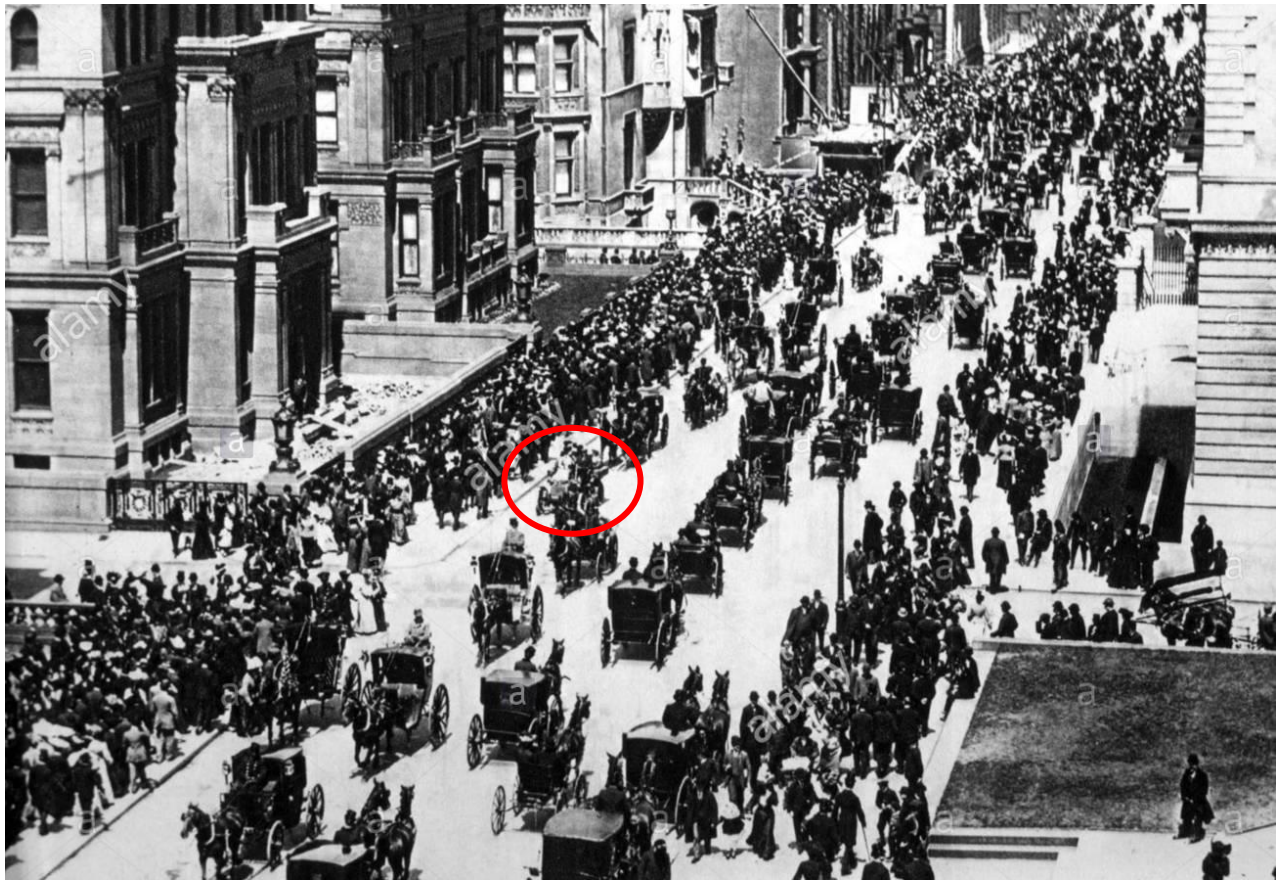
Connected vehicles
- challenges and opportunities

Mathias Johanson, PhD
R&D Manager
Alkit Communications AB

5th Avenue, New York, 1900

Can you spot the car?

5th Avenue, New York, 1900

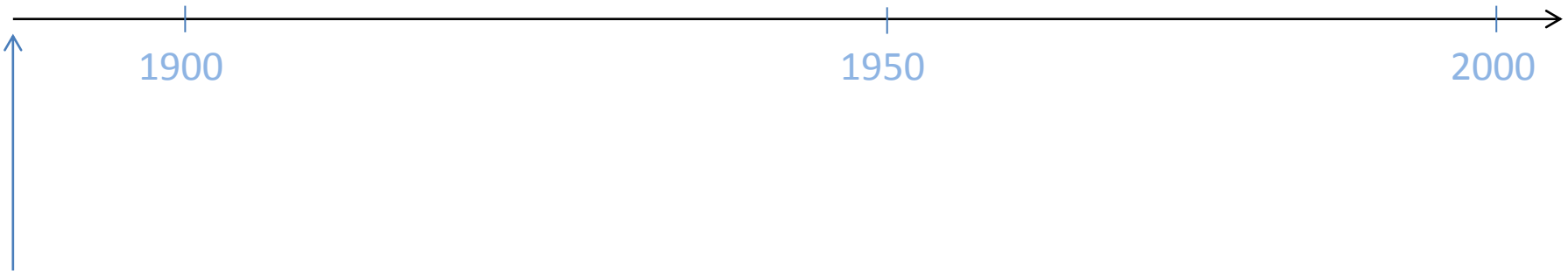


Can you spot the car?

5th Avenue, New York, 1913

Can you spot the horse?

Automotive Innovation Timeline



1875 Internal combusion engine (Nikolaus Otto)

Automotive Innovation Timeline

1885 Benz Patent Motor Car

1900

1950

2000

1875 Internal combusion engine (Nikolaus Otto)

Automotive Innovation Timeline

1885 Benz Patent Motor Car

1886 Daimler Four Wheel Car

1900

1950

2000

1875 Internal combusion engine (Nikolaus Otto)

Automotive Innovation Timeline

1885 Benz Patent Motor Car

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1886 Accelerator pedal, battery ignition, spark plug, ...

1875 Internal combusion engine (Nikolaus Otto)

Automotive Innovation Timeline

1885 Benz Patent Motor Car

1886 Daimler Four Wheel Car

1900

1950

2000

1913 Ford Model T

1886 Accelerator pedal, battery ignition, spark plug, ...

1875 Internal combusion engine (Nikolaus Otto)

Automotive Innovation Timeline

1885 Benz Patent Motor Car

1886 Daimler Four Wheel Car

2006 My Car

1900

Then nothing happens for 100 years...

2000

1913 Ford Model T

1886 Accelerator pedal, battery ignition, spark plug, ...

1875 Internal combusion engine (Nikolaus Otto)

Automotive Innovation Timeline

1885 Benz Patent Motor Car

1886 Daimler Four Wheel Car

Connectivity
Telematics
ADAS
Autonomous driving
electric propulsion
e-services
voice interfaces

1900 | 1950 | Until now! | 2000

1913 Ford Model T

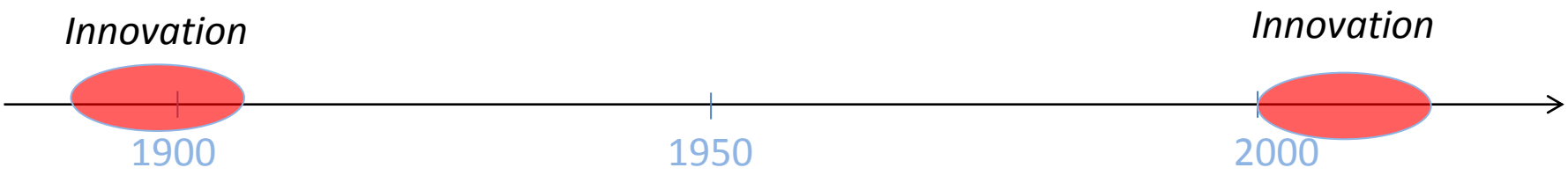
1886 Accelerator pedal, battery ignition, spark plug, ...

1875 Internal combusion engine (Nikolaus Otto)

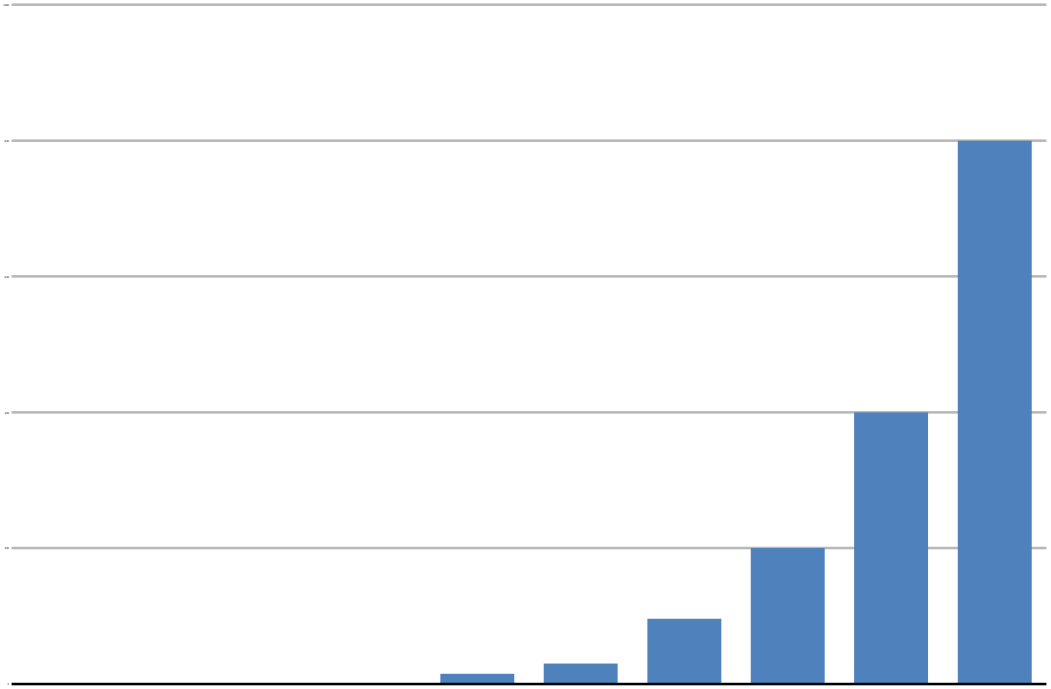
5th Avenue, New York, 2018

Take-home message #1

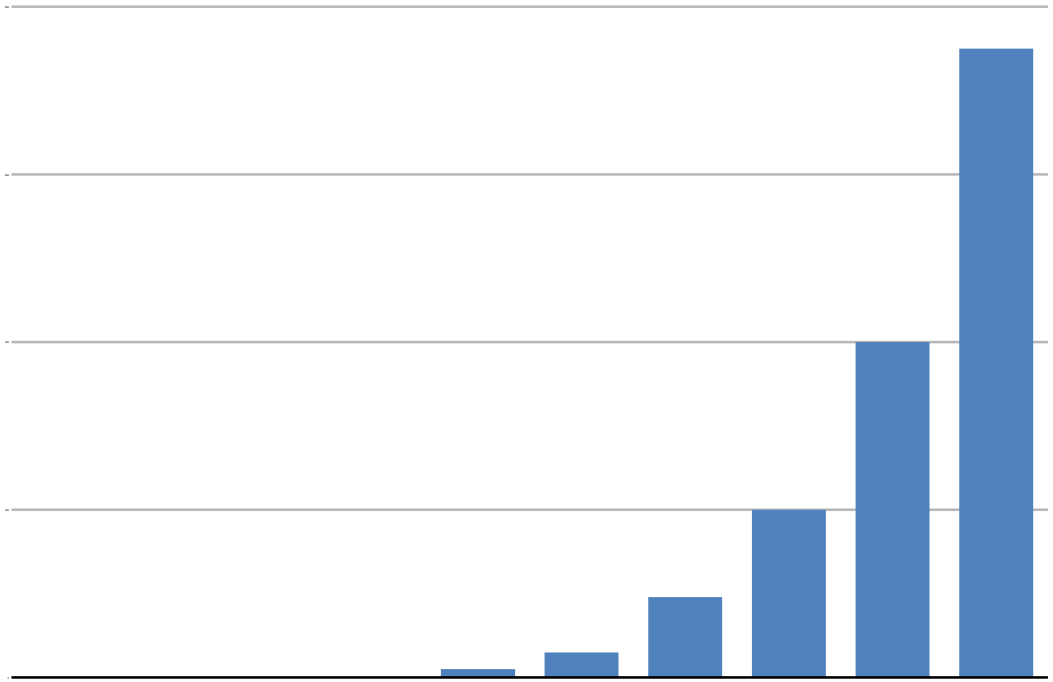
- After a 100 year hiatus there is once again serious innovation in the automotive industry



Size of software in vehicles



Percentage of repain-shop visits due to software related faults

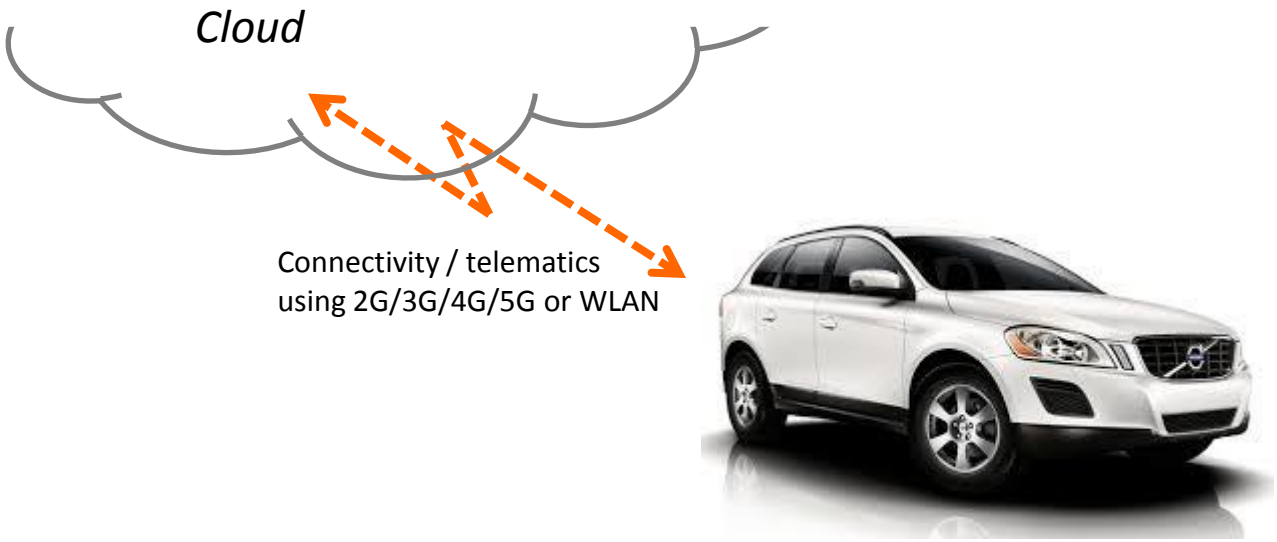


Take home message #2

Cars are turning into computers on wheels

The connected vehicle

- ~100 Electronic Control Units (ECU) in a modern car
- In-vehicle networks interconnecting ECUs
- Connectivity and Telematics enable remote access to data from ECUs (and other in-vehicle data sources)
- New e-services and new business models appearing



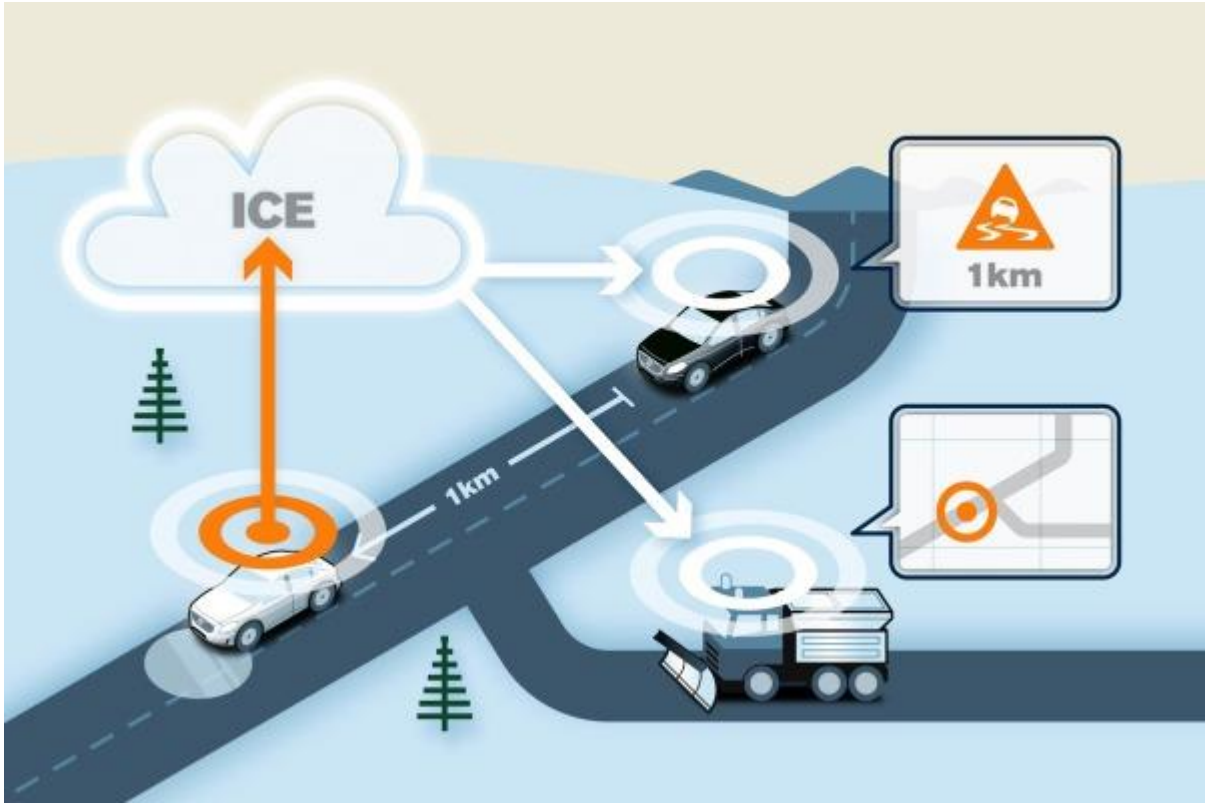
Opportunities

- Enabling **new products features** based on connectivity and **new aftermarket services**
- **Continuous deployment** of in-vehicle software
- Supporting **knowledge-driven product development**
- **Shortening development cycles** by providing ubiquitous access to reliable data from products in use
- **Improving product quality** by finding faults earlier through **online diagnostics and analytics** services
- Supporting **intelligent transportation systems** (ITS) by sharing data
- Promoting **data-driven innovation**

Connectivity as an enabler for new automotive aftermarket services

- Connected collaborative active safety systems
- Remote diagnostics and prognostics
- Predictive / preventive service and maintenance
- ADAS and Autonomous Driving support
- Connected infotainment services
- Continuous deployment of software
- New business offerings based on car-sharing, service-based transportation, etc.

Connected collaborative active safety



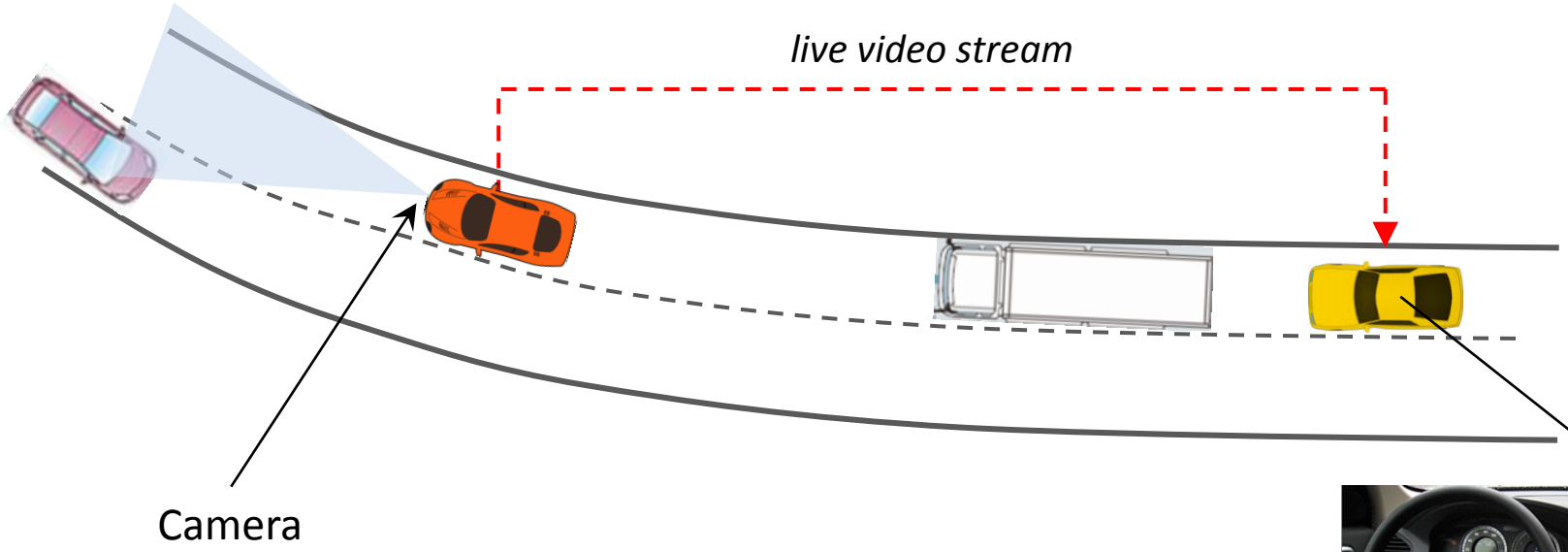
Volvo Slippery Road Alert System

Autonomous driving

- Need for low latency V2V and V2I communication
- Challenging processing and communication of multimedia data (video, radar, lidar, ...)

- Sophisticated development tools for design, test, verification and experimentation are needed by automotive OEMs and component developers

Overtaking support based on v2v video

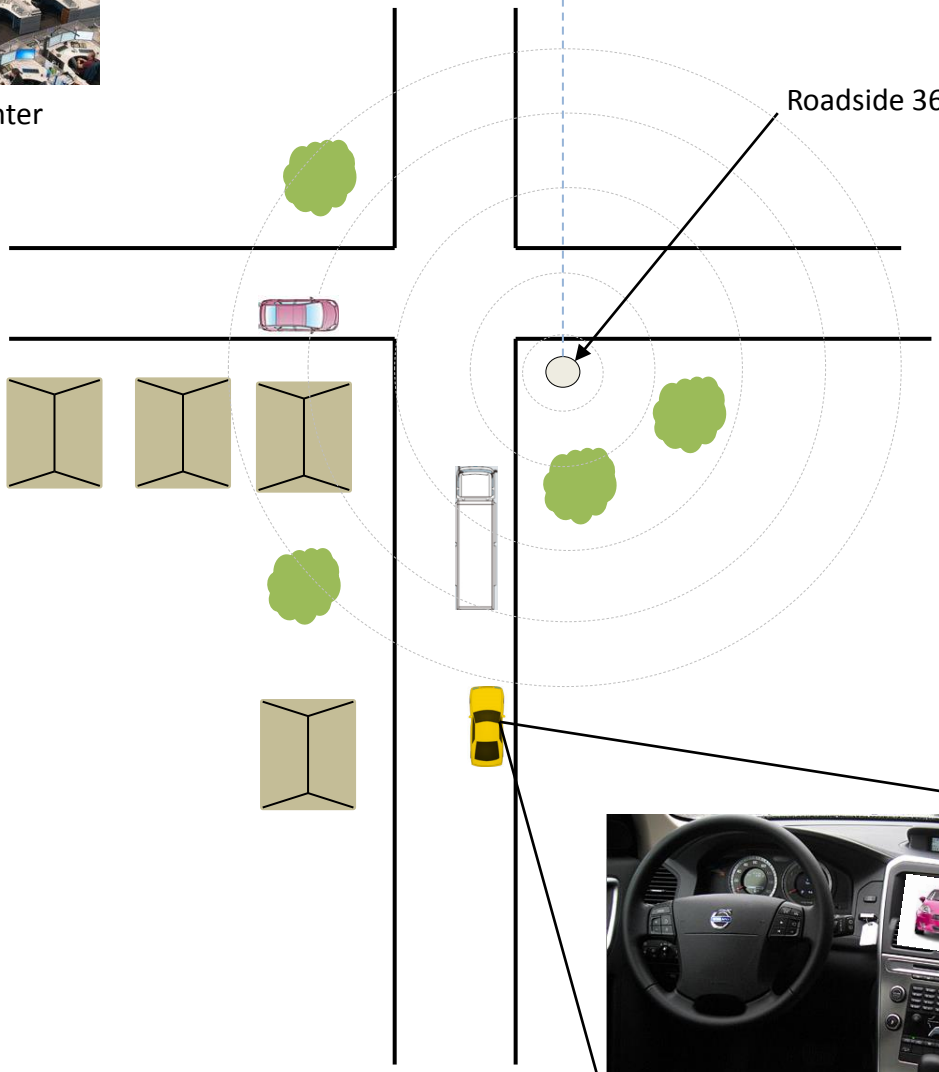


IHU live video display

RETINA

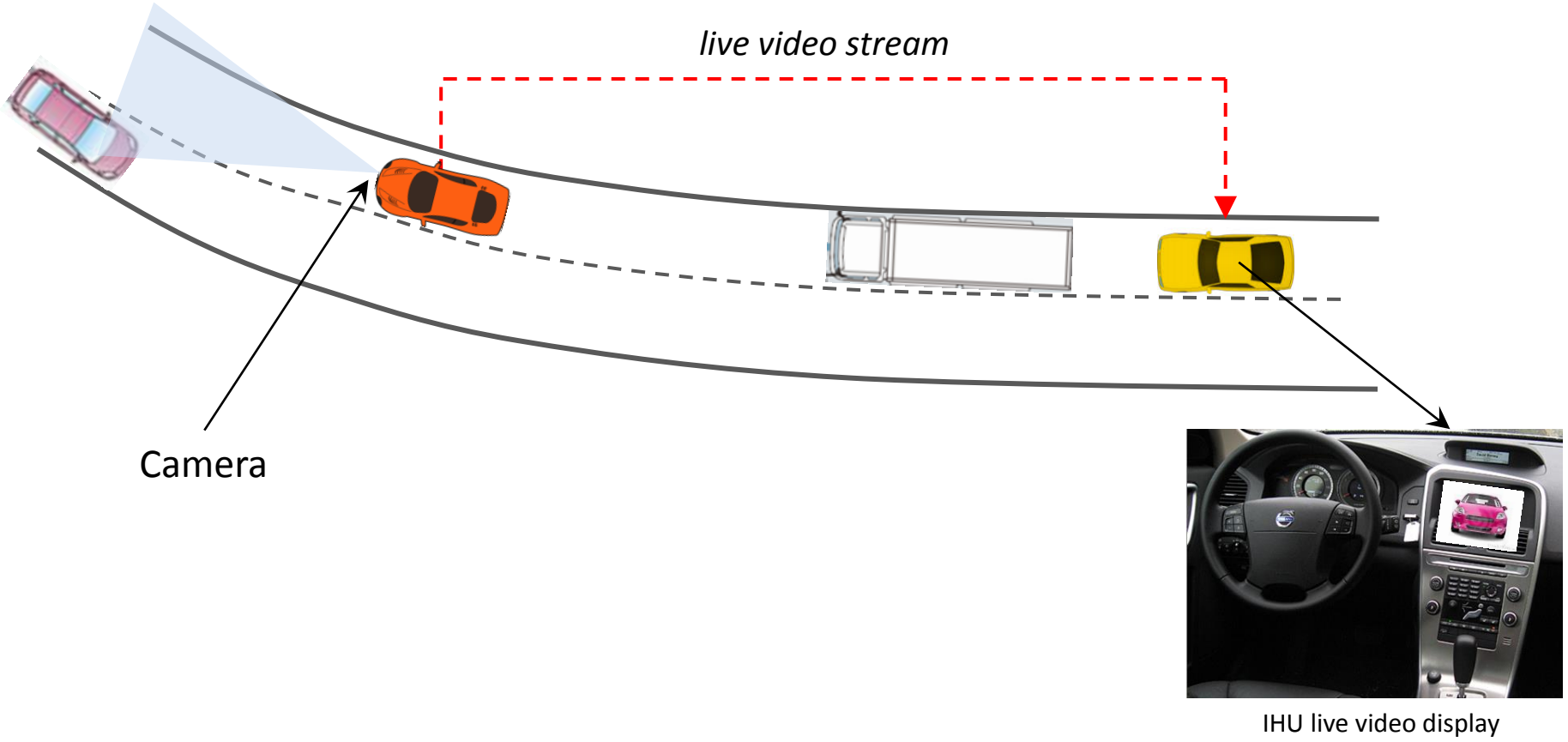
360 video for ADAS and traffic monitoring

Traffic monitoring center



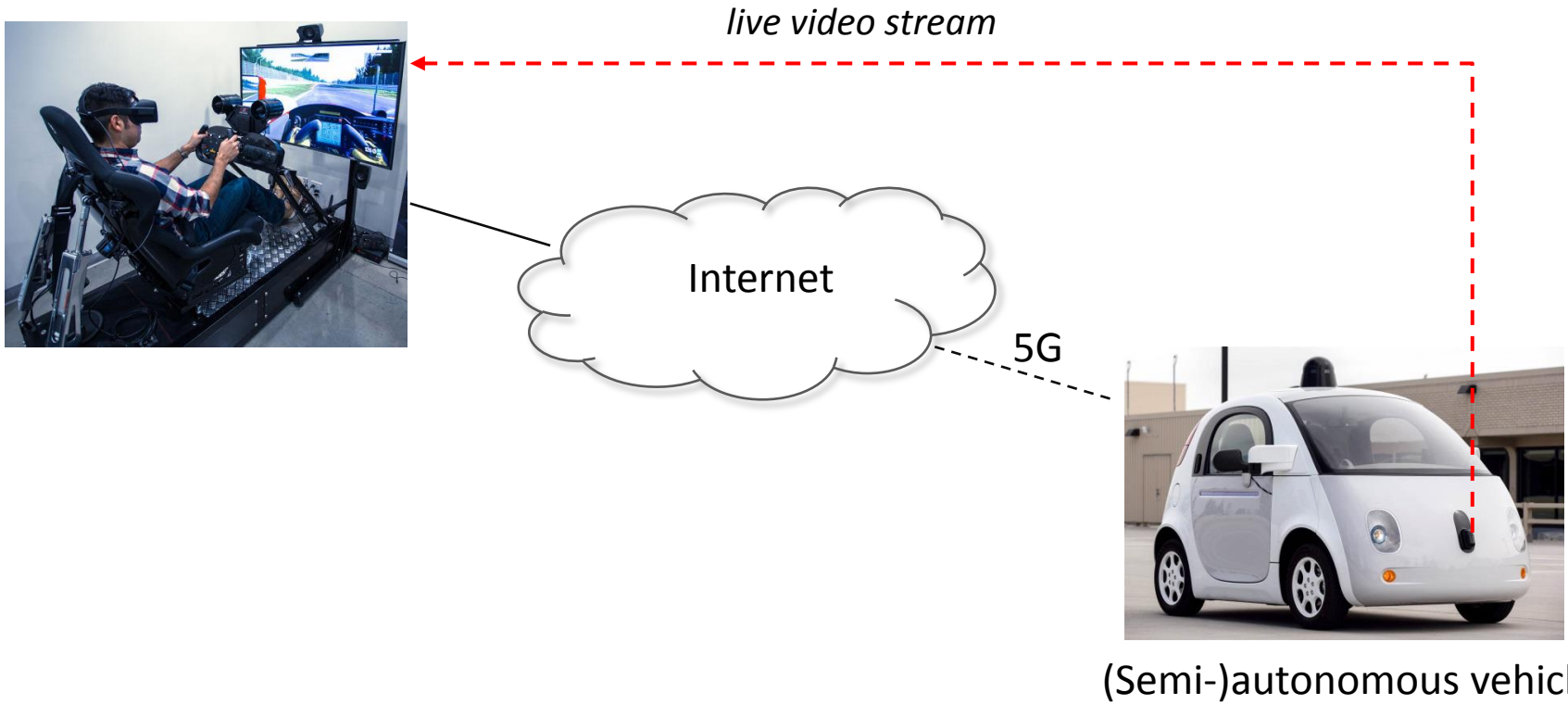
In-vehicle live video display

Overtaking support based on v2v video



IHU live video display

Remotely controlled vehicle



Take-home message #3

- The sky is the limit for new services based on connectivity in the automotive industry

Connectivity, Telematics and Analytics supporting knowledge-driven product development

- Collect and analyze data from connected vehicles for use in product development
- Sensor signals, diagnostics data, user behavior and user experience data
- Both pre-production test vehicles and customer vehicles

Automotive Telematics and Analytics enabling knowledge-driven product development

Capture

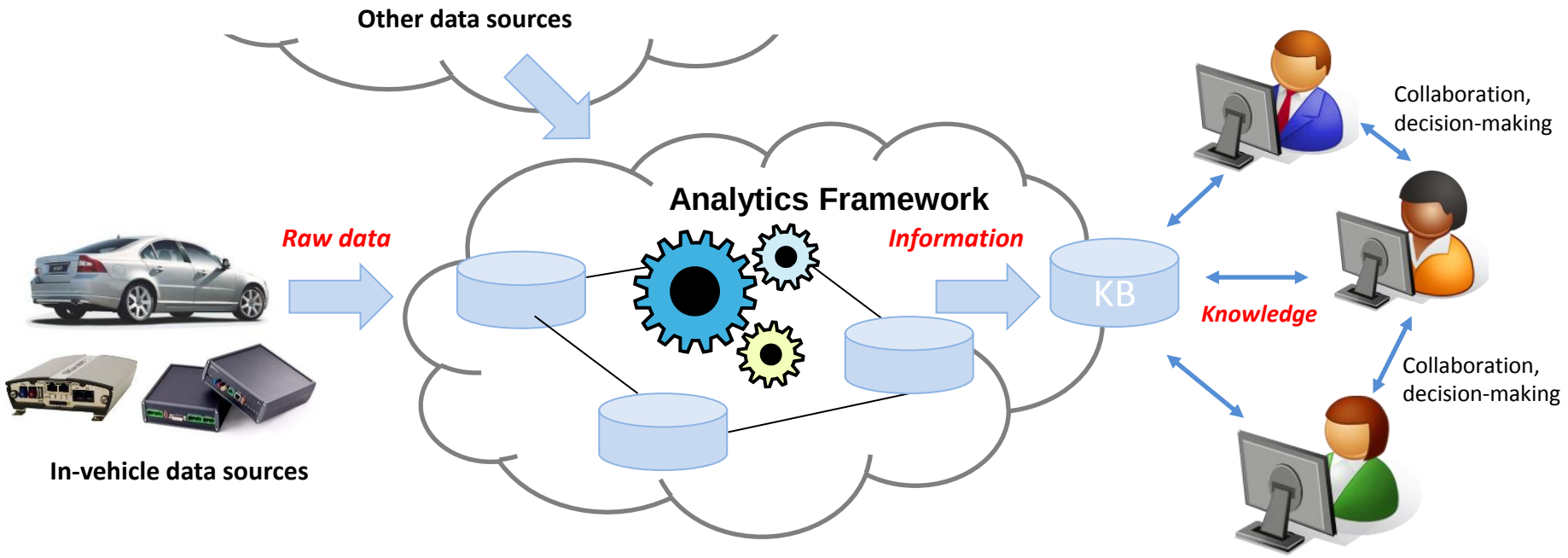
Connectivity,
Telematics,
Diagnostics

Analyze

Big Data analytics,
Data mining,
Cloud computing

Decide

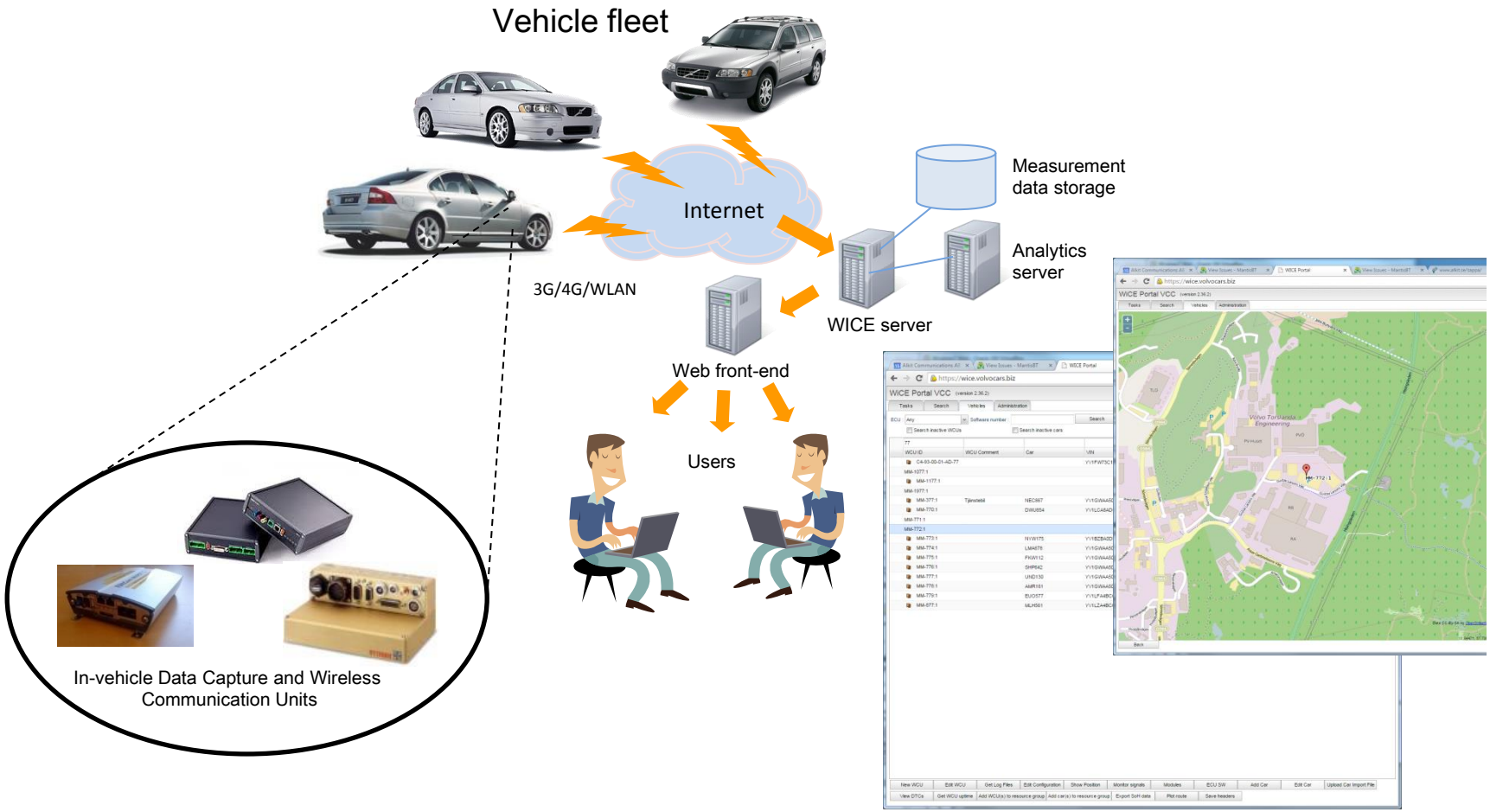
Knowledge bases, data sharing, collaboration



Capture

Connectivity,
Telematics,
Diagnostics

Automotive telematics for product development, testing, validation and fleet management

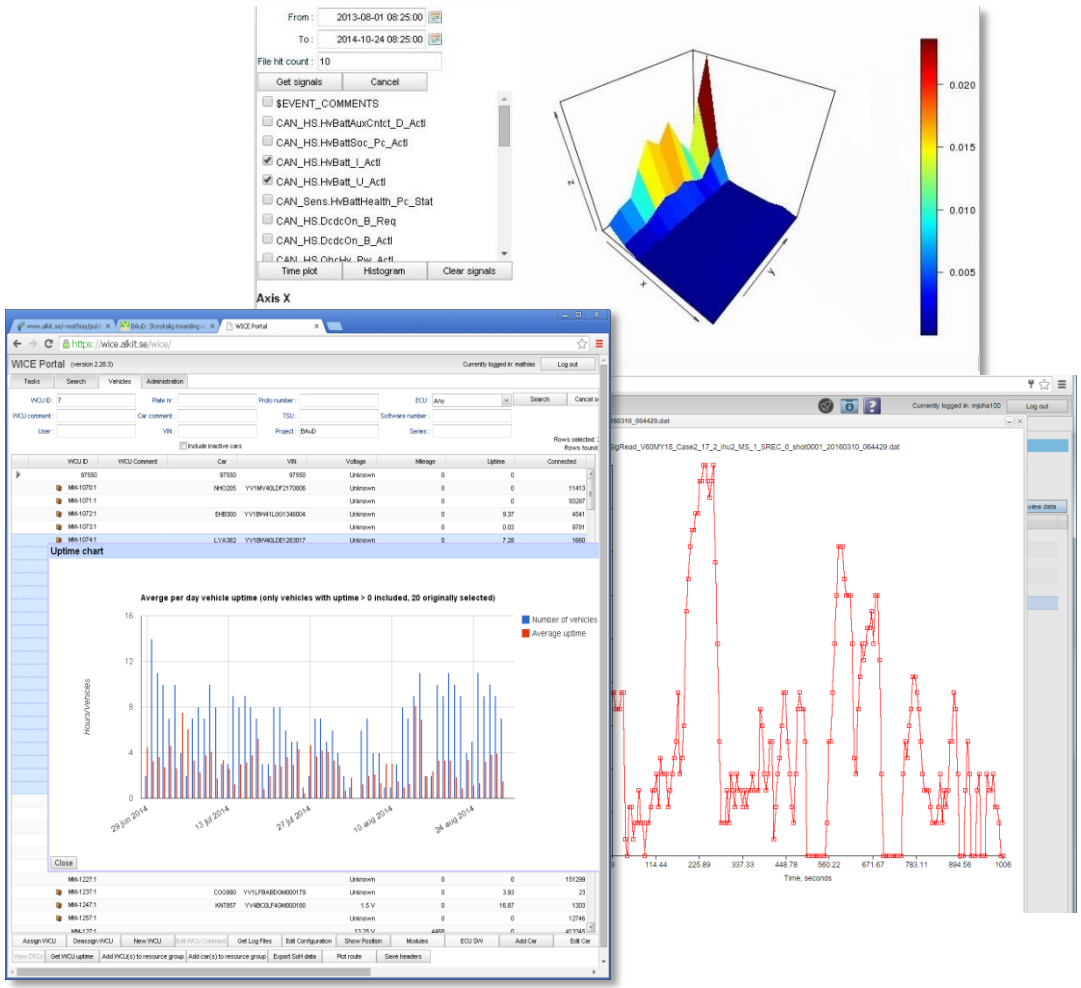


Analyze

Big Data analytics,
Data mining,
Cloud computing

Data analytics and visualization

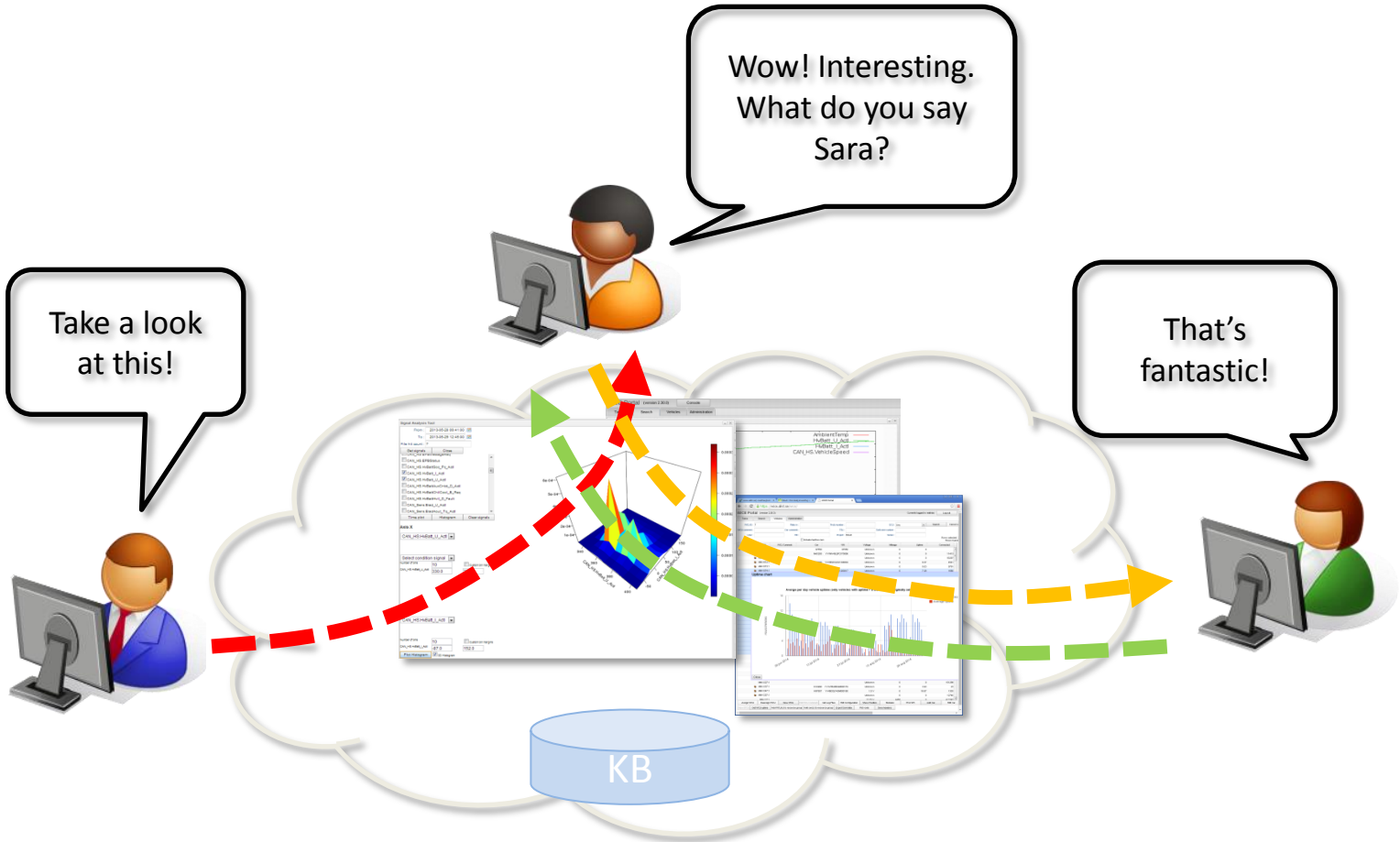
- Aggregates data from fleets of vehicles, analyzes and visualizes results
- Web-based front end integrating analytics and visualization components with Telematics system
- Main focus on time series data analytics & statistics
- Data driven
- Extensible



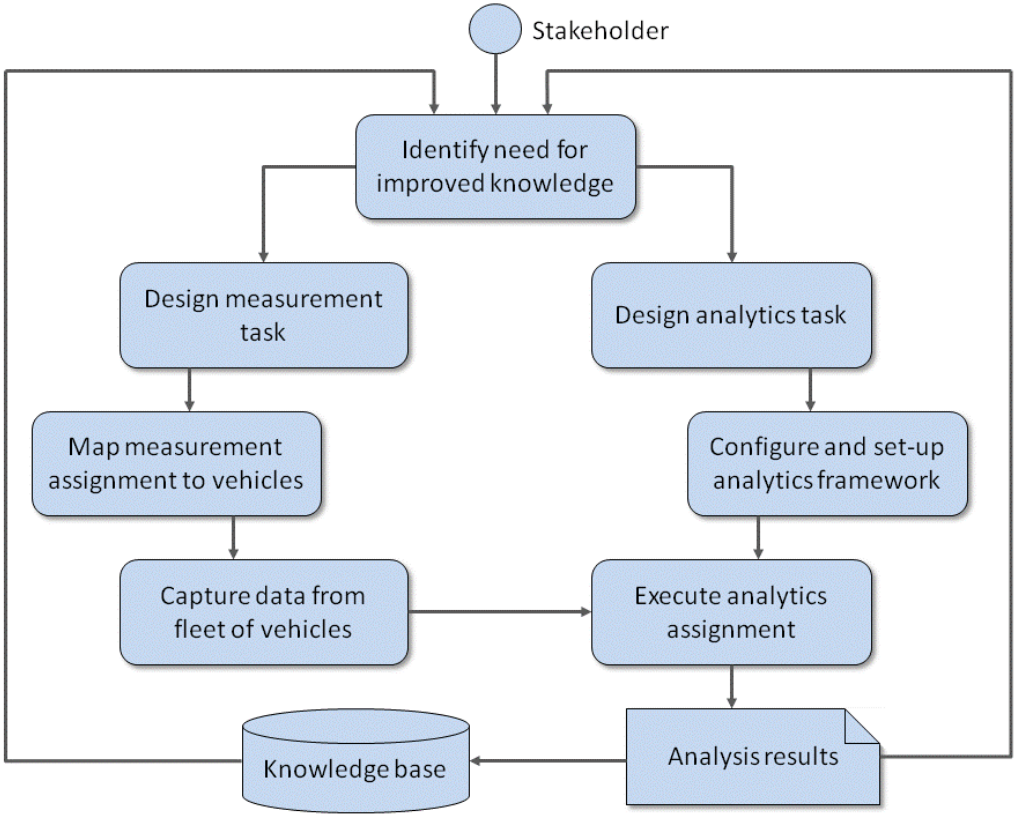
Decide

Knowledge bases, data sharing, collaboration

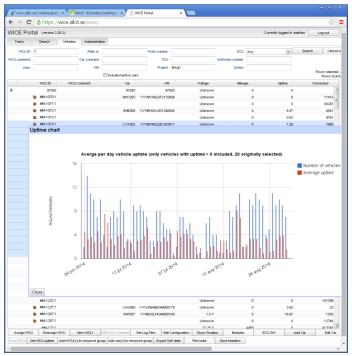
Collaboration and decision-making based on analyzed data



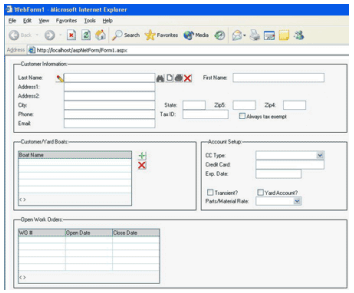
Data-driven analytics approach



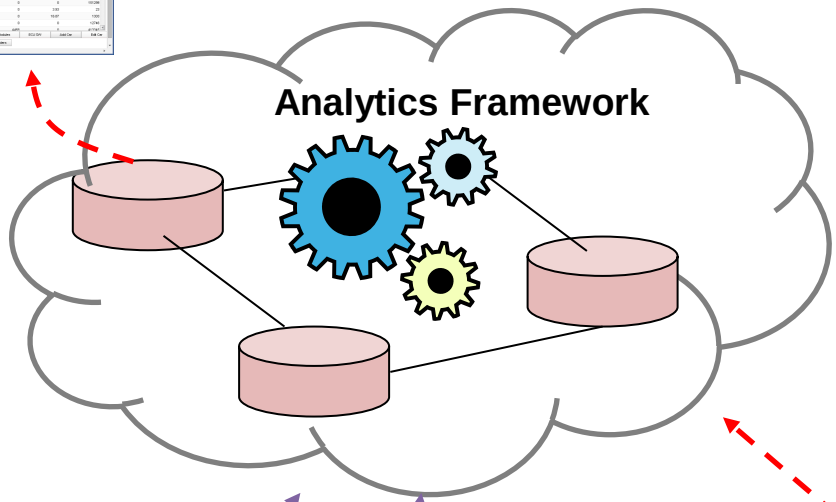
Subjective data capture and analysis

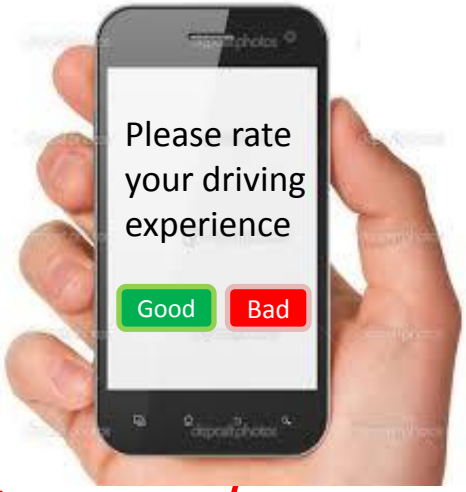


Combined analysis of subjective and objective data



Survey design tool



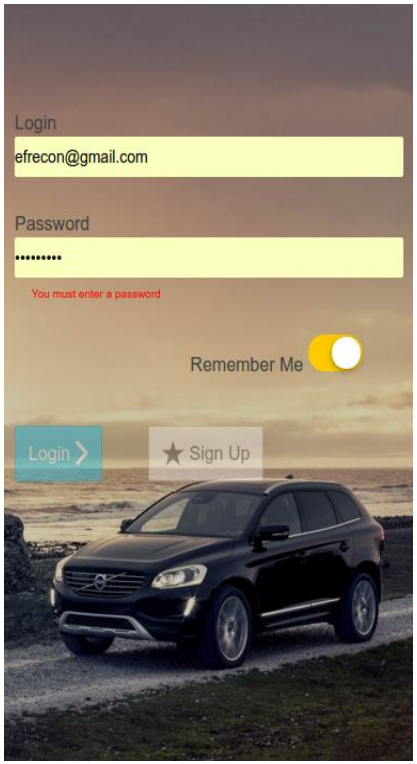


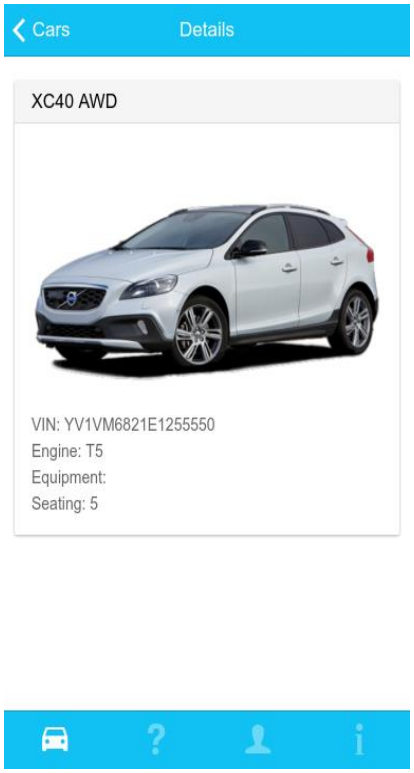
Objective measurement data

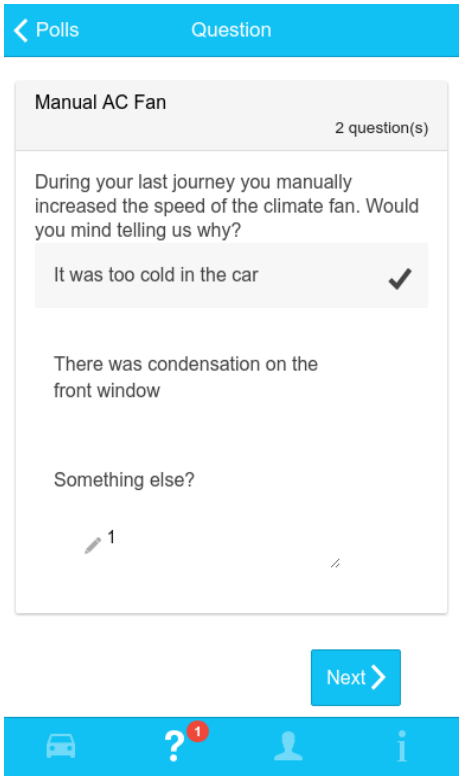
Subjective customer data

Elkit Communications

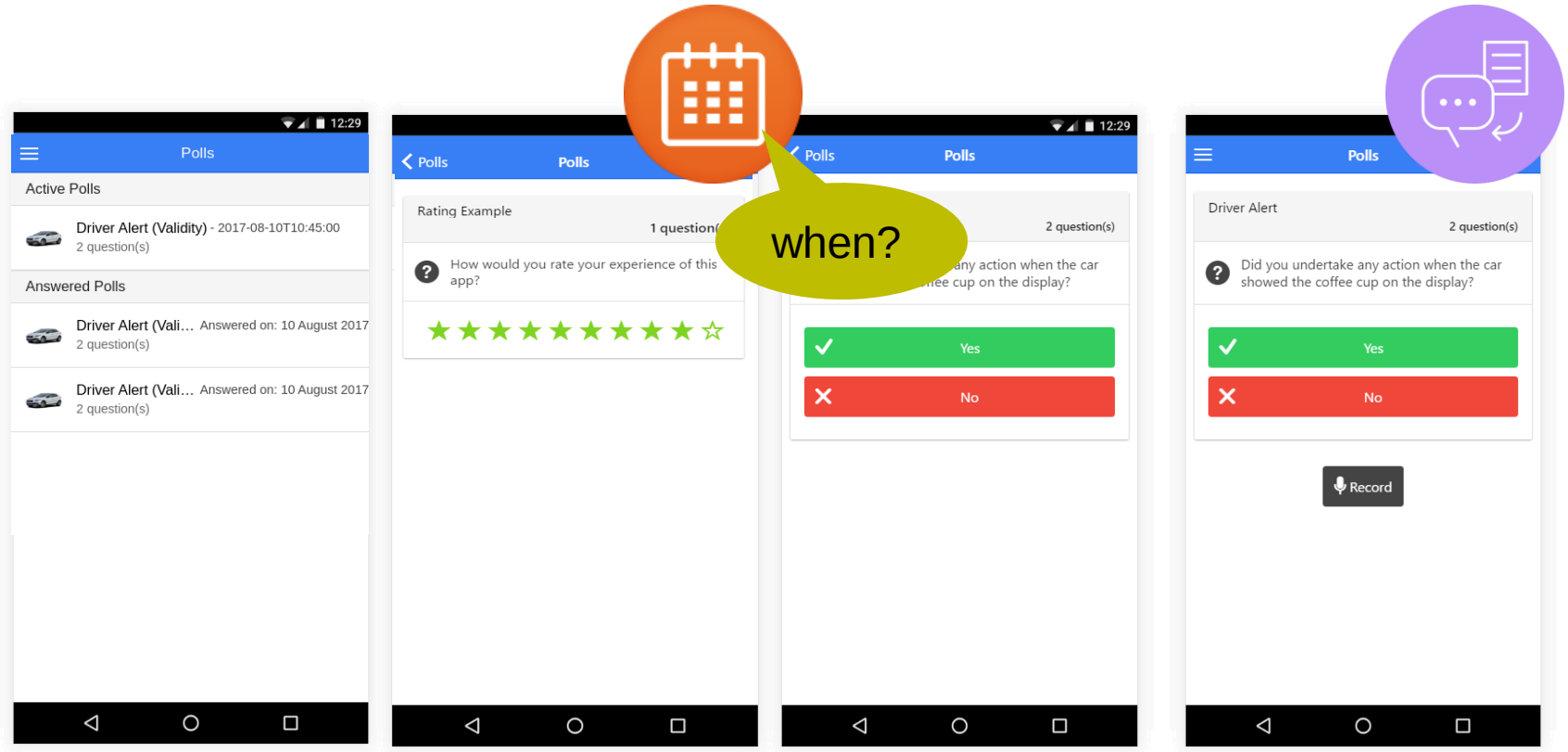
Subjective Data Capture Smartphone App







Subjective Data Capture



- App can capture data using text-to-speech and voice recognition

Concept

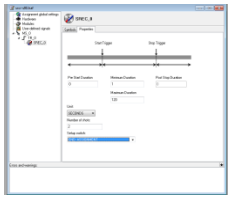
How do customers experience our products?

How are the vehicular subsystems performing?

Product developer

WICE telematics & remote software download

Need for new knowledge identified



Data capture configuration and survey design tools

Design subjective & objective data capture tasks

WICE in-vehicle data logging & telematics

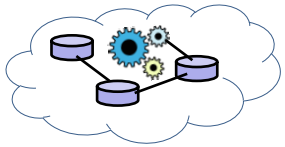
Capture subjective and objective data

Smartphone app

External data sources

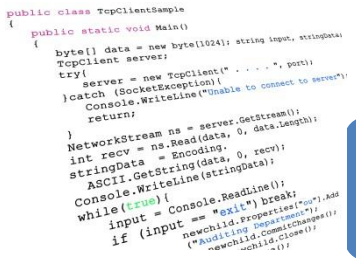
Analyze subjective & objective data

ML training data sets



Cloud-based analytics framework and methodology

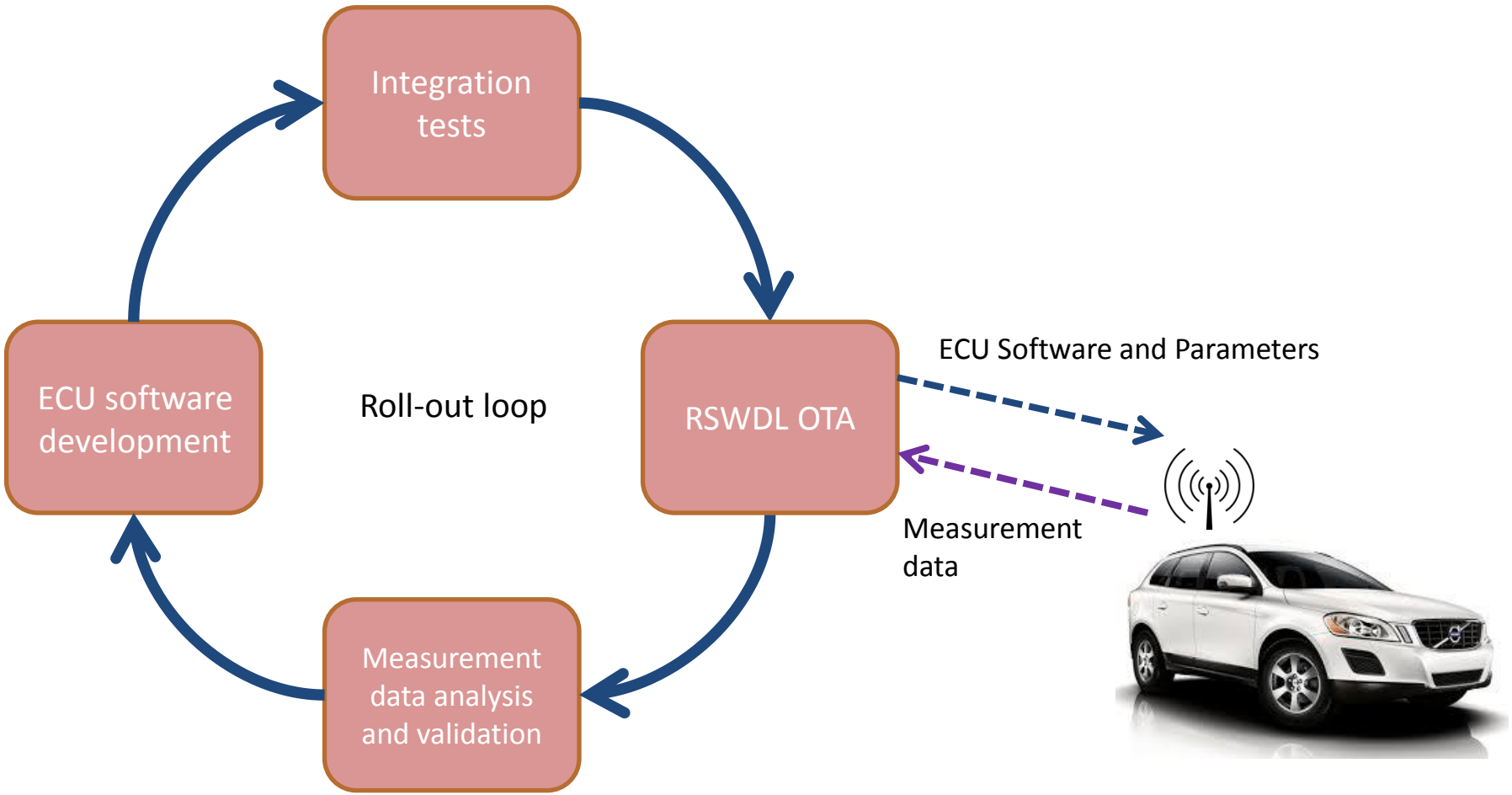
Improve vehicular software based on analyses and ML



Rapid prototyping framework

Continuous deployment (in test vehicle fleets)

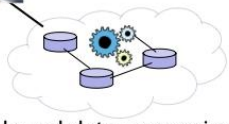
Continuous Deployment OTA



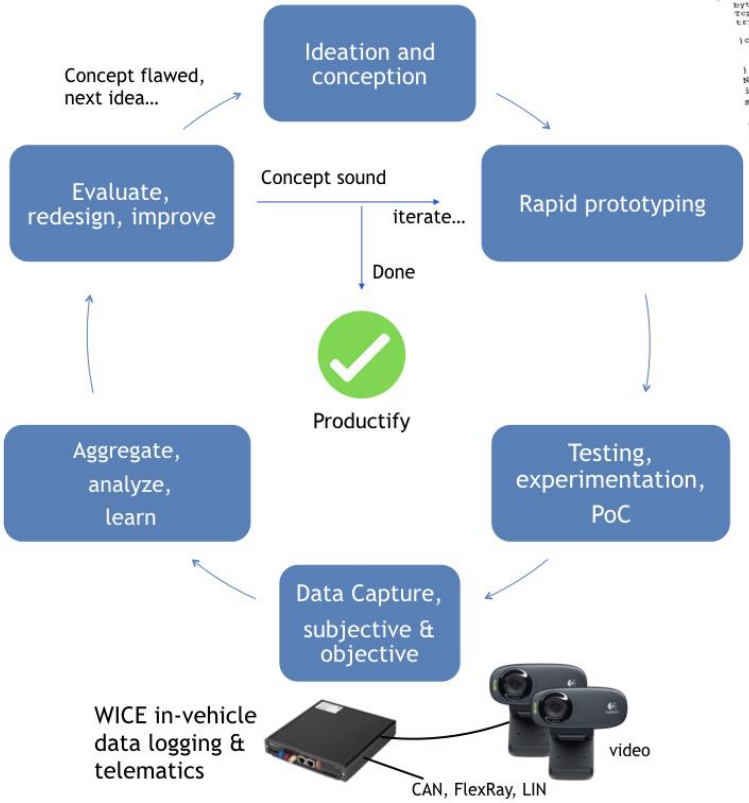
Rapid Prototyping of connected Automotive Services

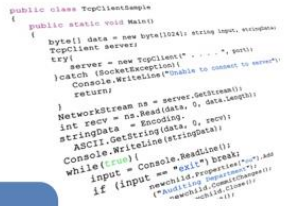
Monitoring, management

ML training data sets



Cloud-based data processing and analytics framework



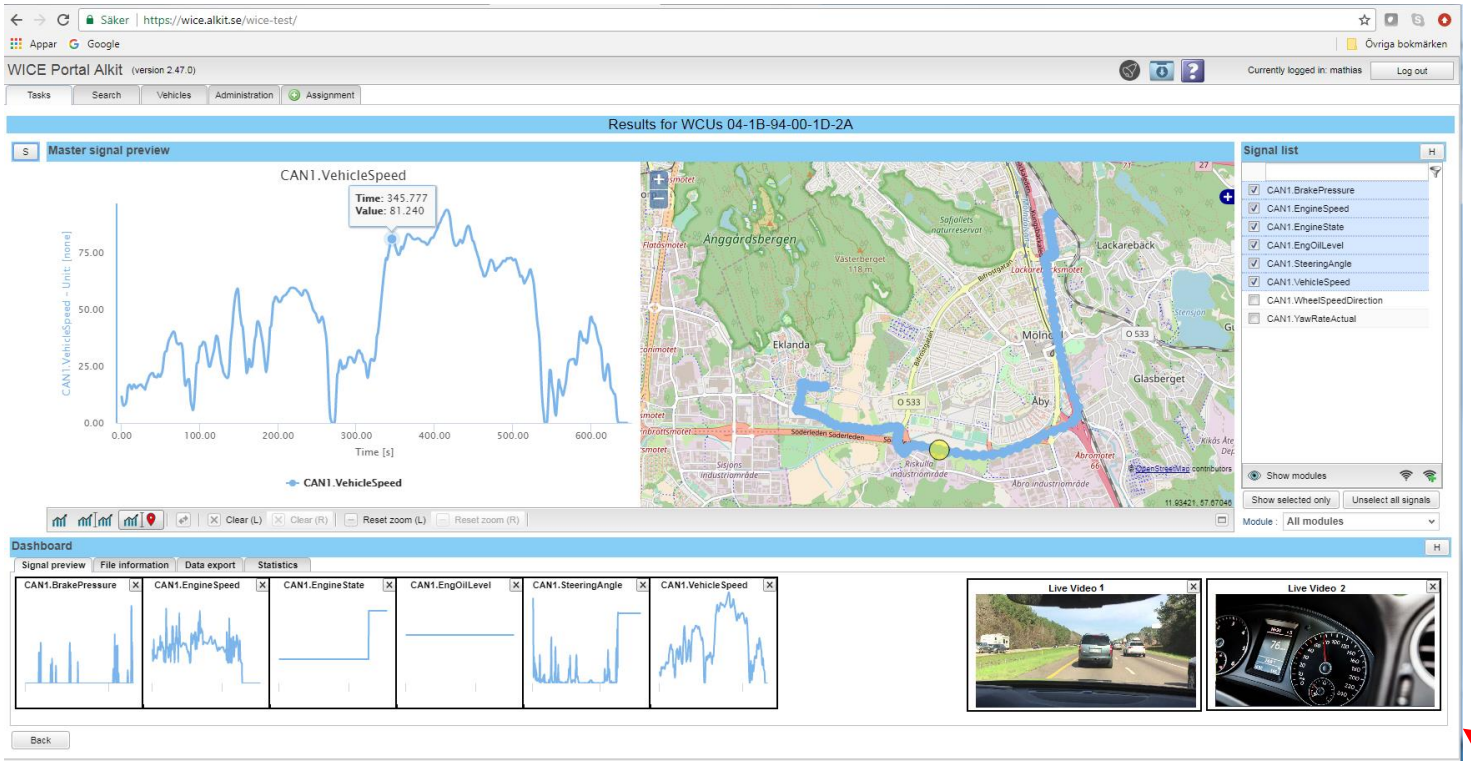


Develop software for new function or service

WICE telematics, RP platform & remote software download

Connected test vehicle fleet

Automotive testing

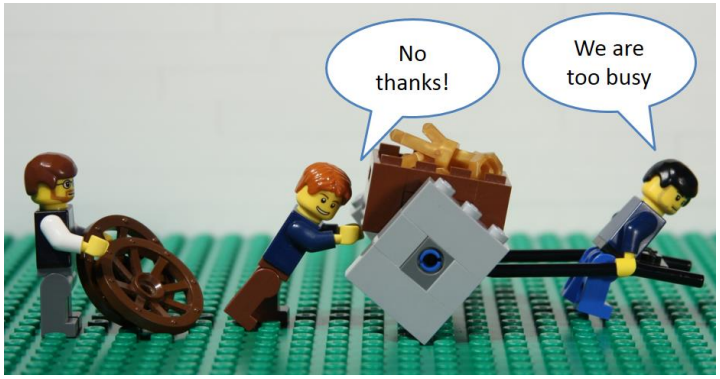


Connected vehicle

Alkit Communications

Take-home message #4

- To stay competitive in the automotive market, product development processes must be both **agile** and **knowledge-based**, promoting **innovation**, while retaining the traditional attention to quality, safety, and economies of scale.



Challenges

- Volume and complexity of data increases
  - How do we design the technological framework supporting capture, analysis and decision-making in a way the is scalable to large numbers of connected vehicles and high data volumes?
- Security and safety
- Privacy preservation
- Product development process affected

Estimated Data Volume

Application	Fleet	Per day	Per year
CAN bus signal monitoring	Customer	560 TB	206 PB
CAN bus signal monitoring	Test	4.5 TB	1.6 PB
Remote Diagnostic Read-Out	Customer	100 GB	36 TB
Remote Diagnostic Read-Out	Test	10 GB	3.6 TB
State-of-Health	Customer	1 GB	365 GB
State-of-Health	Test	100 MB	36 GB
Video / radar / lidar	Test		

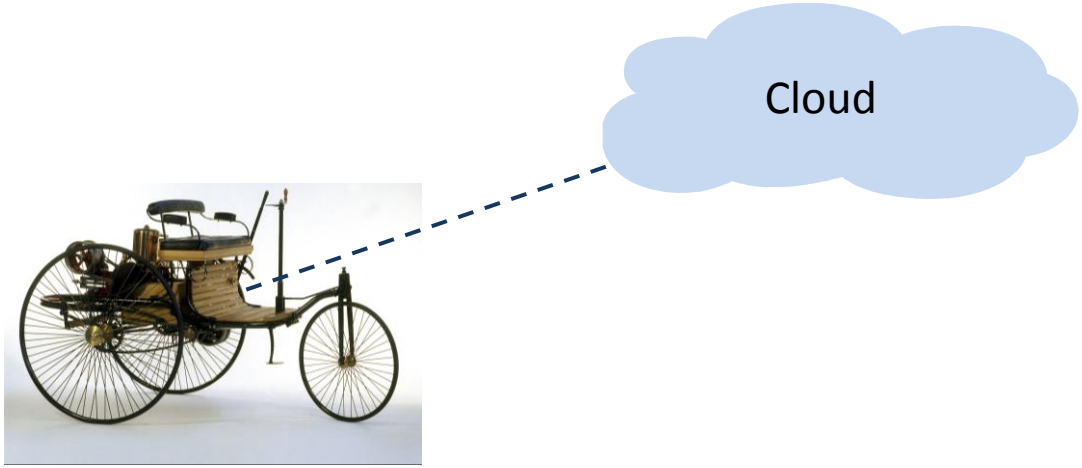
M. Johanson et al. "Big Automotive Data - Leveraging large volumes of data for knowledge-driven product development," IEEE International Conference on Big Data, Washington DC, October 27-30, 2014.

Take-home message #5

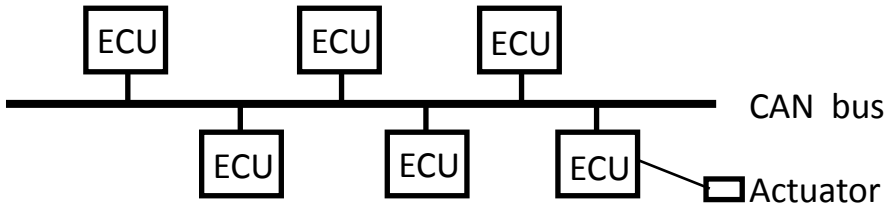
- Automotive data processing systems must be scalable to large volumes of data.

Security & Safety

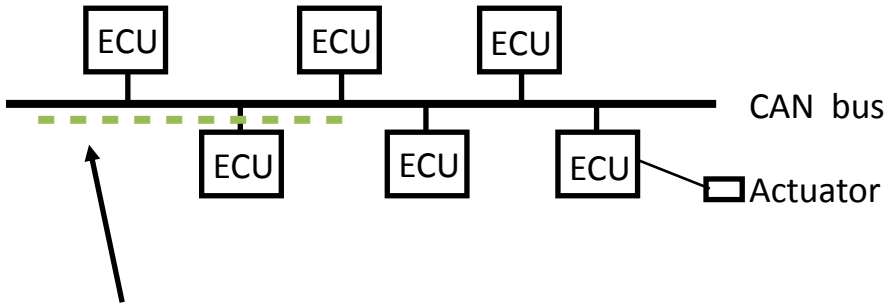
- Safety has always been a major concern in automotive engineering
- Vehicles were not originally designed to be connected



Traditional Electrical Vehicle Architecure

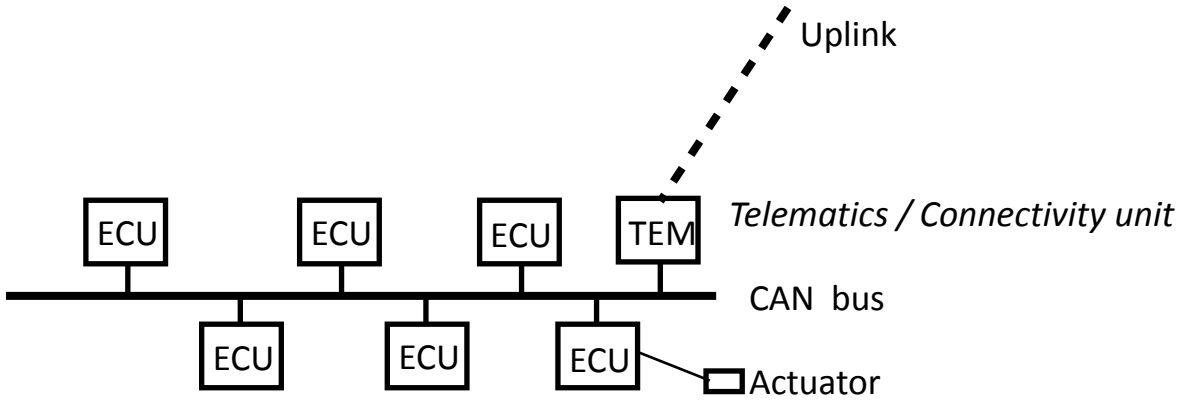


Traditional Electrical Vehicle Architecure

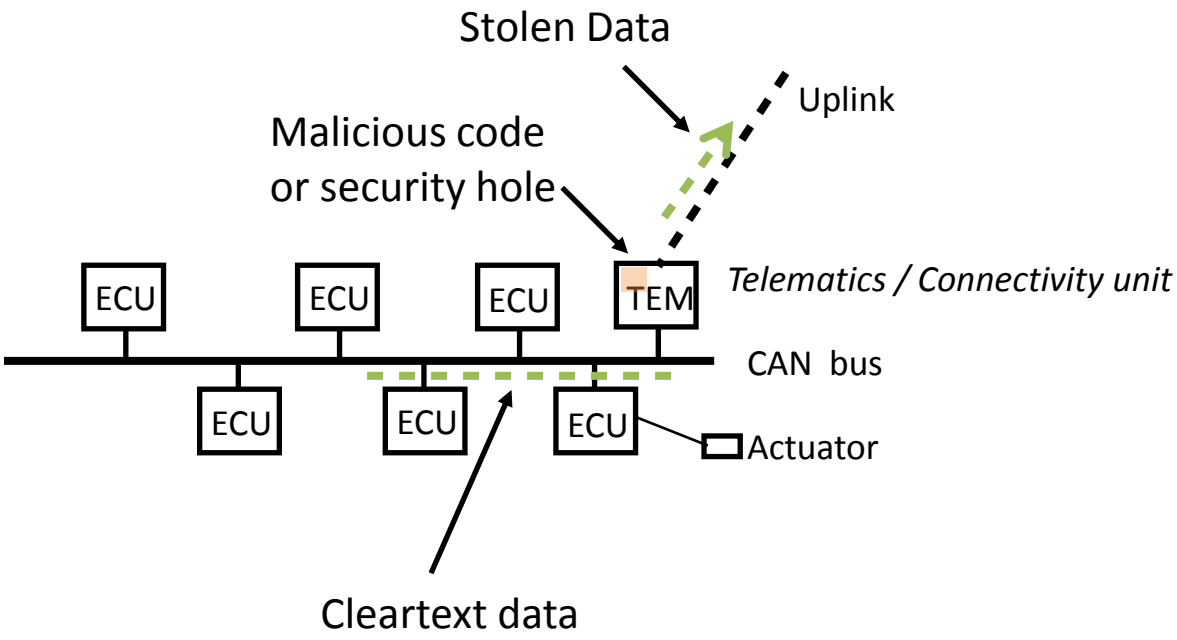


Data is broadcast in cleartext on the communication bus

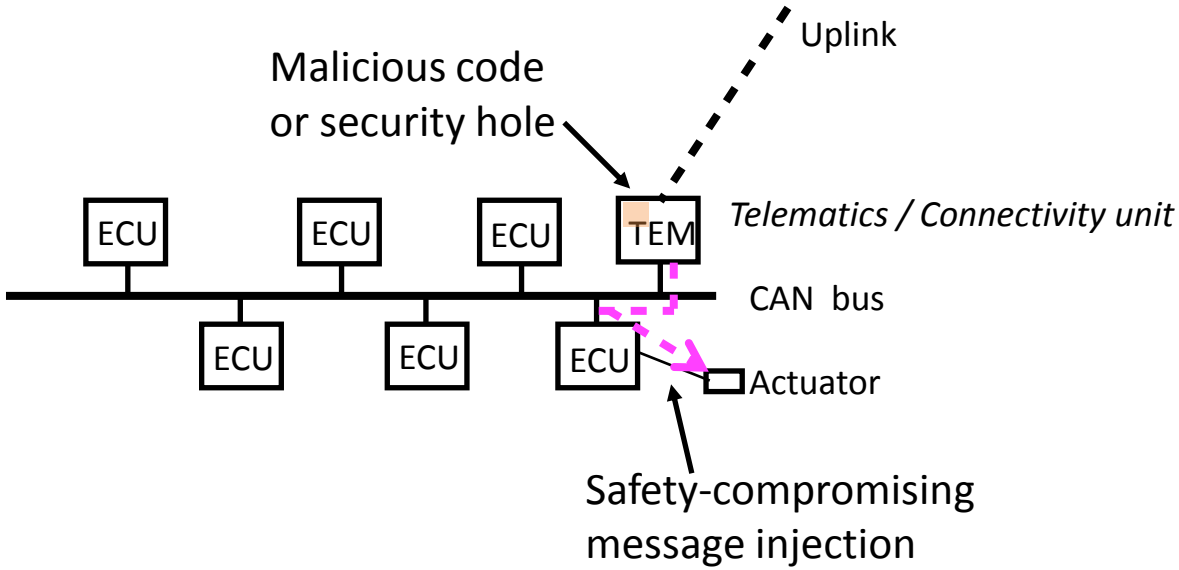
Traditional Electrical Vehicle Architecure with Connectivity



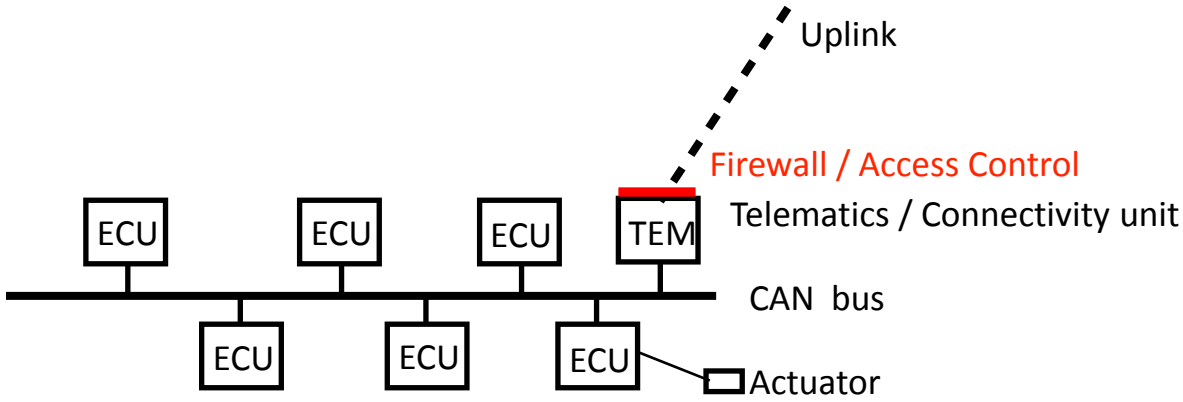
Security problem!



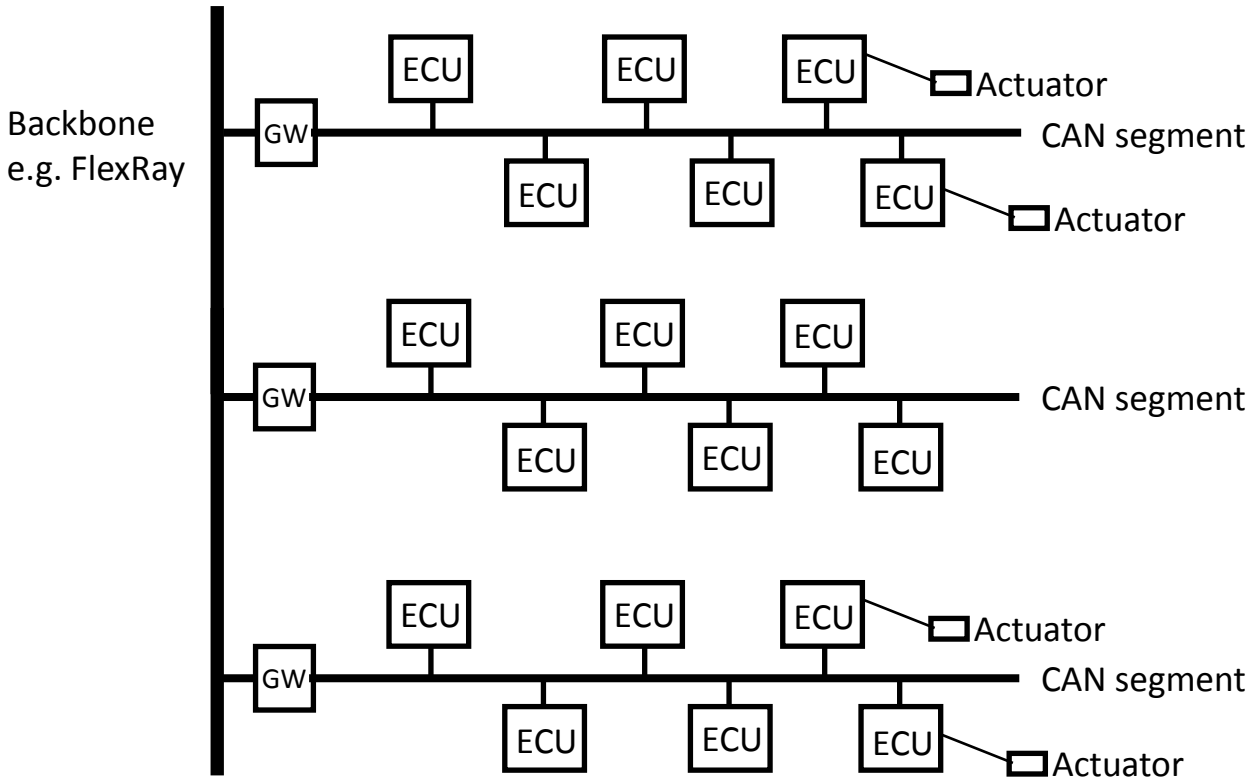
Safety problem!



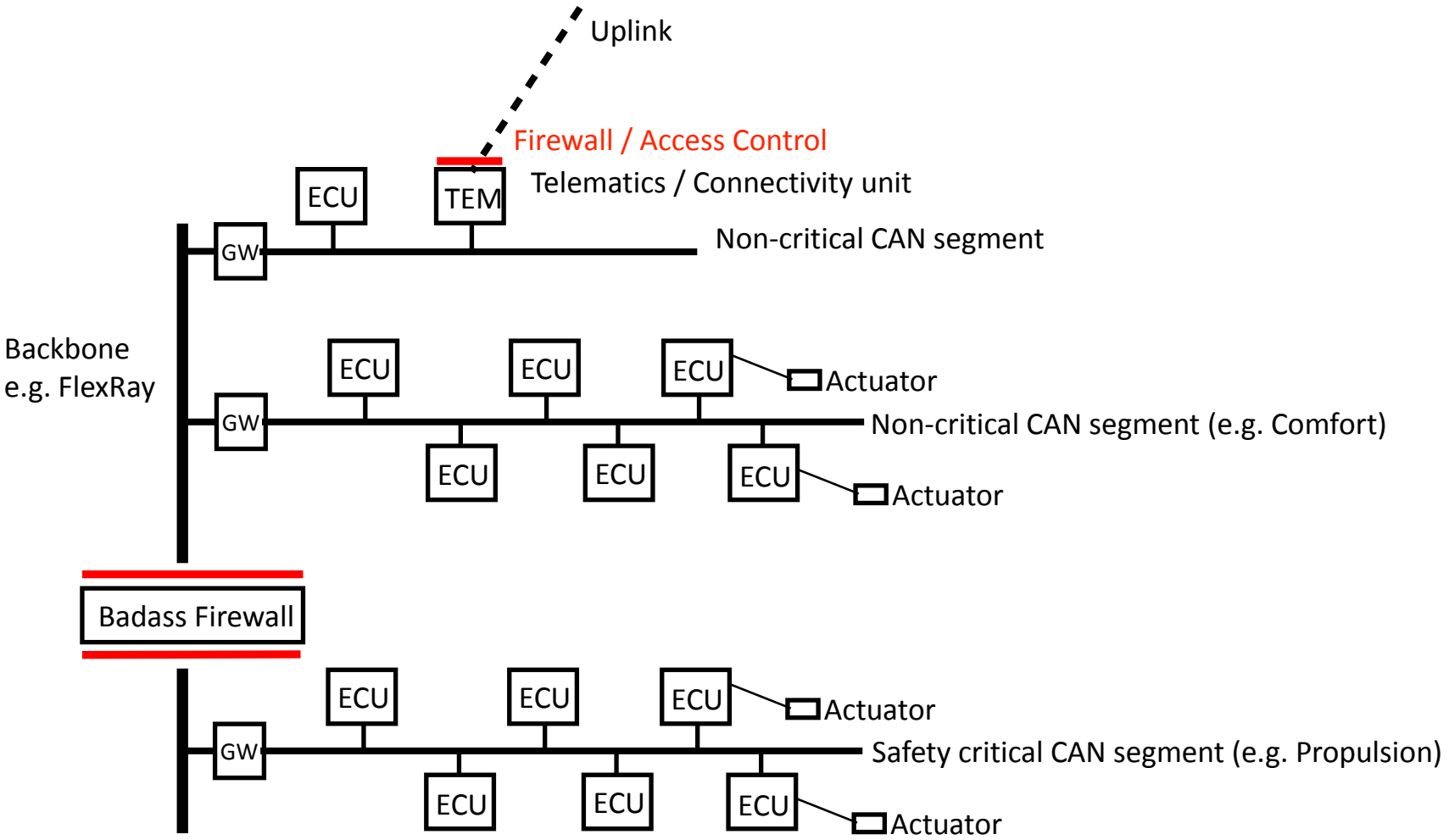
(Simplistic) Countermeasure



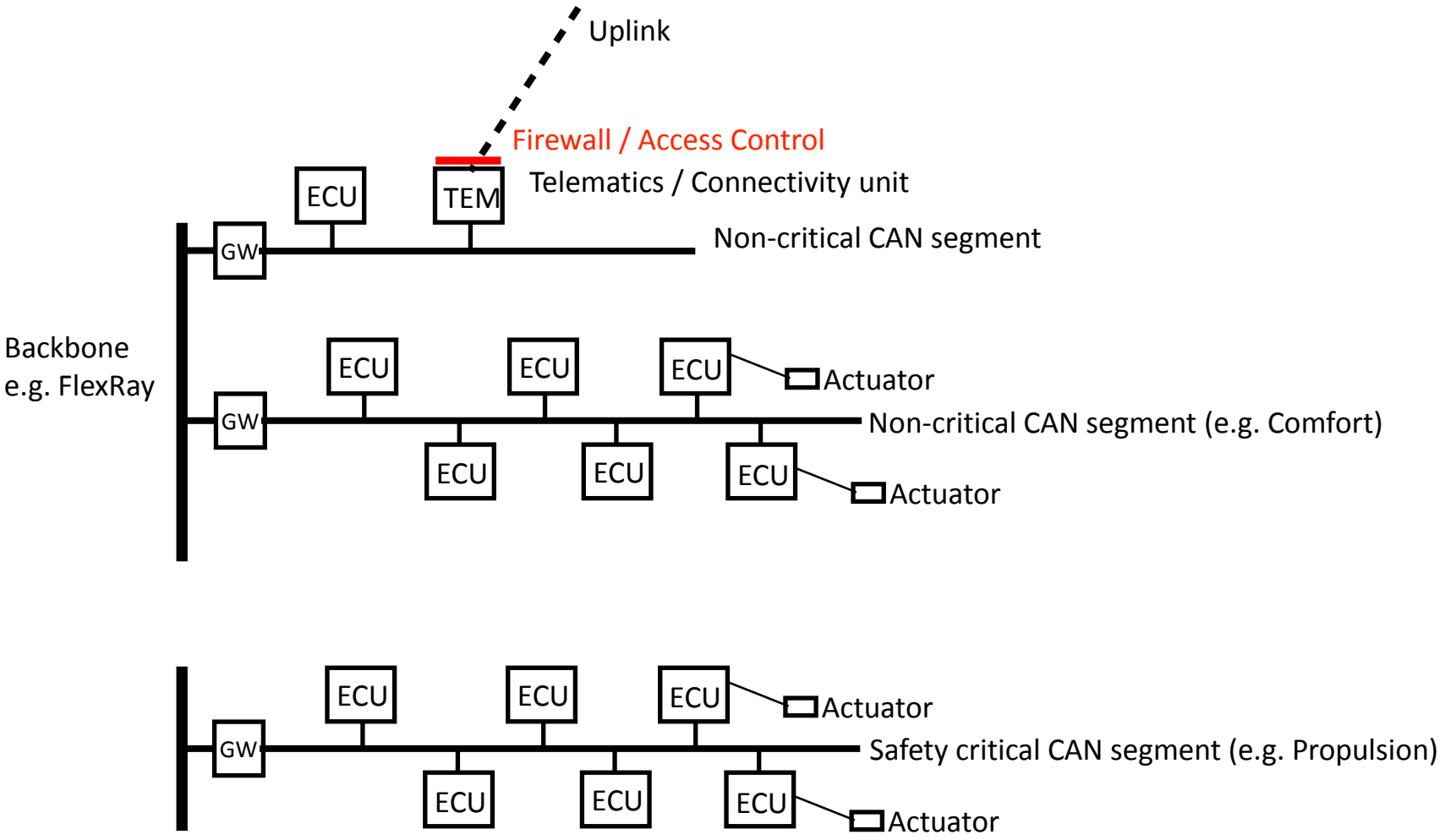
Traditional Electrical Vehicle Architecure (slightly more advanced)



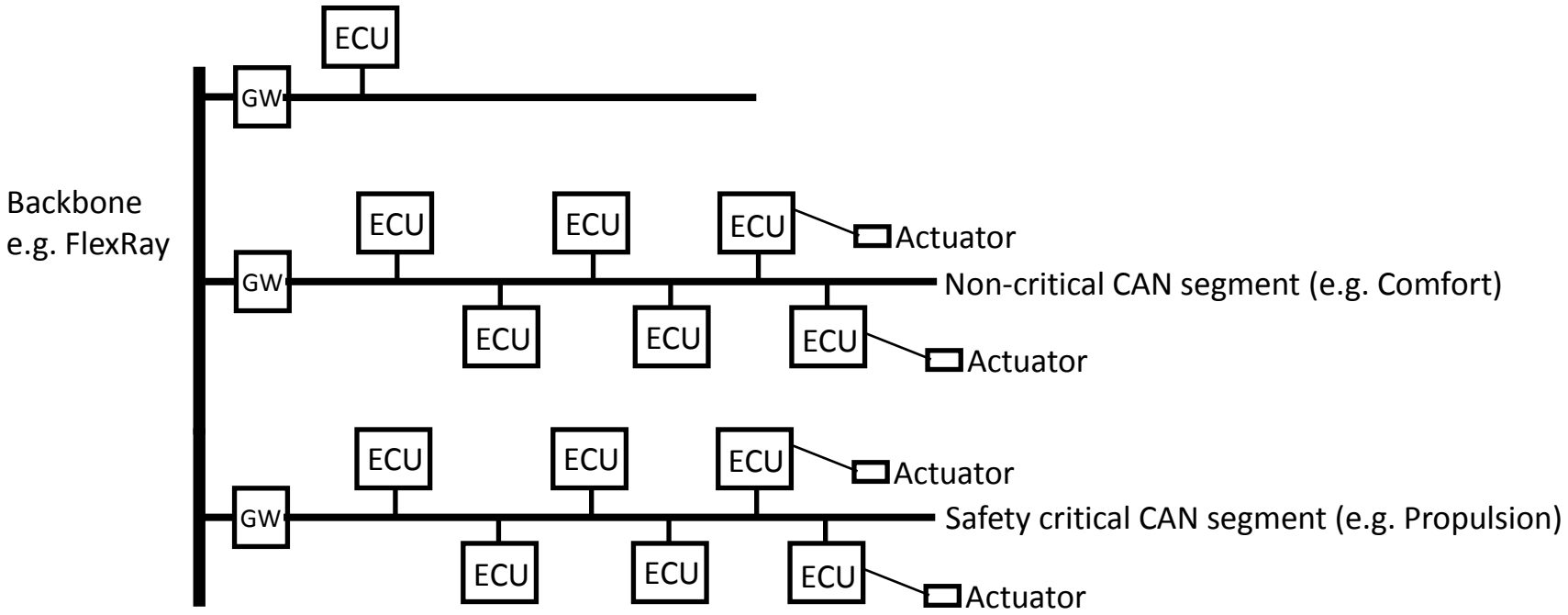
Security / Safety by isolation



Security / Safety by even more isolation



Security / Safety by isolation (back to square one)



Next generation protections

- Security by design
- Safety by Isolation
- Encryption of in-vehicle data communication
- Intrusion detection systems
- Secure operating systems

Take home message #6

- Balance between security measures and agile development / innovation / competitiveness

Privacy

- When collecting large volumes of data from vehicles, users' privacy must be respected
- Incentives are needed for contributing user experience data
- Anonymisation and Pseudonomisation techniques are inherently problematic
- One approach is to use *Differential Privacy*
  - Noise is added to captured data in a controlled way, so that it cancels out at analysis stage

B. Nelson, "Data Privacy for Big Automotive Data", Licentiate Thesis, Chalmers University of Technology, 2017.

Summary and Conclusions

- After a 100 years, there is again serious innovation in the automotive industry
  - It is happening now. Let's not screw it up!
- Cars are turning into computers on wheels
  - Innovation happens in software development. Focus must be on that.
  - Connectivity leads to Big Data
- The sky is the limit for connected automotive services
  - Many new applications and huge benefits
- Competitiveness requires agile development
  - Connectivity & Big Data keys both for new services and agile development
  - Technology platforms must be designed for scalability and flexibility
- Balance between security measures and agile development
  - Security & safety by design
- Privacy mechanisms needed
  - Anonymisation / pseudonimisation often not good enough
- Many unexplored opportunities for cross-sectoral synergies (e.g. between automotive sector and life sciences)

Thank you!