
The Resilient Road

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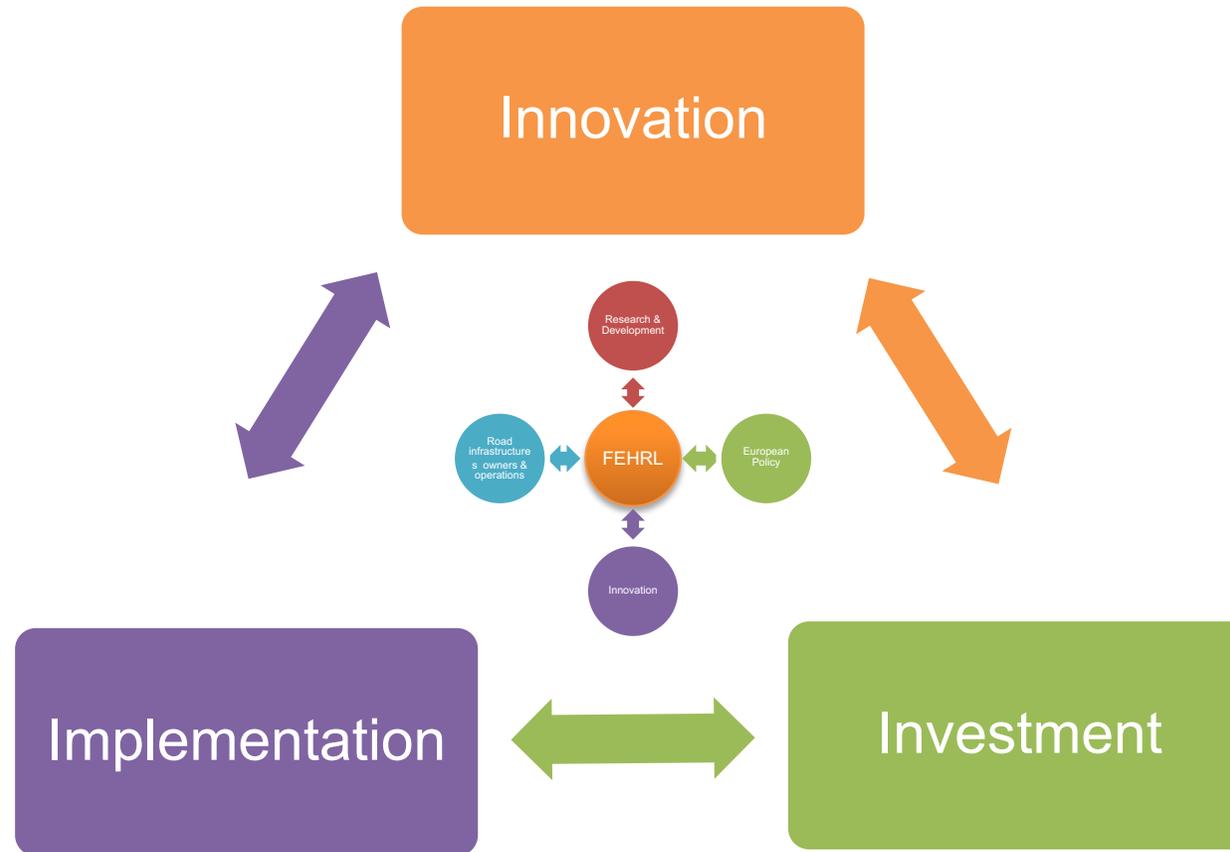
Making transport infrastructure fit for modern mobility by:

- ✓ Identifying R&D&I needs
- ✓ Facilitating the coordination of collaborative R&D&I
- ✓ Promoting research results
- ✓ Facilitating the implementation of matured solutions

FEHRL Members and Associates

		AIT with TUW			ANAS with UNIFI			U. ZILINA
		BRRC			LVCELI			ZAG
		RBI			VGTU			CEDEX
		UNIZGFCE			PCH			VTI
		CDV			NPRA with NTNU & SINTEF			BFH
		DRD			Statens vegvesen			Derzhdor
		IFSTTAR			IBDIM			TRL
		BAST			LNEC			ARRB
		KEDE with NTUA			CESTRIN			NETIVEI
		KTI			IP			FHWA
		TII with UCD & TCD			KARAYOLLARI GENEL MÜDÜRLÜĞÜ KGM			

Deployment is the final goal !!!



Transport infrastructures are the backbone of our economy and social cohesion

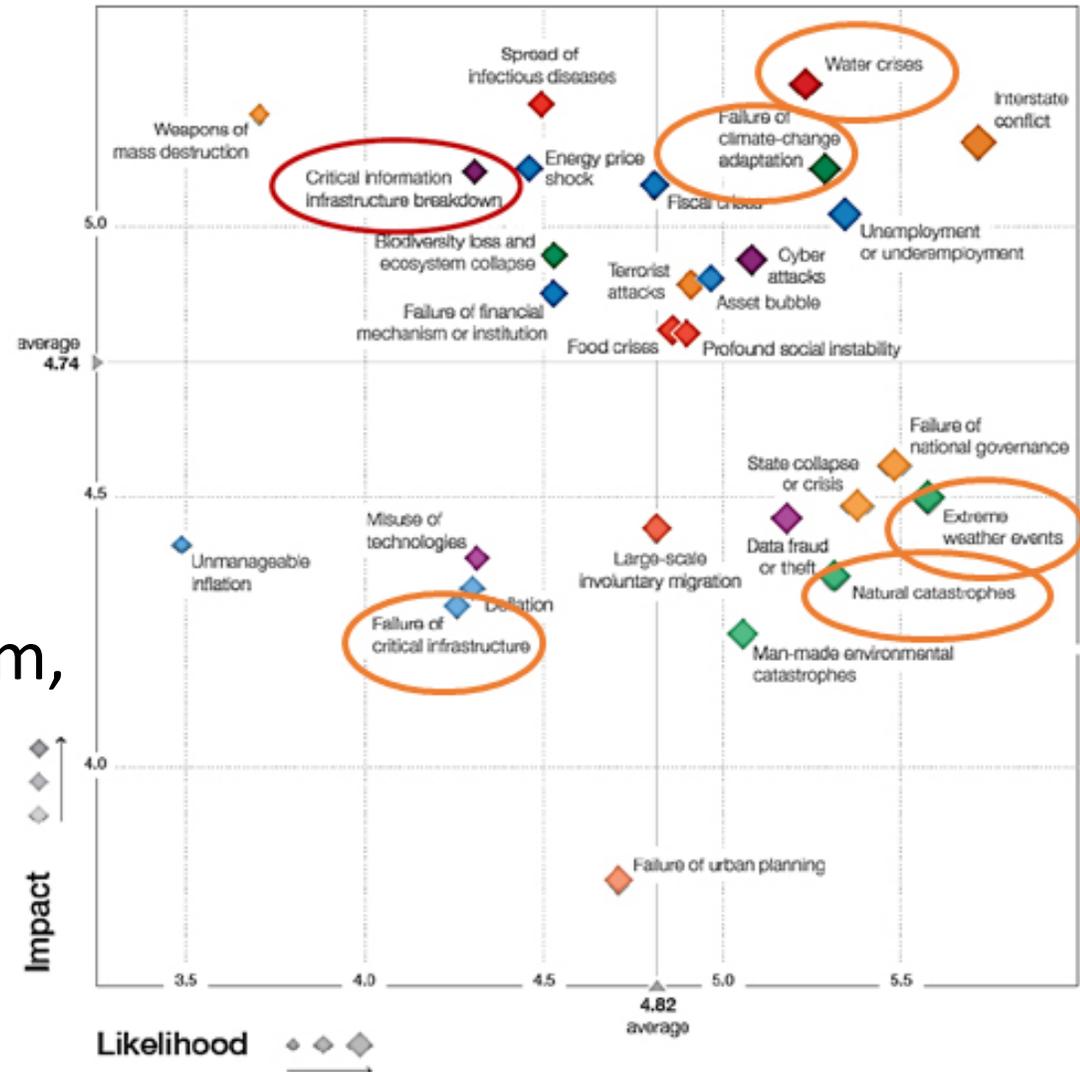
- 40% of the Active Member States' resources are invested in the infrastructure linked to the transport Domain
- +/- 5,5 million kms of roads in Europe, representing an 8 000 billion value
- Direct employment linked to: 5 million
- Indirect employment linked to: 14 million
- European Competitiveness (1% increase of the Gross National Input (GNI) supported with 1.5% increase for the transport infrastructures)



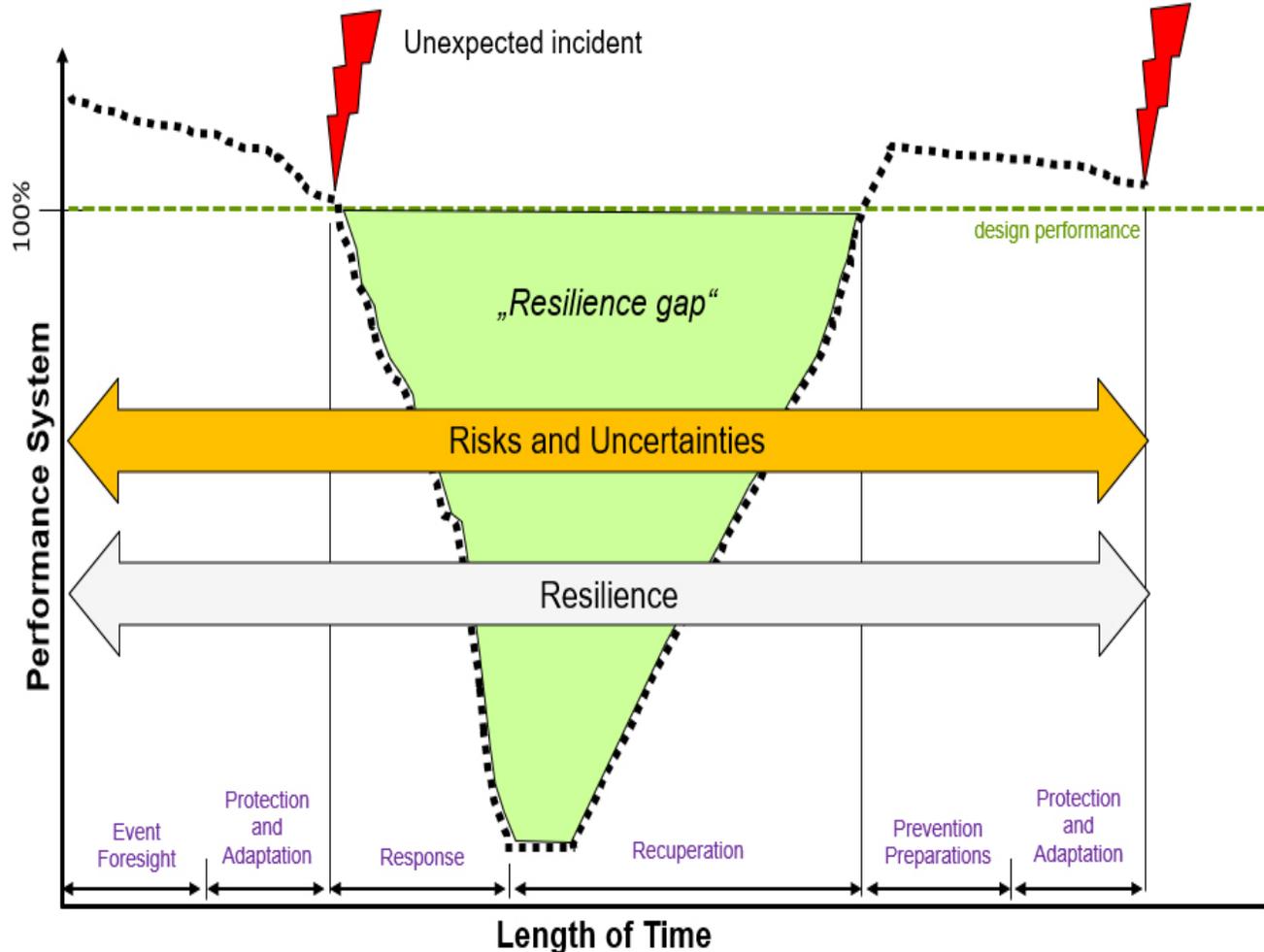
Resilience – a major concern worldwide

World Economic Forum – Global risks 2015

- Natural disasters: blizzards, tornadoes, floods, hurricanes, wildfires, heat waves, earthquakes and other natural hazards...
- Human-induced disasters: acts of terrorism, financials crises, social unrest, cyber attacks...



From crisis management to resilience



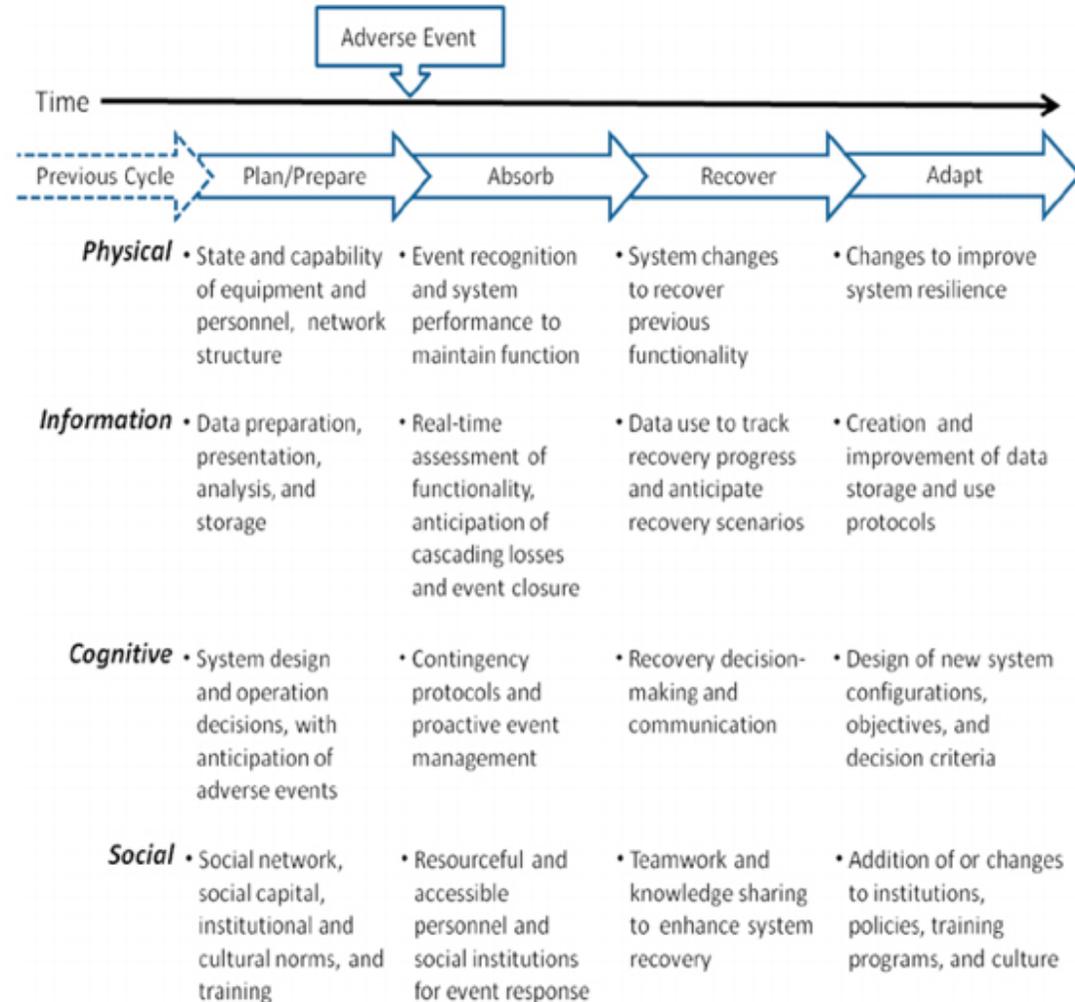
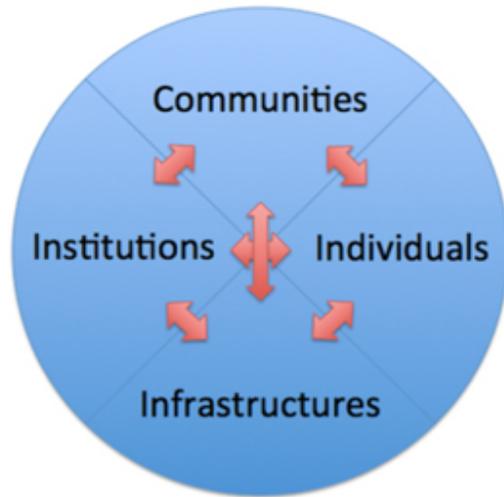
From:

- FEHRL Scanning Tour 2017 (Jürgen Krieger, BAST & all)
- EU-US Transportation Research Symposium - Transport Resilience: Adaptation to Climate Change - C. Marolda, October 2016

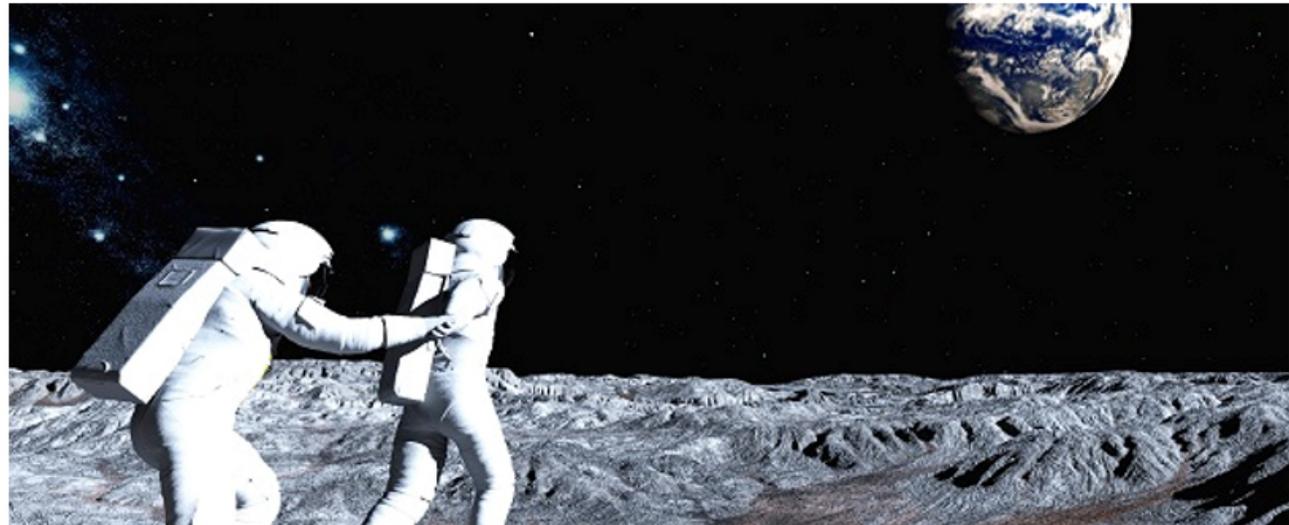
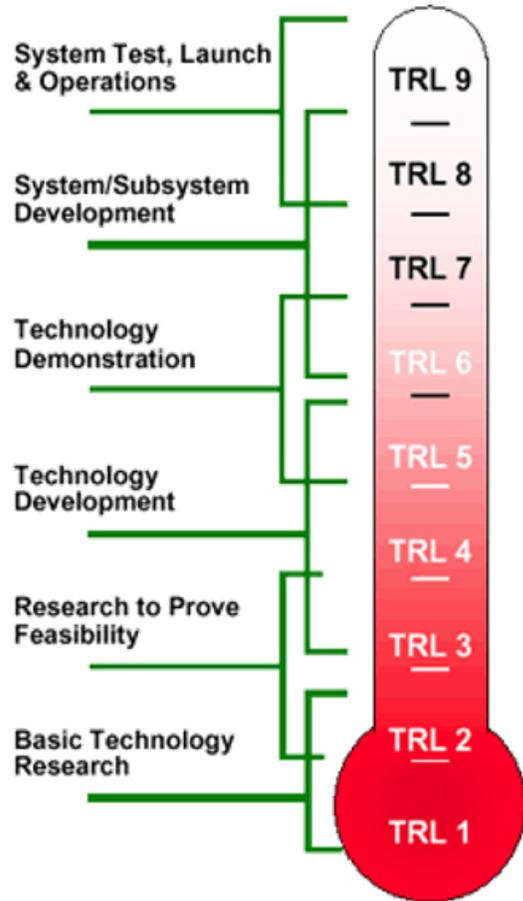
A resilience system is composed of:

- Reduction in the failure probability,
- Reduction of failure consequences in terms of mortality, damage and negative consequences on the Economy and the Social system,
- Shortening of the time needed for repairs (restoration of a specific system or of a series of systems to their 'normal' operating level).

Resilience is not just about infrastructure, it is also about individuals, communities and institutions



Resilience apprehension will only succeed through **FEHRL** a proven political commitment



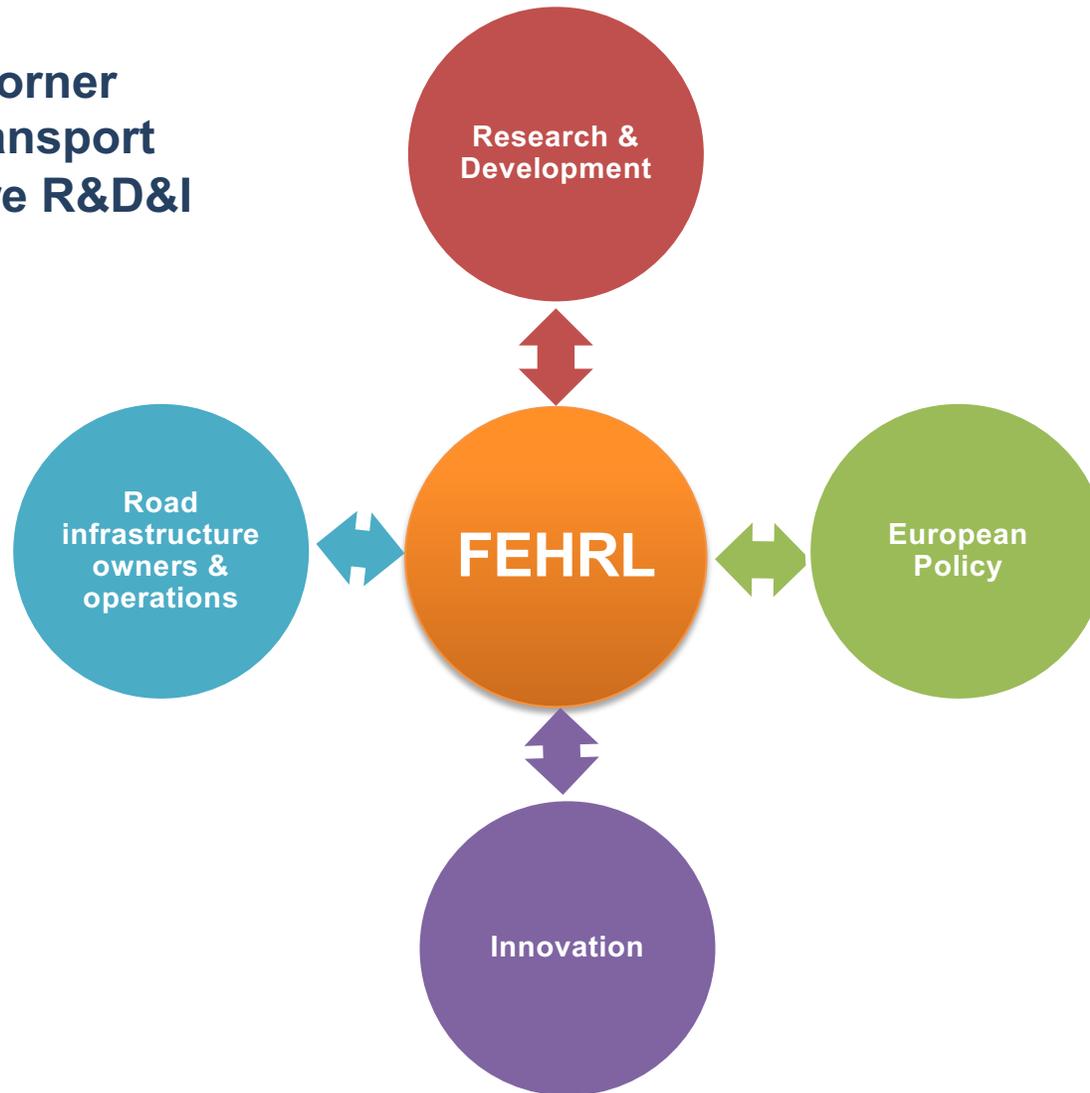
(...) We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win (...)

John F. Kennedy, 12 September 1962, Rice University Football Stadium

NO to one-way thought and unilateral action

YES to Dialogue, Respect, Comprehension, Trust and Engagement

**FEHRL – a corner
stone for Transport
Infrastructure R&D&I**



35 top R&D centres in Europe & Worldwide

Active cooperation with

- MoU FEHRL - ECTP
- ERTRAC
- ENCORD
- EAPA & EUROBITUME
- EUPAVE

- 1/3 of FEHRL Members are NRAs
- Cooperation with CEDR

Regular cooperation with the European Union Institutions

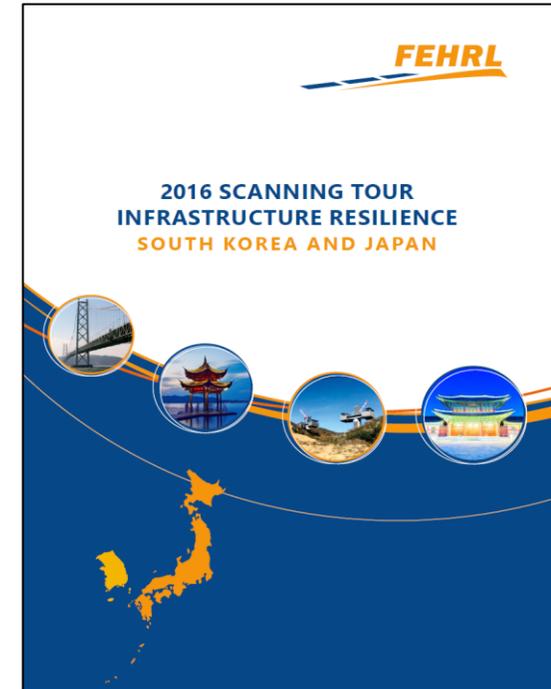


Get what is best

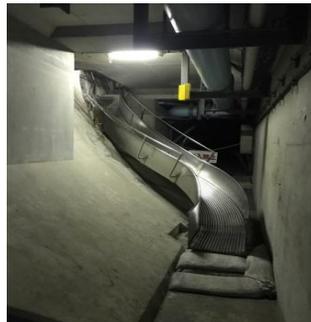


Principle results - Preparation

- Using Big Data for Smart Roads, Smart Systems and Smart data, communication between the Road and its user, vehicle and infrastructures
- Data confidentiality and data transfer **to road users, in real-time**
 - Smart bridges and highways gather a lot of sensory data in real-time (V2V and V2I)
- Use of **warning systems** covering earthquakes, floodings and droughts
 - Early warning quickly transferred to the road users
- **Building emergency exits**



Pictures taken at the Weather and Traffic Broadcasting studio and KEC Traffic Information Centre



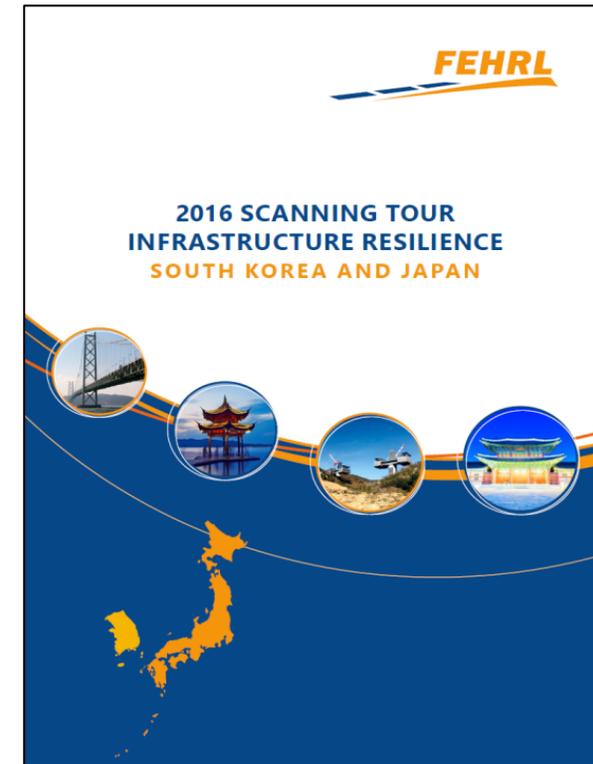
Emergency escape facilities – Tokyo Wan Aqua-line



Tokyo Wan Aqua-line

Key Results - Robustness

- The focus is on reducing the impacts of disasters and maintaining an aging infrastructure
 - Robustness and redundancy, **quick mobilization of resources** (suspension cables, equipment, engineers and technicians)
- Standards and notation
 - **Efficient classification of damages caused to highways** during the Hanshin-Awaji, in 1995
- Inspection strategy based on risks
- Trusted relationships with stakeholders



震災直後 Immediately after the earthquake



復旧後 Restored viaduct

Source: Hanshin Expressway Earthquake Museum Brochure 2009



ex 한국도로공사

Source: Heungbae Gil, Ph.D Research Director, Korea Expressway Corporation

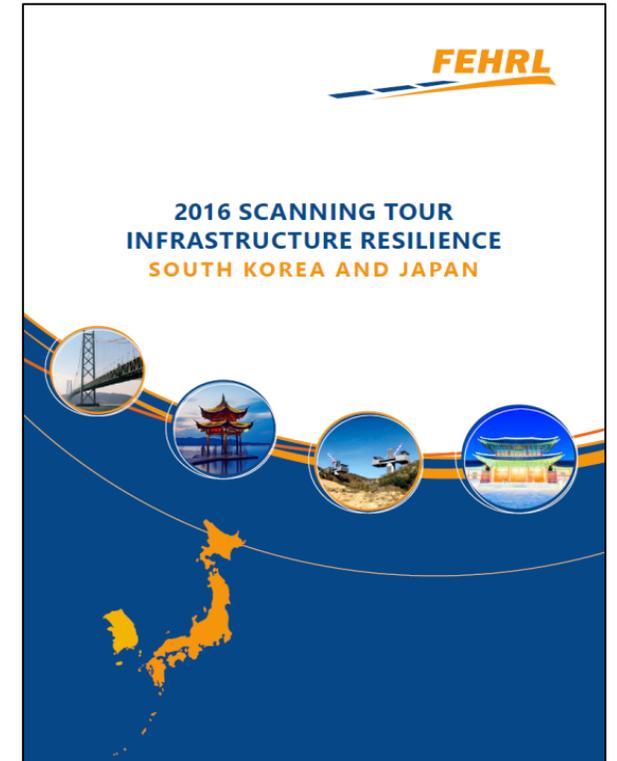
Key Results – Recuperation and Adaptation

Recuperations

- ❖ Rapid rescue, repairs and recovery following disastrous events

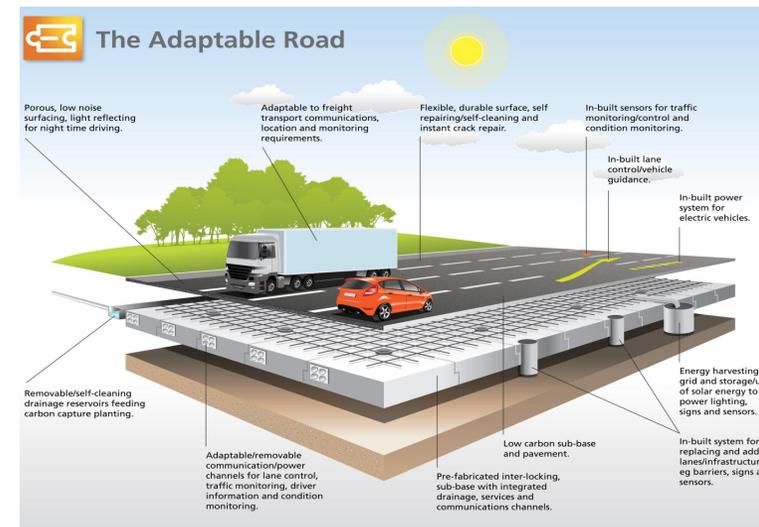
Adaptation

- ❖ Efforts aimed at prevention and lessen the impact of future catastrophes



Towards a common VISION and understanding of research NEEDS

- 1st generation - the bridge
- 2nd generation - the paved road
- 3rd generation - the smooth road
- 4th generation - the continuous road/motorways
- 5th generation - **FOREVER Open Road (FOR)**



The Forever Open Road

- Integrates innovation in infrastructure, vehicle technology and intelligent transport systems

– the Adaptable Road



– the Automated Road



– the Resilient Road





The Adaptable Road

Porous, low noise surfacing, light reflecting for night time driving.

Adaptable to freight transport communications, location and monitoring requirements.

Flexible, durable surface, self repairing/self-cleaning and instant crack repair.

In-built sensors for traffic monitoring/control and condition monitoring.

In-built lane control/vehicle guidance.

In-built power system for electric vehicles.

Removable/self-cleaning drainage reservoirs feeding carbon capture planting.

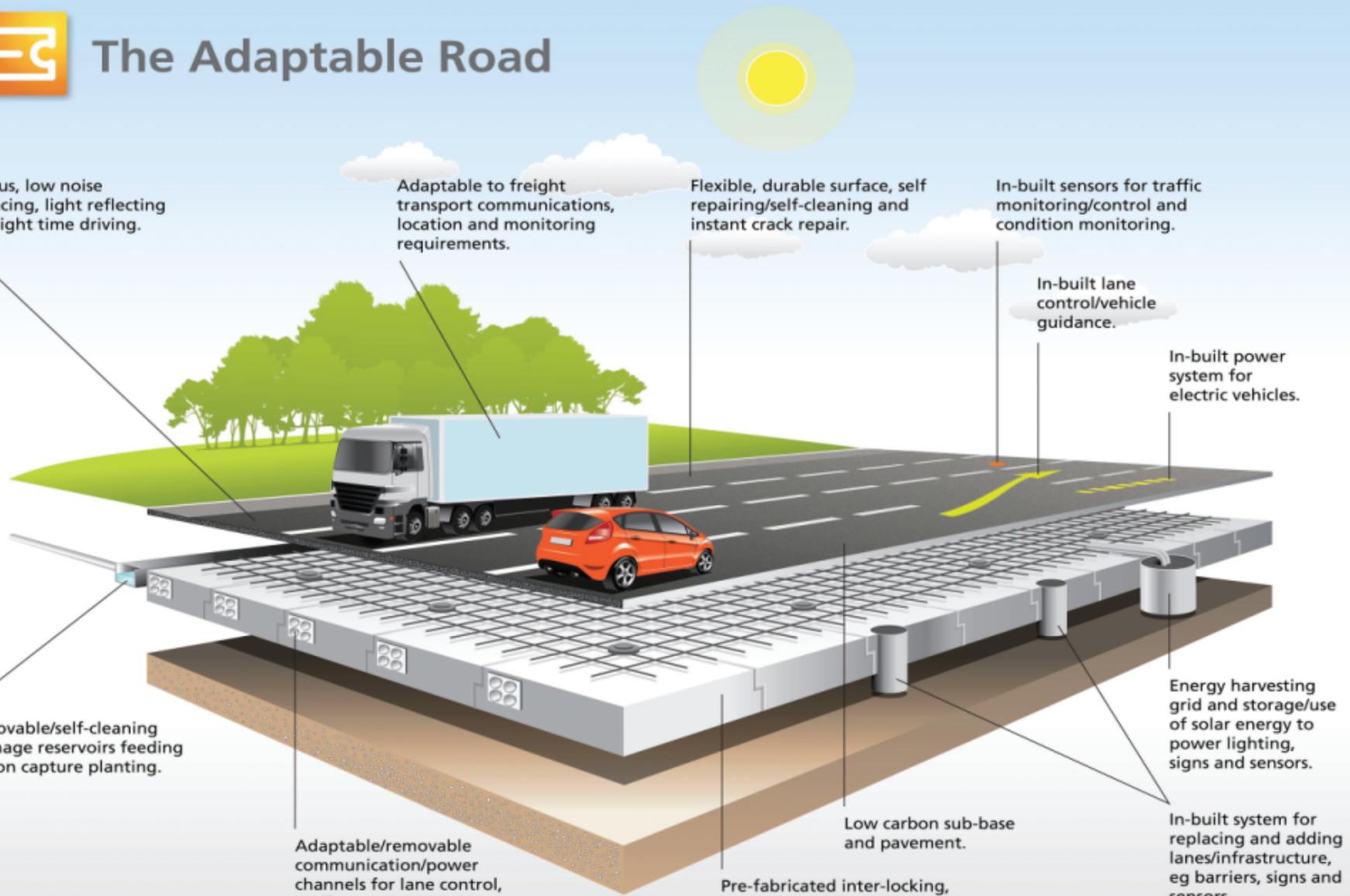
Adaptable/removable communication/power channels for lane control, traffic monitoring, driver information and condition monitoring.

Pre-fabricated inter-locking, sub-base with integrated drainage, services and communications channels.

Low carbon sub-base and pavement.

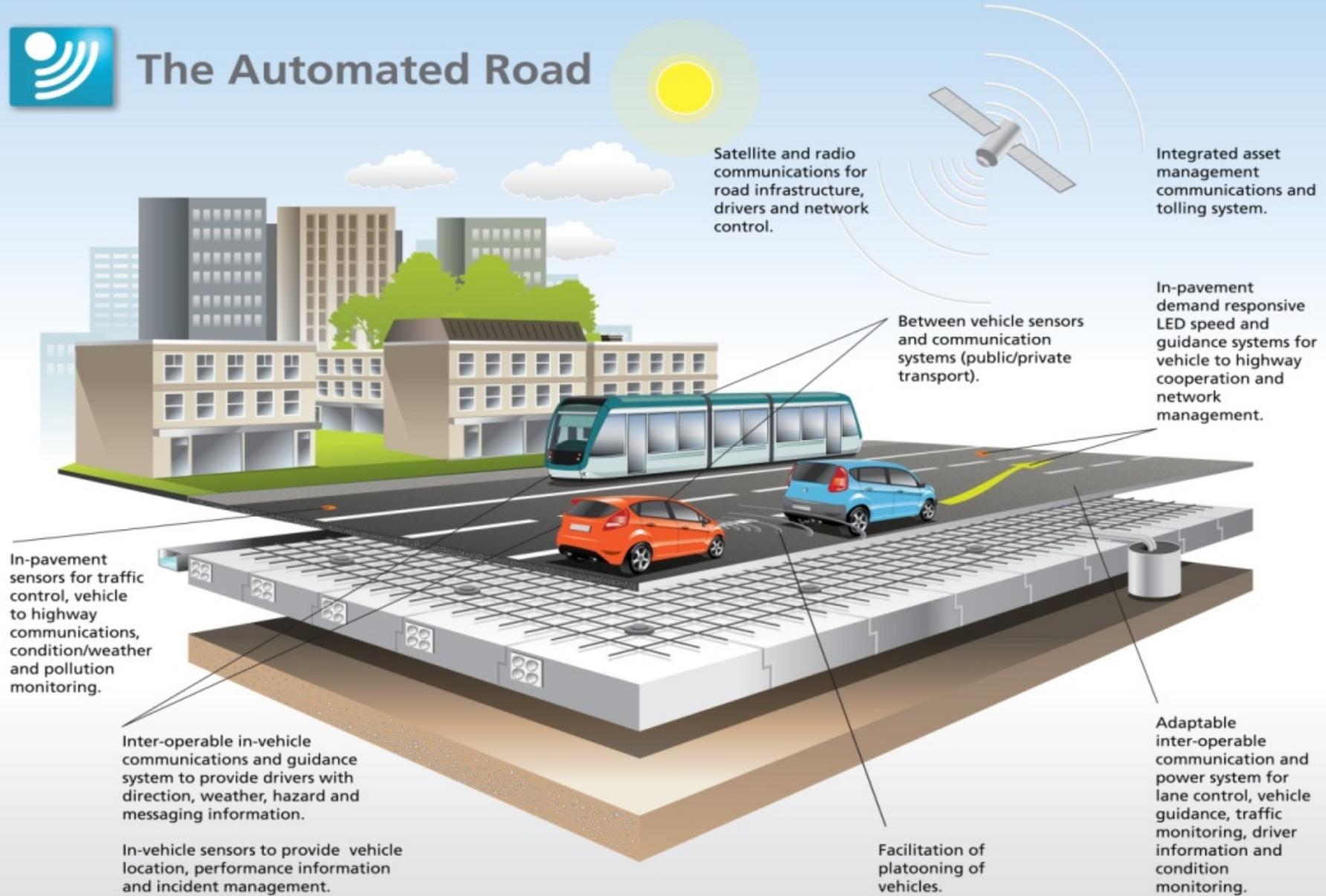
Energy harvesting grid and storage/use of solar energy to power lighting, signs and sensors.

In-built system for replacing and adding lanes/infrastructure, eg barriers, signs and sensors.



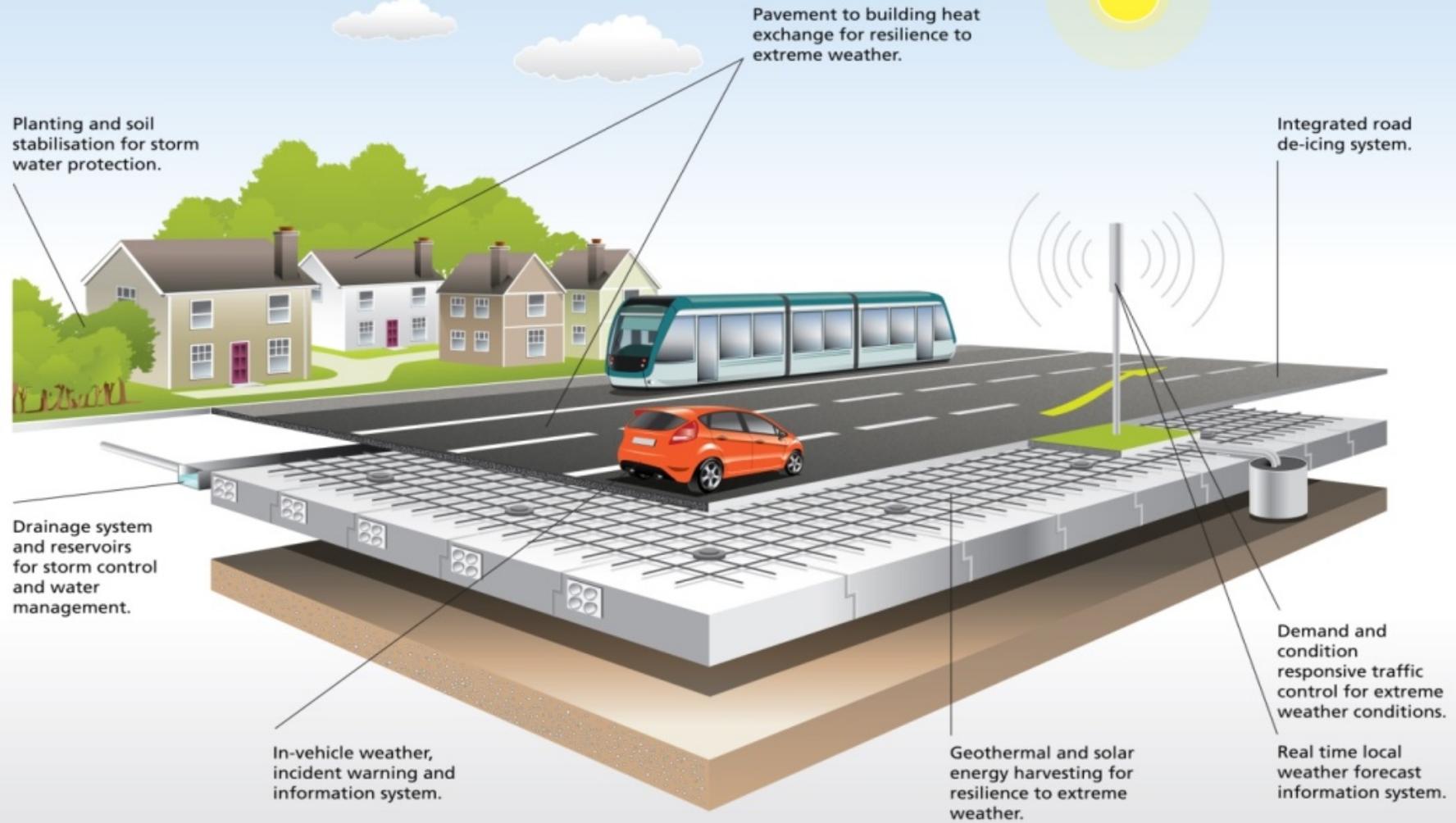


The Automated Road





The Resilient Road



Resilient Roadmap - Background



- Currently, Europe's transport systems struggle to cope with extreme weather events (droughts, heavy rain and snow, storms ..
- Climate change is predicated to increase the frequency and severity of extreme weather events
- The entire transport infrastructure will be significantly impacted by climate change affecting the way Europe's transport sector plans, constructs and maintains infrastructure in the future
- The cost of not adapting to climate change will be €100 to €250 billion

Background



- On the basis that there will be significant impacts from climate change, the Resilient Roadmap aims to determine how road transport infrastructure should adapt to the inevitable changes, increasing resilience to the potential effects of climate change.
- The Roadmap sets out the steps required to maintain and improve the resilience to extreme weather of road transport networks and specifically the key Trans-European Network (TEN-T)



Resilience against extreme weather





Resilience against extreme weather

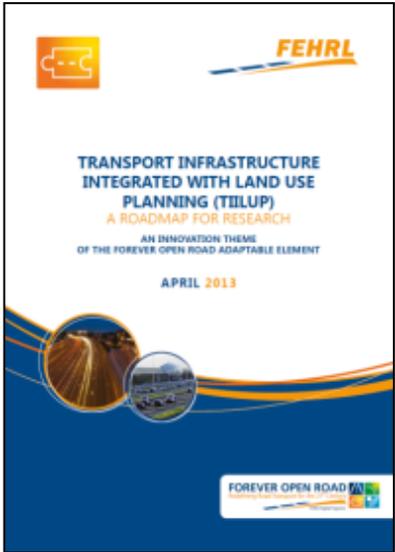
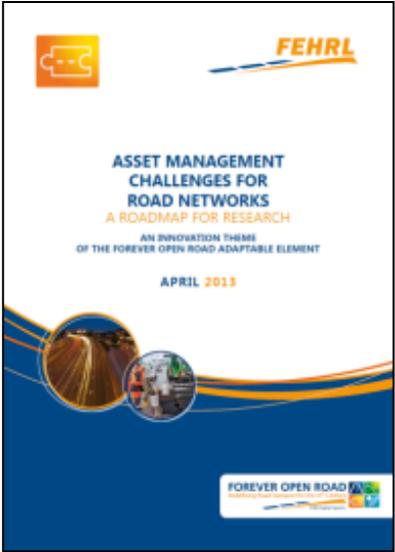


Torrential rain has severely impacted several parts of northern England. Credit: PA



Aerial view of the flooded area of Orihuela, Alicante, eastern Spain 14 September 2019. EPA/MANUEL LORENZO

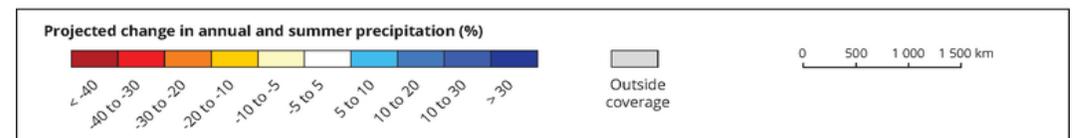
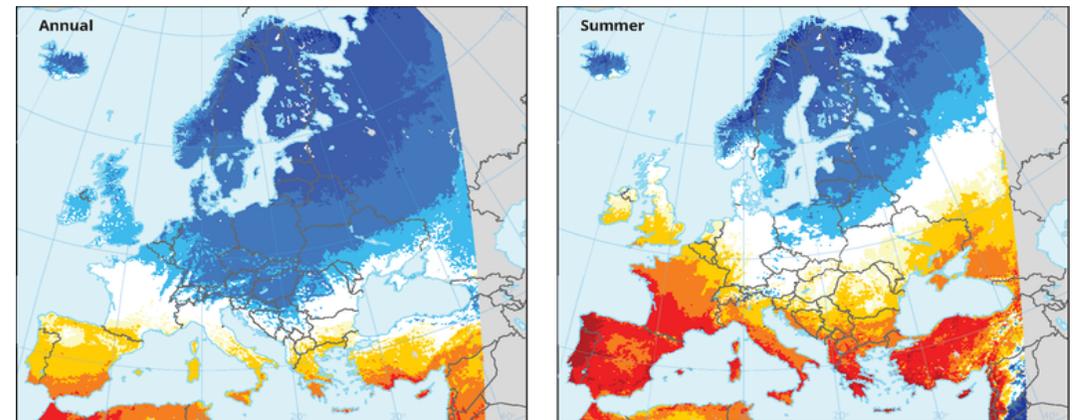
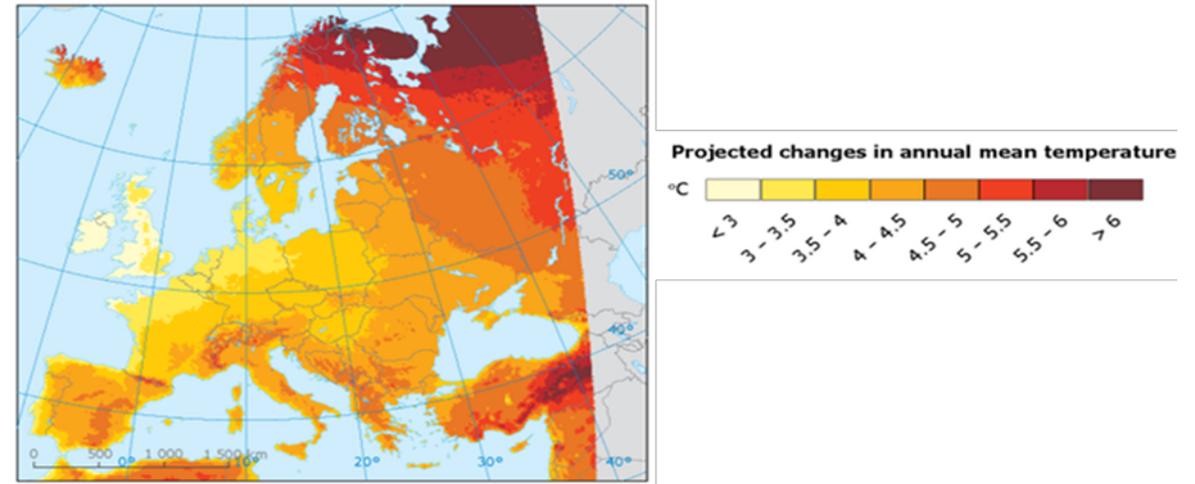
Roadmaps



Drivers for the Resilient Road

Climate change projections

- A general increase in temperature across Europe,
- Extreme weather events may become more frequent, intense and longer lasting
- Vulnerability to climate change varies widely across regions:
 - In low lying countries with islands and extensive coastlines such as Denmark; sea level rise has affected land drainage, causing groundwater to reach the surface temporarily or permanently, causing 'blue spots' triggering road closures.



Drivers for the Resilient Road



Potential Impacts of Changing Climate on Transport Infrastructure

Extreme weather events and man-made acts will impact on both the infrastructure and network operations, and can be both

- short term (e.g. surface flooding blocking a road or high winds temporarily closing a bridge) or
- longer term (e.g. significant damage to infrastructure such as a bridge collapsing as a result of scour or high river flow).



23 December 2011 Last updated at 22:51

Severe road delays as defect closes Hammersmith flyover



Defect shuts Hammersmith flyover leading to delays

Motorists faced miles of tailbacks and severe delays in west London as a flyover which forms a key route in and out of the city was shut for repairs.

Transport for London (TfL) said the Hammersmith flyover, which carries traffic from the M4 and A4, would be shut until at least early January.

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Drivers for the Resilient Road

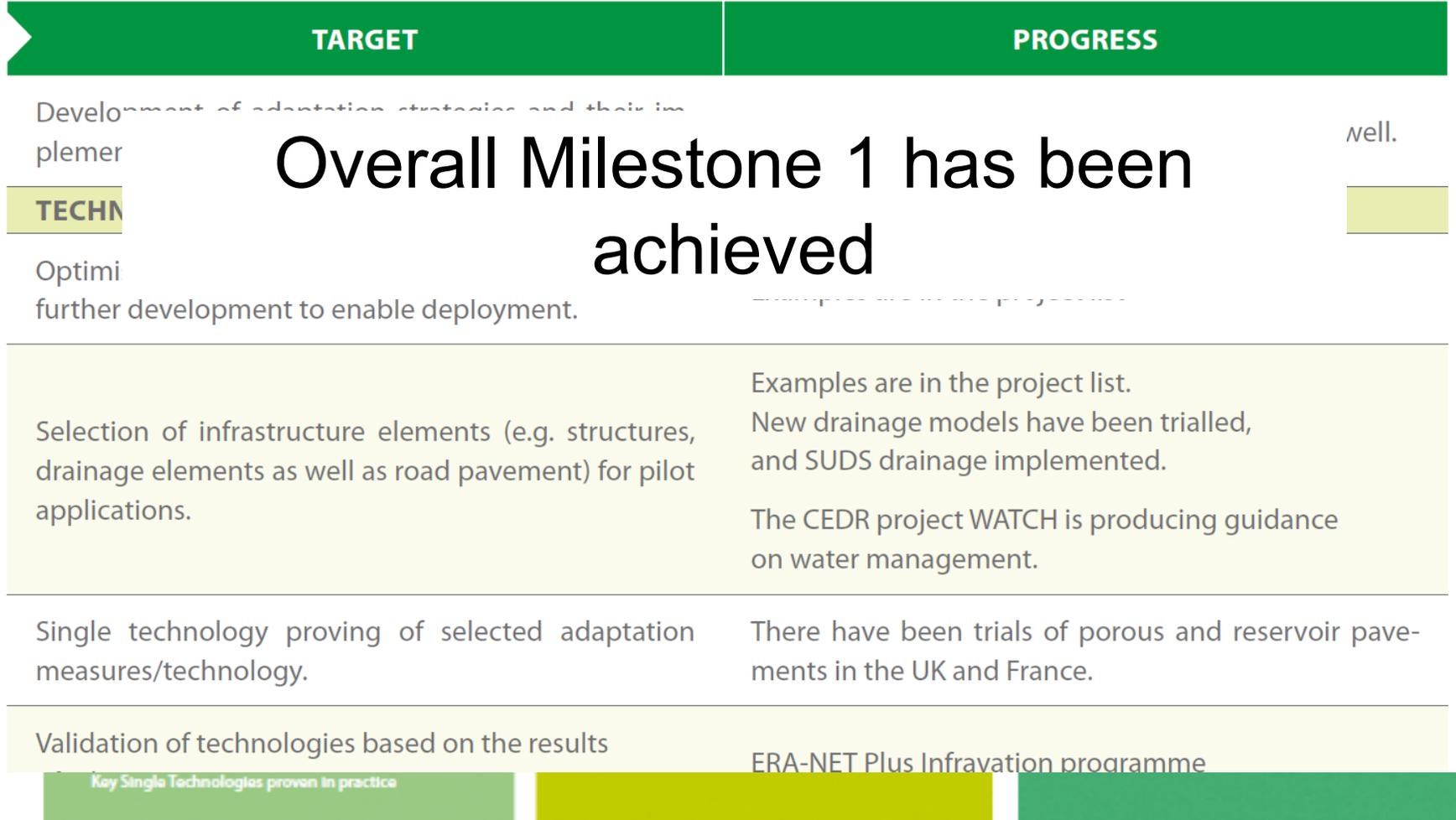


Preparation for the use of e-mobility, intelligent driving systems

- Advances have pushed forward the development of e-mobility and intelligent driving systems.
- This will require central data servers to coordinate all information and activities.
- Increased control and monitoring through, for example, sensor systems and intelligent driving systems, will allow road operators to implement traffic control measures in response to weather events to provide routing information, and will also enable vehicles to act as sensors and provide information on road and environmental conditions.

-
- Development and implementation of risk-based methodologies
 - ❑ Development of risk-based methodologies to assess the vulnerability of the road network to extreme weather events
 - Development and application of technologies
 - ❑ Design of resilient drainage systems, soil strengthening and rock stabilisation techniques and early warning systems
 - Development and introduction of management and adaptation strategies
 - ❑ Development of guidelines for maintaining the expected performance levels of infrastructure systems and strategies to cope with disruption during extreme weather events

Milestones



Supporting Programmes

Stimulating Other Programmes

European Commission Intelligent Transport System – USA



CED RESEARCH



Bundesministerium für Verkehr, Luft- und Seefahrt

Supporting Projects



THE RESILIENT ROAD															
Vulnerability Assessment and Identification of Adaptation Solutions									Geotechnics			Pavements			
KEYROADS	SWAMP	ADVIS RIVA	RAIN-EX	ALTRAIN	SERON	ROADAPT	INTACT	SECMAN	PANDA DEVICE	MATOSOL	CARACEC	ADSVIS	ROSANNE	WATCH	PAST

THE RESILIENT ROAD														
Operational Management									Bridges and Tunnels			Regulatory Framework		
ADSVIS	DESIGN STANDARD	ROAD DES'N	SYSTEMS	INFREALERT	RESILIENS	ROADAPT	DETECTOR	SKRIBT / SKRIBT +	EXPANSION JOINTS	HEUMANS BRAINJOINT	SKRBT / SKRIBT +	PHOTOPAQ	DEVELOPMENT	OASIS

Conclusions



- FEHRL's scanning tours including a number focusing on resilience and adaptation to climate change and extreme weather events, and in 2016 on 'Infrastructure Resilience' are intended to facilitate exchange of knowledge and partnership building.
- Over the next few years, there will be a move towards identifying existing and developing demonstration projects of technologies.
- An increasing number of external organisations will play an important role in the implementation of technologies developed as a result of the FOR programme

FOREVER OPEN ROAD

Redefining Road Transport for the 21st Century



Thank You

FORx4 - FOREVER OPEN ROAD, RAIL, RUNWAY AND RIVER

Infrastructure Innovation for seamless mobility

