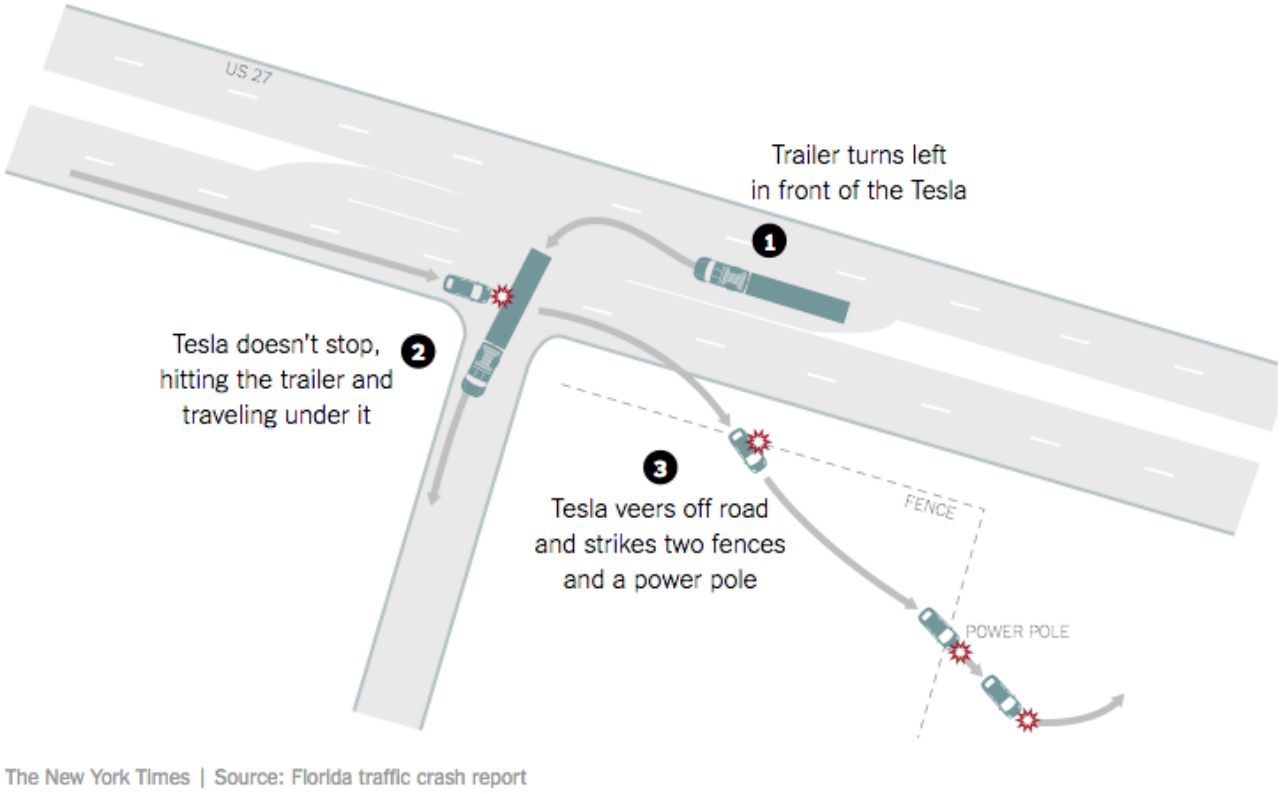


- 27 people were killed in Durban, South Africa
- The truck driver claimed that the brakes failed

Source: YouTube, youtu.be/DAdSrXEPu6Y

Could That Really Happen?

- It already has with ADAS (Tesla Autopilot)



- NTSB investigation still ongoing

Source: The New York Times, 7/12/2016

So Who Is to Blame?

- Disclaimer: This is only my personal opinion
- There is a long history of human drivers attempting to assign blame to the car's systems
  - Brake failures
  - Steering failures
  - Exploding tires
  - Accelerating cars
- Sometimes that turned out to be true, other times not
- My view is that the same process will be used to figure out who to blame in accidents involving ADAS/SDC
- For the most part, these issues will be settled in the court system through lawsuits

Where Are We Headed?

What's Next for ADAS?

- Higher reliability with more development and testing using real-world feedback
- Better sensor integration
- Better integration of individual functions
  - For example, blind-spot monitoring should feed into ACC
- Today: Scene Awareness
  - Each separate system sees only its own "scene"
- Tomorrow: Surroundings Awareness
  - Each system helps each of the other systems

Self-Driving Cars – Why?

- There are some obvious benefits:
  - Better use of time spent in traffic
  - Less traffic, fewer accidents
  - Better mobility for those who cannot drive
  - Quicker pizza delivery (PizzaLyft, anyone?)
- But self-driving cars open up a host of new opportunities in the sharing economy

SDCs in the Sharing Economy

- Cars designed for delivery of goods could be much lighter and emissions-free
  - They may even have a special compartment to bake the pizza on the way…
- Cars designed to carry people could be much safer
  - Non-traditional (safer) seating positions
  - No glass windows (hey, it's my talk)
  - Better weight distribution for improved handling

SDCs in the Sharing Economy

- Self-driving cars would be better for the environment
  - Fewer human errors, fewer accidents, less traffic, less pollution
- More people would be willing to look at cars as a shared resource
  - Fewer owned cars, more people per car, fewer cars on the road
  - Fewer homes with garages (again, it's my talk)

SDCs – When?

- Your guess is as good as mine
- Defined-use cases: 3-5 years
  - Uber has been using SDCs in Pittsburgh for about a month, and so far so good
  - Uber and others like it can utilize SDCs much sooner than the general public
- SDCs for the general public: at least 7-10 years
  - Will be expected to perform near-perfectly in all conditions – that's a very tough problem

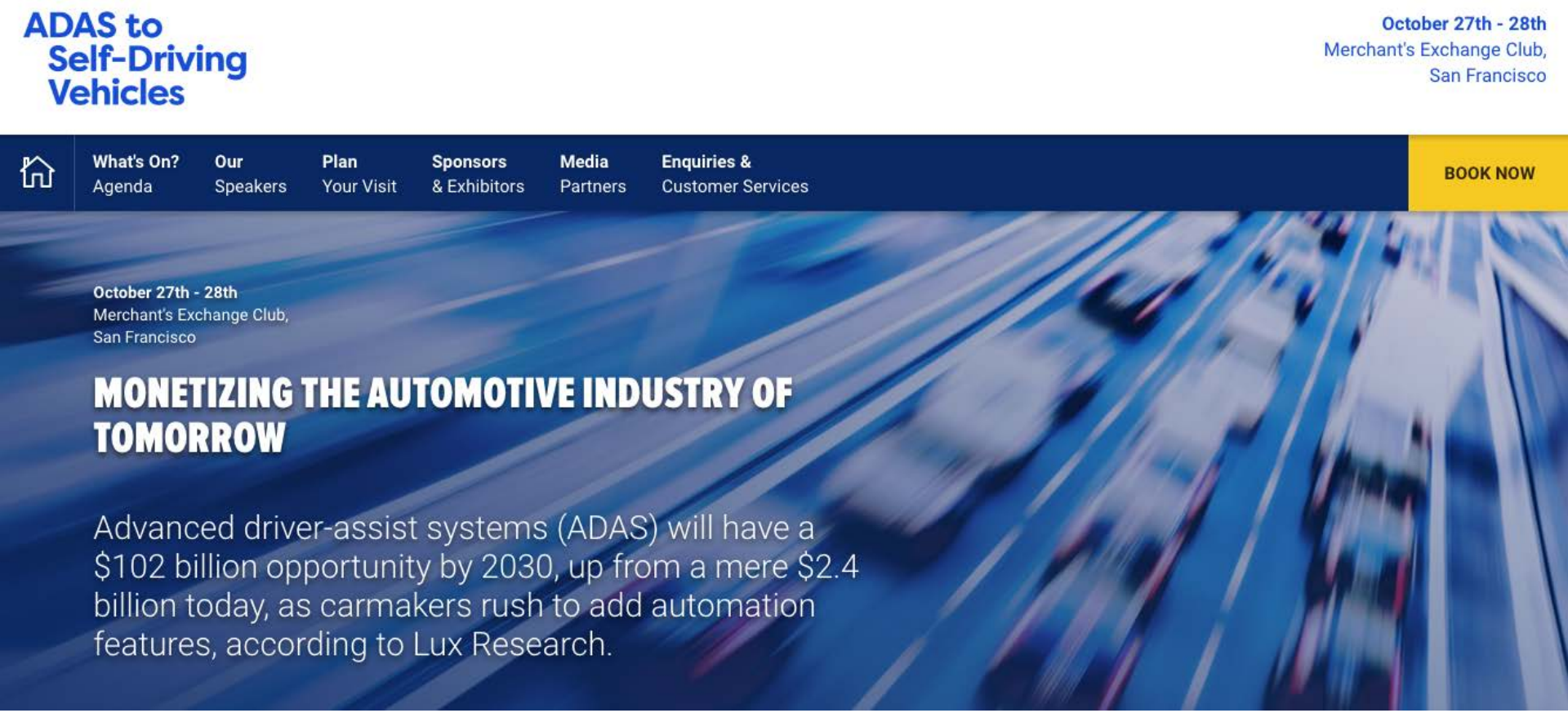
SDCs – How?

- Maybe all SDCs will be defined-use cases for the foreseeable future
- In the sharing economy, each of us could simply utilize different types of SDCs (and, in some cases, maybe even cars driven by actual humans) depending on our needs
  - Type A SDC drives kids to school in the morning and picks them up in the afternoon
  - Type B SDC drives adults to work and back
  - Type C SDC drives retirees to their activities
  - Type D SDC drives the whole family and their picnic gear to the beach on the weekend

Conclusions

- ADAS is here to stay
  - But most of these systems need to be further refined
- Self-Driving Cars are coming
  - The potential societal benefits are too big to ignore
  - Lots of work still to be done before they are at a reliability level where the public can accept them
- The “Whose Fault Is It?” question is likely to be sorted out in the courts over several years

For More Information…



Source: Informa TMT, tmt.knect365.com/adas-self-driving/