



Beyond 4G: 5G and G5 !!!

Maurice Geraets

NXP Semiconductors



NXP – a global innovator

Established in 2006

(formerly a division of Royal Philips)

Net sales: \$4.8 billion in 2013, >60% in Asia

Employee base:

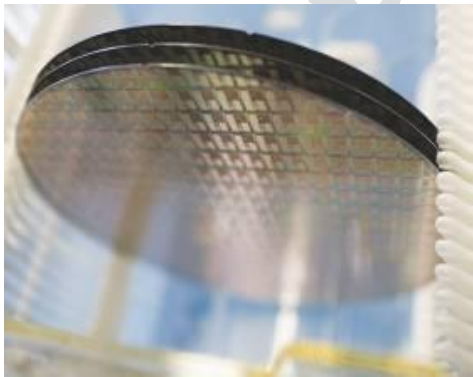
~ 25,000 employees in more than 25 countries

Manufacturing in Europe and Asia

Strong Innovation Pipeline:

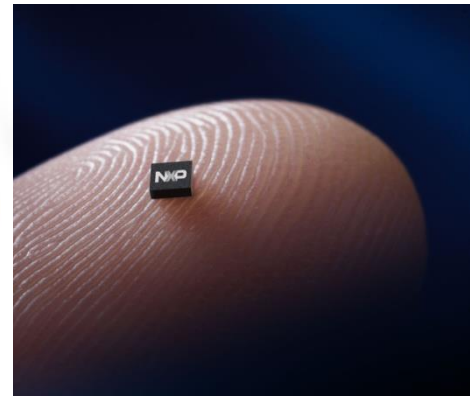
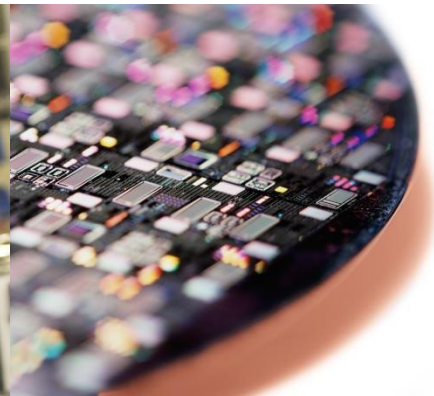
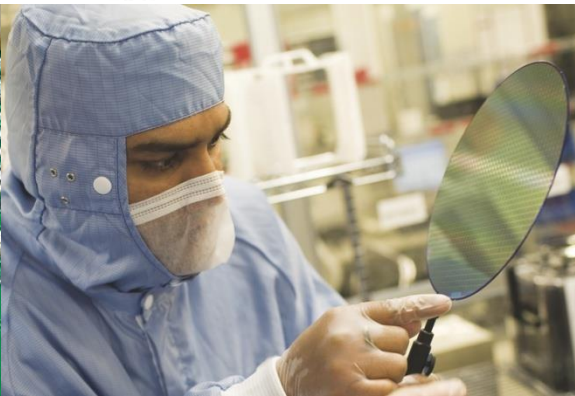
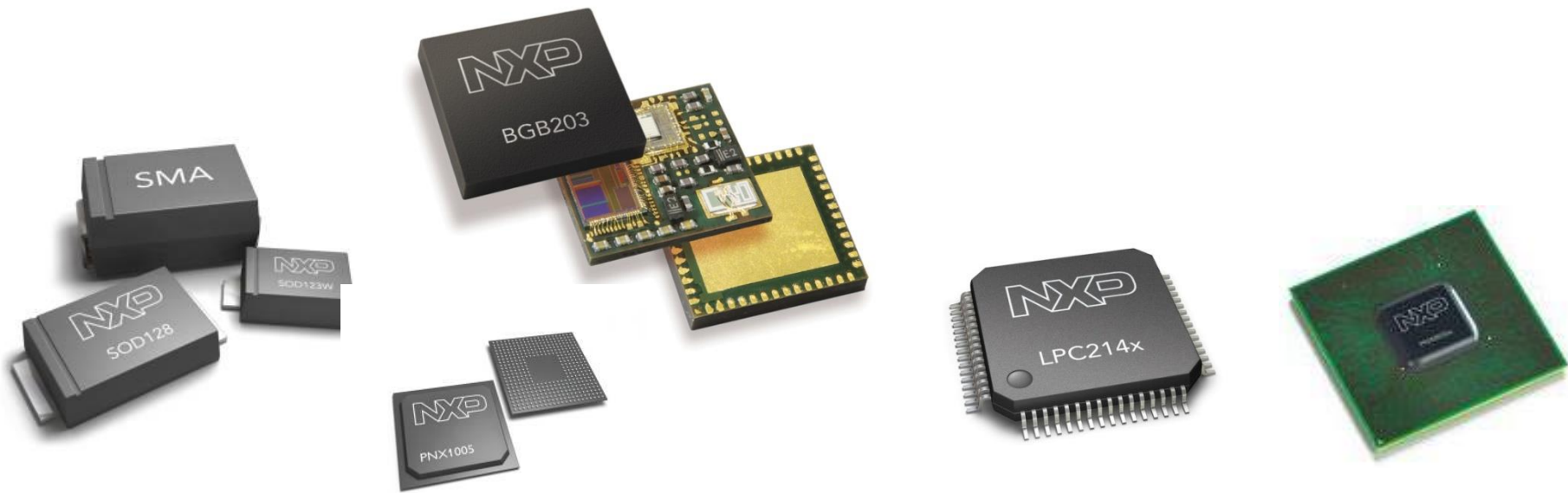
- R&D in Europe, US and Asia
- Over \$550M / year in R&D
- 3,200 engineers
- 11,000 patents

Global #1 Semiconductor Player in Security and Automotive Connectivity



SECURE CONNECTIONS
FOR A SMARTER WORLD

**We produce > 70.000.000.000 chips per year
> 10.000 different products**



NXP Semiconductors in The Netherlands

▶ Eindhoven:

- Headquarters
- Research & Development



▶ Nijmegen:

- Advanced Manufacturing
- Research & Development
- Novio Tech Campus



NXP Semiconductors: 6th Private R&D Investor

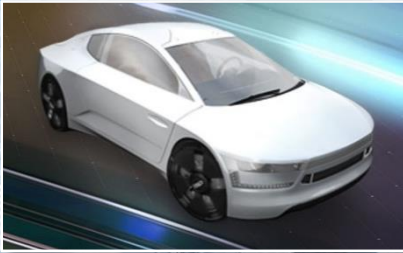
Top 30 Bedrijfs-R&D 2014

	Uitgaven (miljoen euro)					Wereldwijd		Personeel in Nederland (fte)				Octrooien
	2013	2012	2011	2010	2009	2013	2013	2012	2011	2010	2009	2013
1 ASML, Veldhoven	775	619	576	496	426	968	4275	3747	3284	3070	2200	120
2 Philips, Eindhoven	728	744	698	627	707	1733	3947	3943	4194	4075	4269	4014
3 KPN	443*	448*	120	140	120	443	1638	1225	1225	1461	1474	47
4 Shell, Amsterdam/Rijswijk	302**	314**	398**	356**		955						244
5 Royal DSM, Geleen/Delft e.a.	249	242	237	222	221	515	1423	1481	1571	1486	1460	514
6 NXP Semiconductors, Eindhoven/Nijmegen	185*	189*	193	207	238	480	1370	1260	1360	1350	1400	616
7 Crucell, Leiden	176	181	100	68	48	208	498	451	403	301	244	209
8 Océ-Technologies, Venlo	132	144	149	152	153	181	790	810	811	801	826	166
9 Unilever, Vlaardingen	129**	150**	137**	165**	149	1000	819	925	905	1120	1180	
10 DAF Trucks, Eindhoven	129	140	143	118		129	900	881	805	667		

Source: Technisch Weekblad, editie 15-2014

Secure Connections for a Smarter World

Connected Car



Cyber Security



Portable & Wearable



Internet of Things



Four Mega Trends are shaping our Society ...
and drive the Electronics Industry

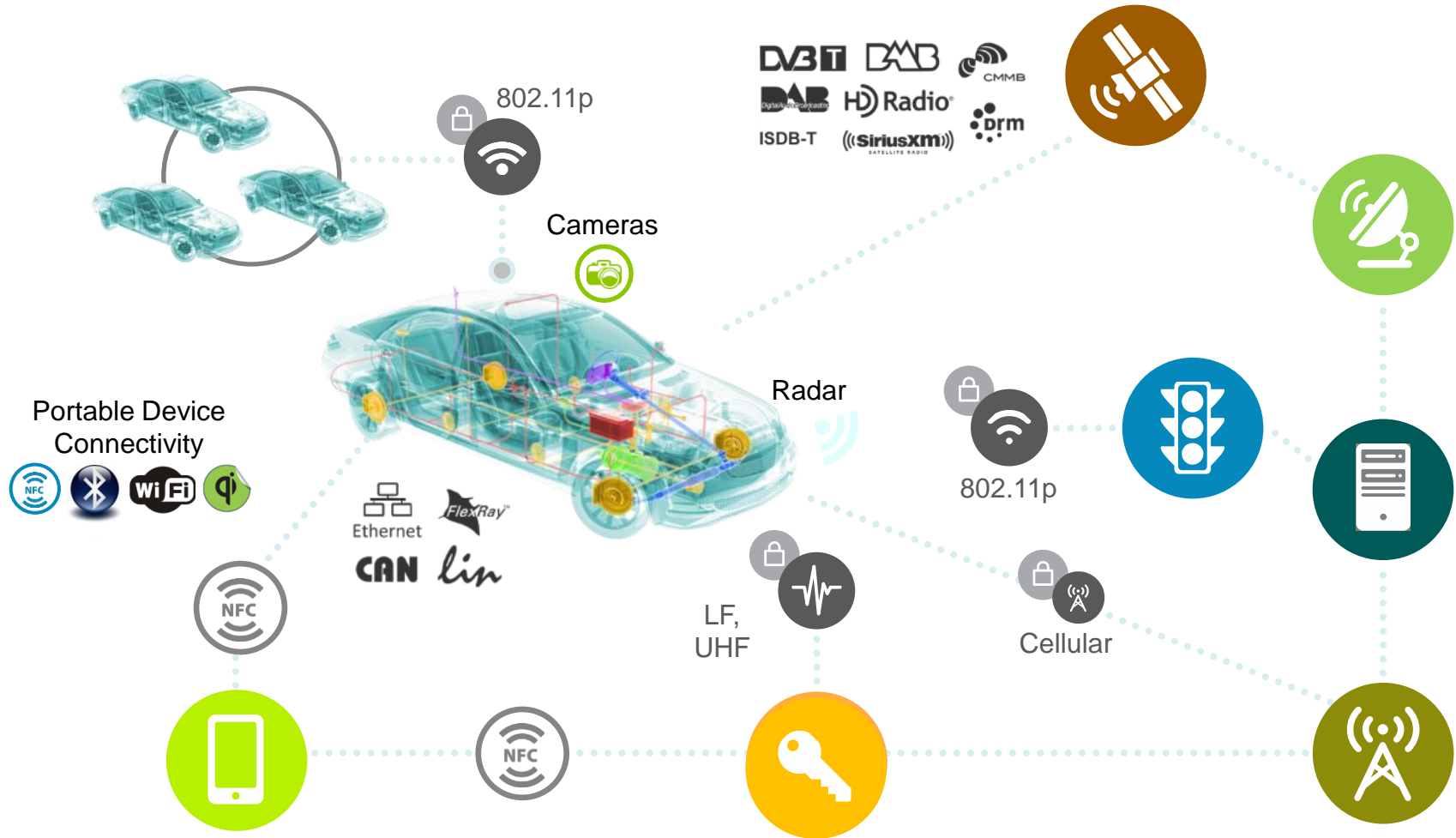
Energy Efficiency, Connected Devices, Security, Health



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FOR A SMARTER WORLD

NXP Connects the Car

... communication between cars, people, infrastructure



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3 Mega trends drive Auto market

SEAMLESS CONSUMER ELECTRONICS EXPERIENCE



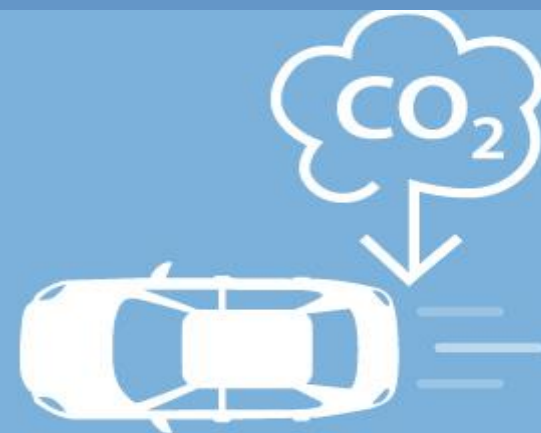
In the US people spend one hour per day in the car

ADVANCED DRIVER ASSISTANCE → SELF-DRIVING



Every year 1,3 million people die of car accidents

ENERGY EFFICIENCY



EU mandates CO₂ reduction of 20% by 2020

Imagine you TRUST your car so much, you will sit backwards to ENJOY entertainment @80mph

SEAMLESS CONSUMER ELECTRONICS EXPERIENCE

Passengers choose how to best use travel time (i.e., work, entertainment)



ENJOY

Connectivity couples
CE & Auto cycles

ADVANCED DRIVER ASSISTANCE → SELF-DRIVING

The car takes care of the driving



TRUST

Massive growth



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ADAS towards Self-driving

The race towards fully automated cars in '20-'25

Evolution (Conti → #1 Auto T1 player)

Revolution (Google → #1 Internet)



Evolution from **Active Safety** to **Advanced Driver Assistance Systems** to **Highly Automated by 2020** and **Fully Automated Cars by 2025**

Developing **Fully Automated** cars from the start, targeting 2020 introduction

ADAS is getting momentum in the news and stock market





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Cars need to sense, think and act better than humans can

Sense

Driver Monitoring

Environment & Vehicle Sensing

Connectivity Including Backend (BE)

IBM CISCO

Think

Modeling

Driver Model

Vehicle Model

Environment Model

HAD Functions (Command Generation)

Congested Traffic

Parking

City

Highway

Act

HMI Close the Loop

BE

Backend Services

IBM CISCO

Action Motion Control

Actuators

Brakes

Engine

Gearbox

New entrants eyeing to earn revenue from big data (self driving cars generate up to 1GB per minute) and offering value add services (e.g., Pay As You Drive)

Autonomous Driving enabled by complementary systems: C2X + Radar + Camera



C2X

- Fast communication & cooperation (platoon)
- No vision necessary - Look around corners
- Long range – up to 2km
- 360° view

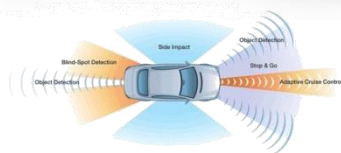


Like Elephants in a platoon



Camera

- Visionary identification of objects (e.g. people, cars, buildings etc.)
- Safety warnings
- Autarkic



Radar

- Object detection to adjust speed/steering to situation
- Vision to objects needed
- Autarkic

Car2X – saving lives, increase convenience



- ▶ **Superior** & complementary to Radar & Camera
 - “Seeing around corners” beyond line of sight
 - 360° bi-directional communication
 - Long-range distance (up to ~1-2km)
 - Reliable – not sensitive to weather etc.
- ▶ Ad-hoc network **complementary** to Cellular
 - No network latency & infrastructure!
- ▶ US Legislation for **crash avoidance & safety**

Significant potential
beyond Safety

▶ **Car-2-Infrastructure:**

- wide range of services
- can reduce public sector cost

Traffic management /
„green wave“



Unique Car-2-Car use-cases

Emergency Electronic Brake Warning



Do Not Pass Warning



Left Turn / Intersection Assist



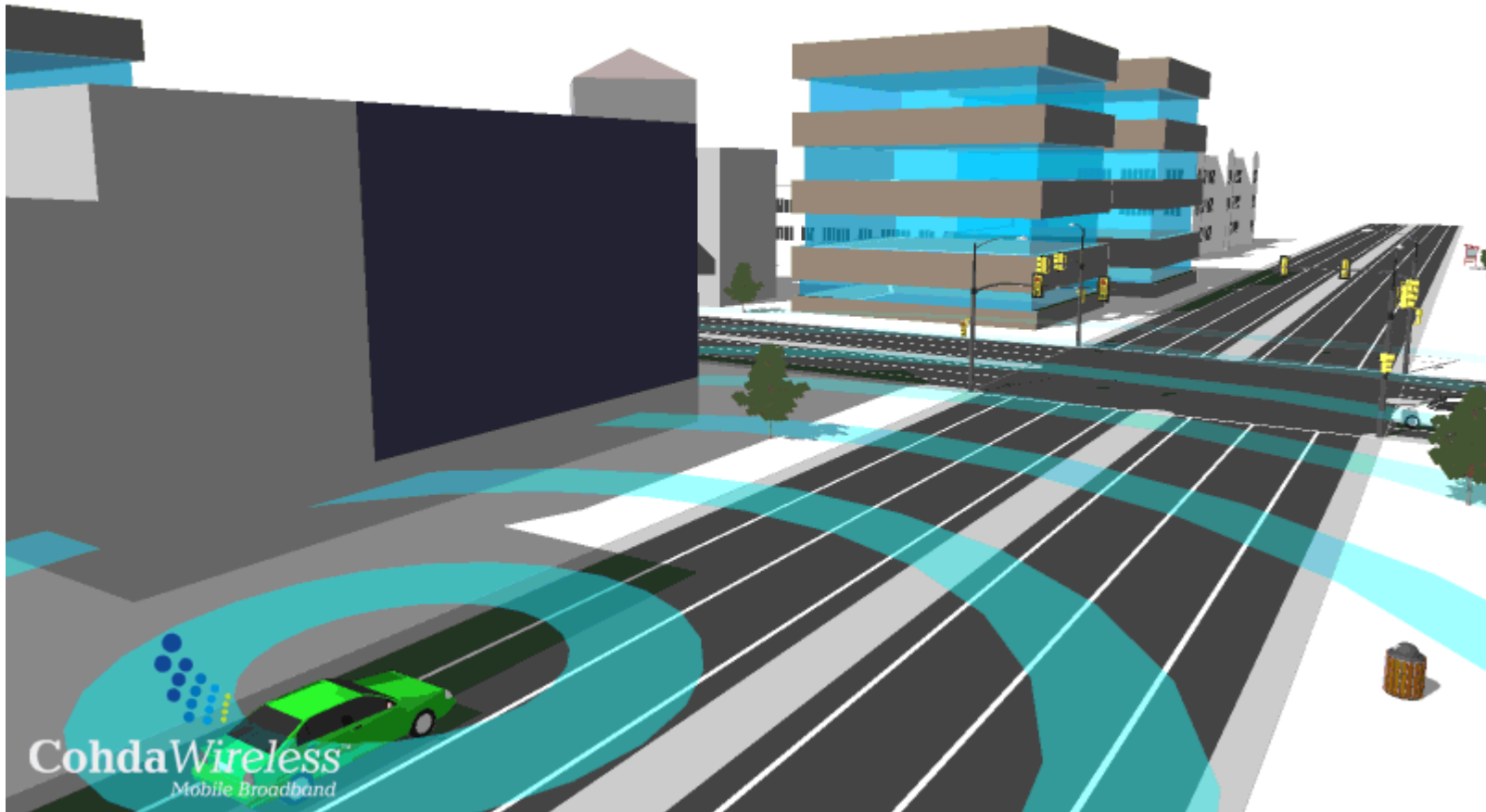
Hazardous location



Emergency vehicle



C2X – Seeing around corners

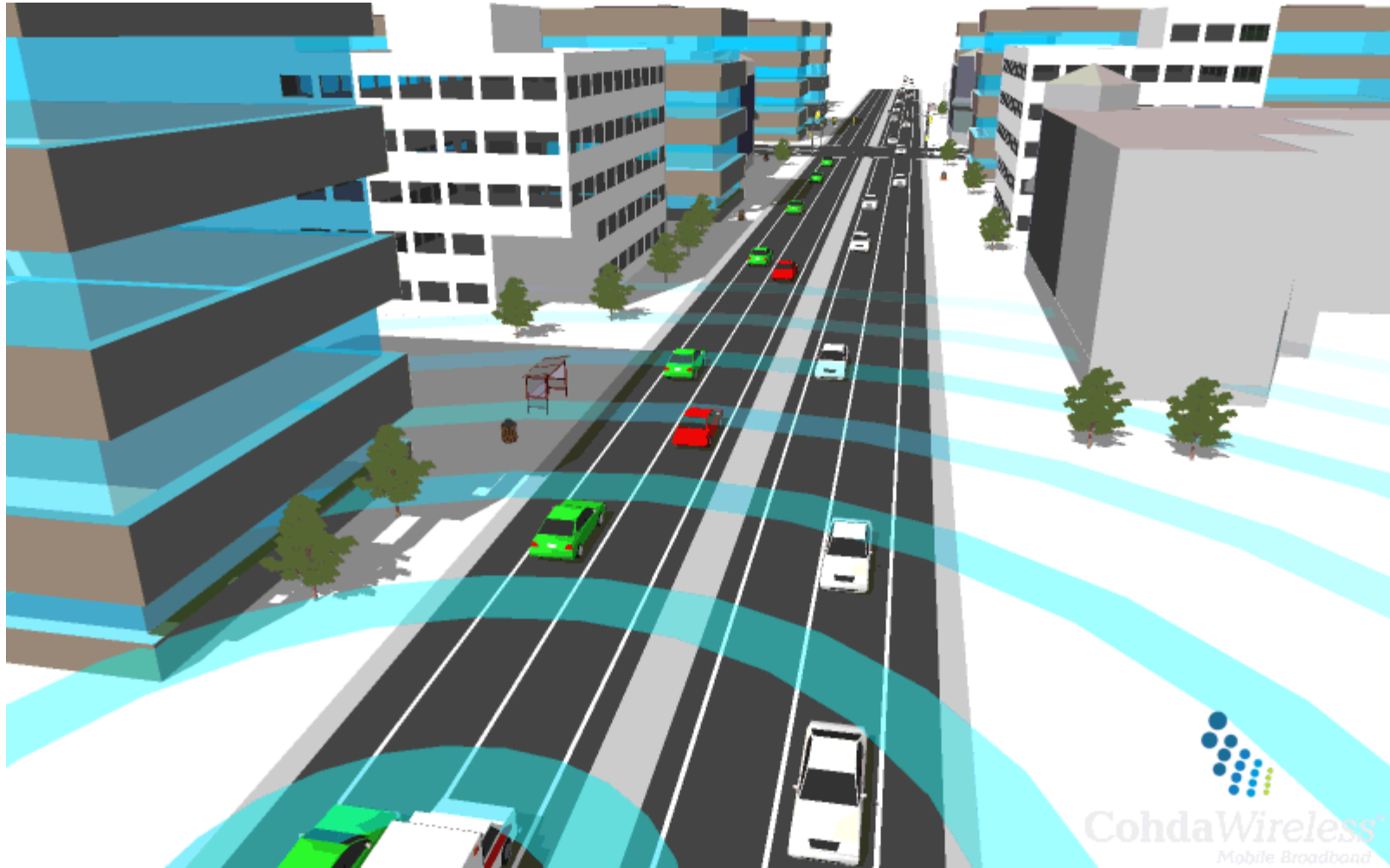


Courtesy of Cohda Wireless



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C2X – Emergency vehicle warning



Courtesy of Cohda Wireless



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C2X – Hazard warning



Courtesy of Cohda Wireless



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ITS C2X safety applications



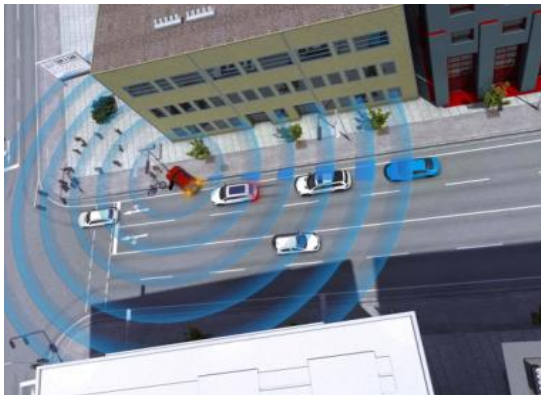
Emergency Vehicle



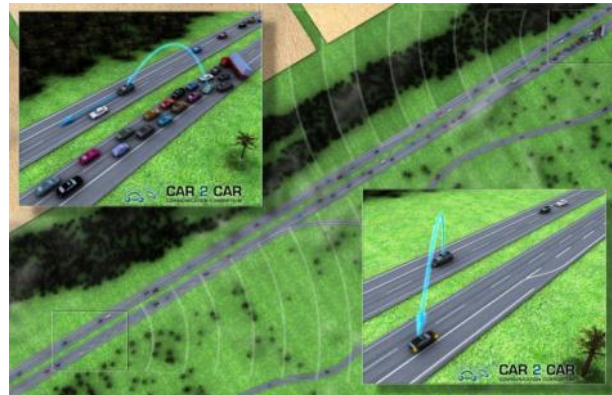
Green Light Optimal Speed Advisory



Hazardous Location Warning



Warning Lights on



Avoidance of traffic jams



Local Road Works Warning

C2X valued in 1.65 Mio km of driving

Question: what function would you like to have in your car?

- ▶ 500 participants joined
 - 41000 hours of testing
 - 1650000 KMs of driving
 - 30 Terabyte of data
- ▶ Highest-rated functions:
 - traffic jam end warning
 - Signal phase and time of traffic light
 - Emergency Brake light
 -

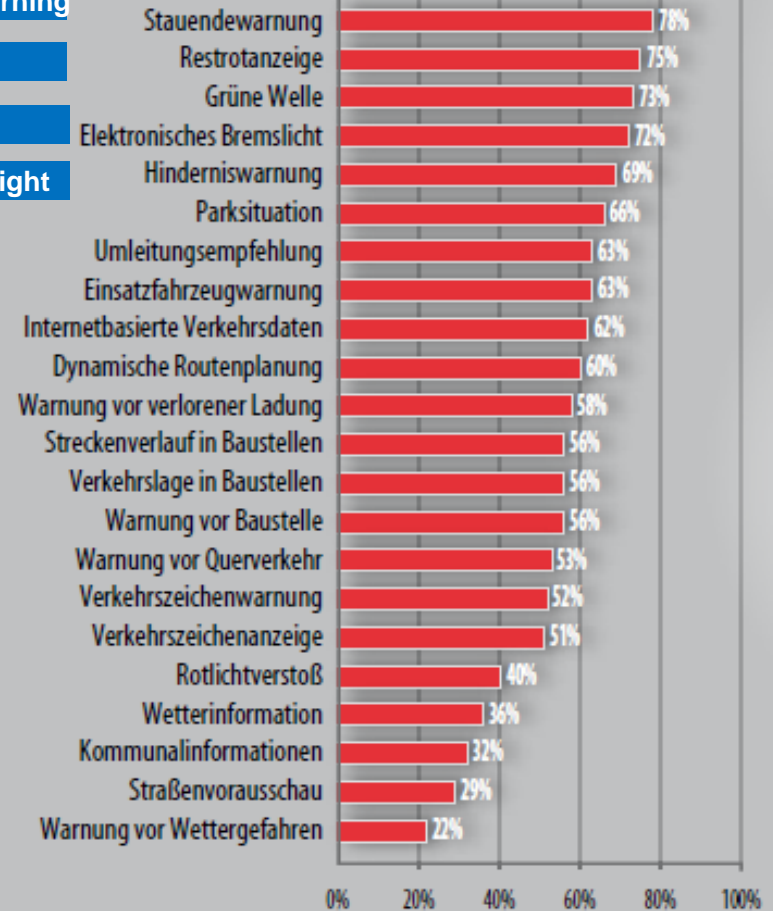


Traffic Jam Ahead warning

Time-to-Green

Green-wave

Emergency Brake Light



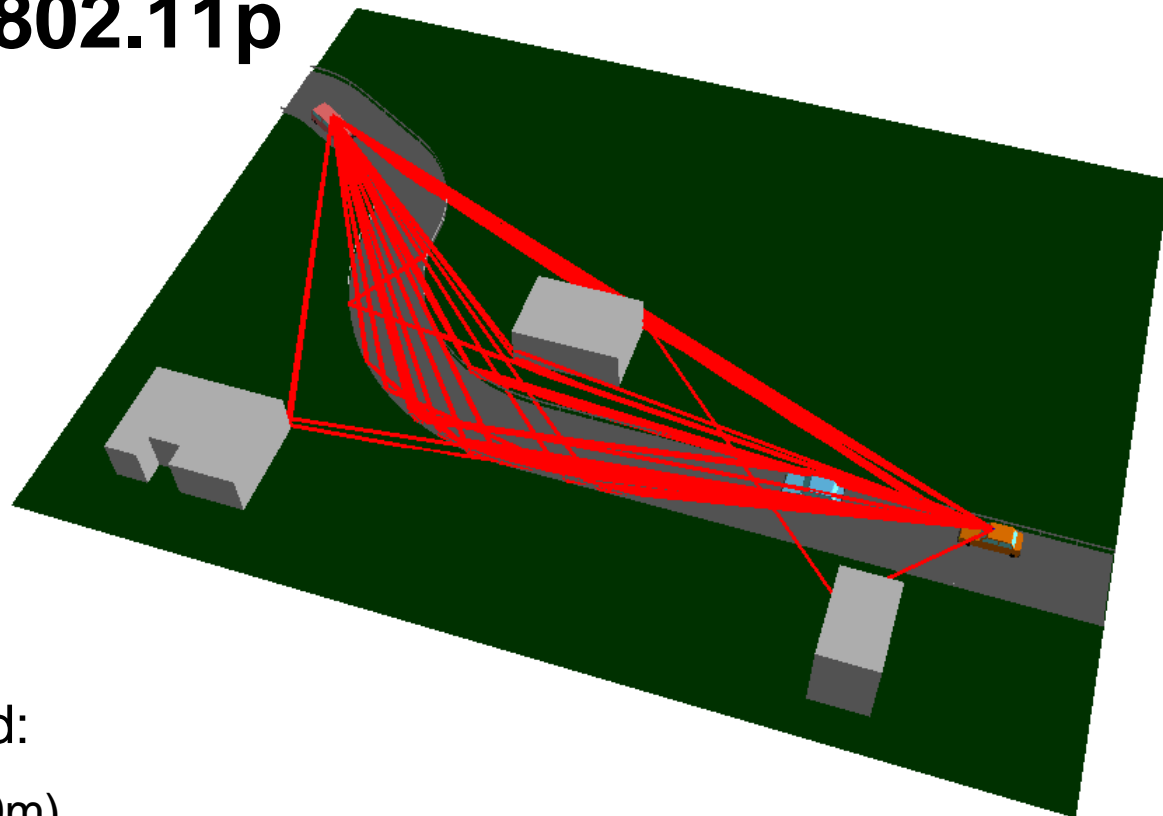
ADAS & HAD depend on Connected Car technology

User benefit	System solution	Connectivity
Full 360° Environment Perception	Sea-of-Sensors; updated Machine Learning and Object Detection	Cellular
Safe & Comfortable “Look Ahead” Environment Perception & Actuation	Extend Horizon Sea-of-Sensors through Virtual Sensors	802.11p
Travel strategy	Cloud / Local Services (traffic, weather, green wave, parking, multi-modal)	Cellular, 802.11p, DVB-T, DMB, HD Radio, ISDB-T, SiriusXM, CMMB, DRM
Automated Navigation	Up-to-date Maps Lane-Level Positioning	Cellular, DVB-T, DMB, HD Radio, ISDB-T, SiriusXM, CMMB, DRM
Make Driving Time Most Valuable Time Favorite Apps & Info on your HMI (HUD)	Portable Device Integration	Cellular, NEC, Bluetooth, WiFi, Qi



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Car2x: G5 / IEEE802.11p

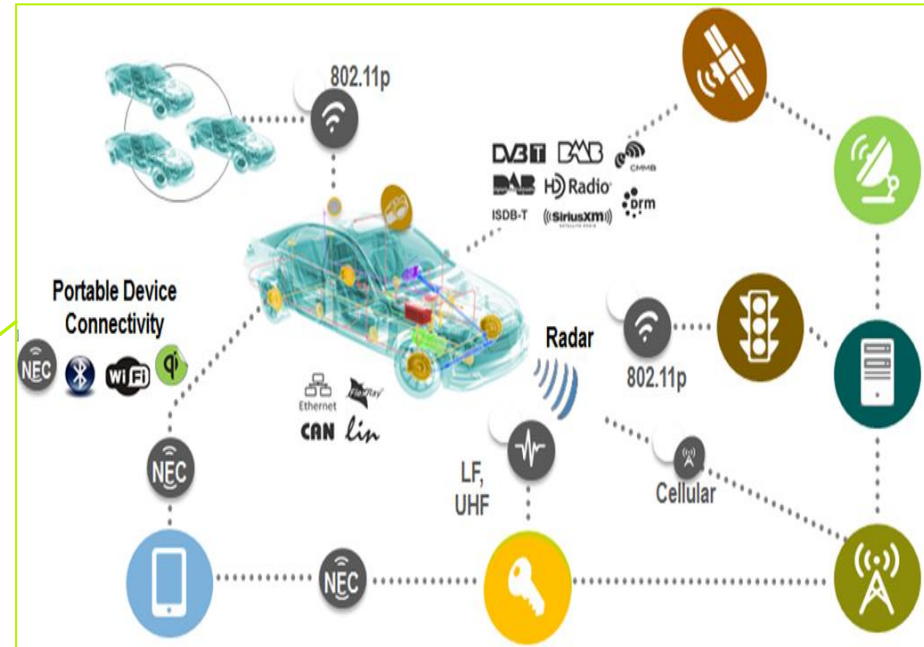
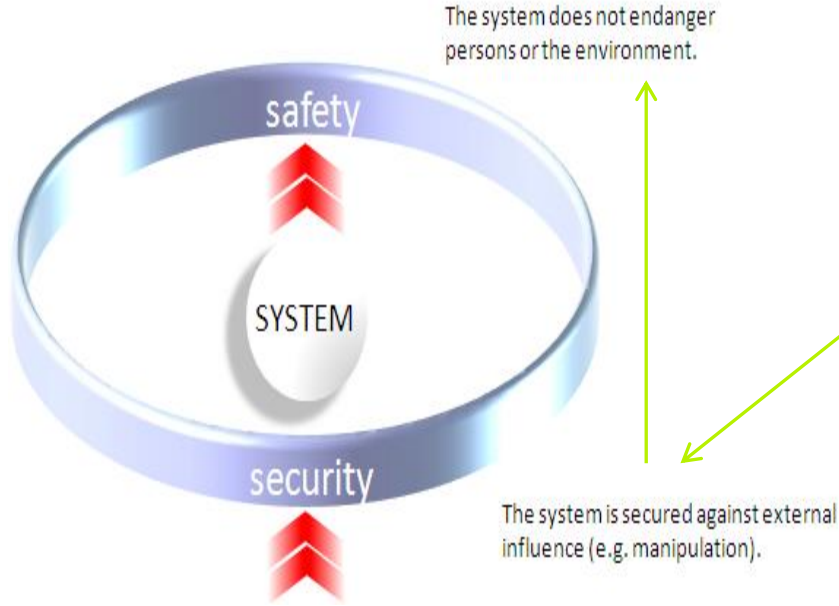


IEEE802.11p is WiFi based:

- ▶ **Longer ranges** (up to 1000m)
- ▶ **High (relative) speed of vehicles** (Doppler)
- ▶ **Low latency Robust** under automotive harsh conditions
 - Rapid changes in multi-paths reflections
 - Long excess delays to indoor

Connected Car, ADAS and HAD drive innovation priorities to system security and functional safety

ISO26262 functional safety and security



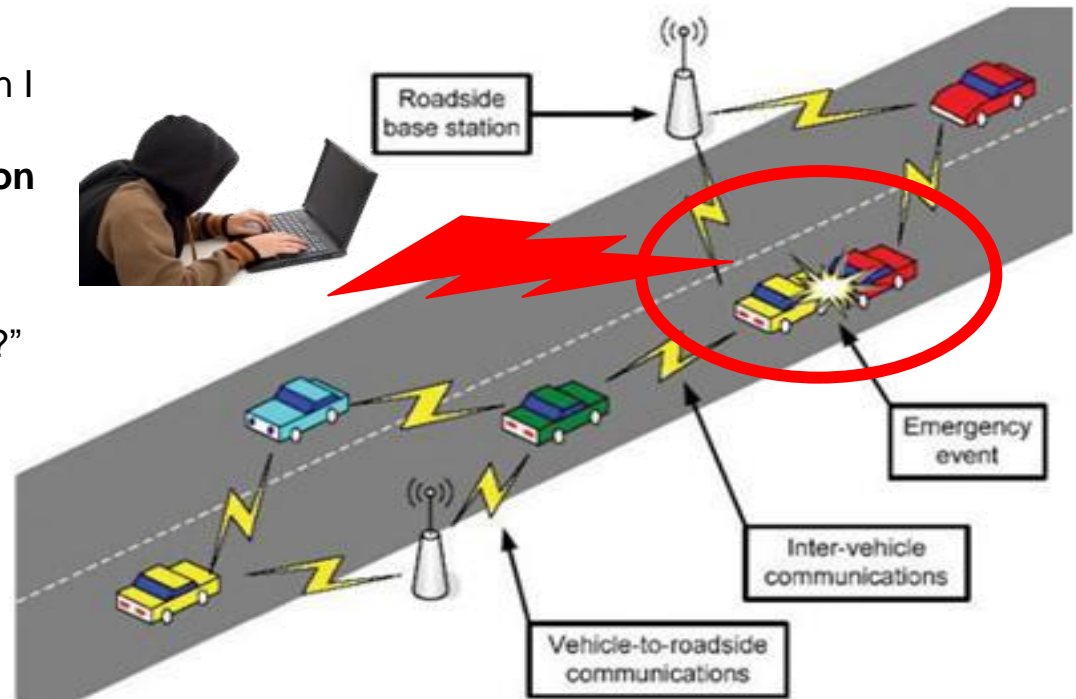
Potential security & privacy issues

Security:

- ▶ "Was the message **not modified**?"
- ▶ "Did it really **originate** from car A? Can I trust car A?"
- ➔ Solution: apply message **authentication**

Privacy:

- ▶ "Can someone **track** me while driving?"
- ➔ Solution: use **pseudonyms**



Pseudonyms and Privacy

- ▶ Tracking a vehicle is feasible (and easy) if it always uses the same identifiers
 - MAC address, IPv6 address, key/certificate, ...
- ▶ A vehicle therefore uses pseudonyms
 - Multiple pseudonyms, each with limited lifetime
 - Pseudonyms switched at strategic moments (engine start, every X minutes,...)
- ▶ The pseudonym is synchronously changed across the communication stack
 - Other identifiers (e.g. MAC and IPv6 address) are derived from the pseudonym
- ▶ The use of pseudonyms makes tracking much harder (but not impossible)
- ▶ Example scheme:
 - Every week, a vehicle uses a set of 20 fresh pseudonyms

Field trials world wide with NXP engagement

 U.S. Department of Transportation
Federal Highway Administration

DELPHI
Driving Tomorrow's Technology

USDOT ASD

Establishes a real world model deployment site (vehicle communications environment)

Partners

Delphi,
Cohda Wireless

Spookfiles

Dutch project to prevent and reduce phantom traffic jams

28 Partners, >15M Euro

Continental

simTD

Shaping tomorrow's mobility through researching and testing car-to-x and its applications

Partners

Continental, Daimler, Audi, BMW, Opel, VW, Cohda Wireless

sim^{TD}

Score@F

Regional Field trial in Paris region to apply car2x technology

Partners

Renault, PSA,
Cohda Wireless



PSA PEUGEOT CITROËN

SCORE@F

ConnectSafe

Australia's first field trial and on-road demonstration of dedicated short range communications

Partners

University South Australia,
Cohda Wireless



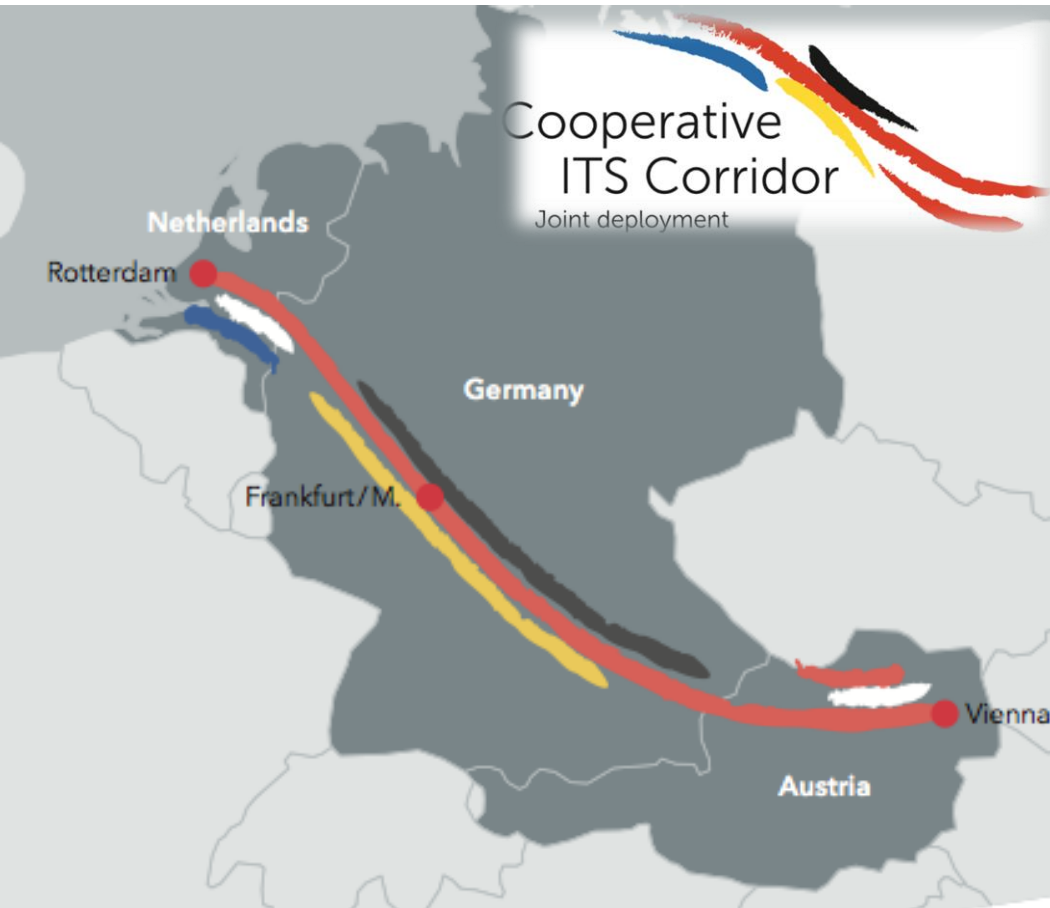
Institute for
Telecommunications
Research



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Deployment: Cooperative ITS Corridor



MOU between The Netherlands, Germany and Austria to deploy in 2015 cooperative mobility on this corridor to improve traffic safety and reduce congestion

