Title	Impact of integrated winter road maintenance on transport system resilience
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INTEGRATED WINTER ROAD MAINTENANCE AND THE TRANSPORT SYSTEM RESILIENCE

Winter maintenance management and planning

Extreme weather condition risks

- In the **U.S.**:
  - 7,400 fatalities and 670,000 injuries due to weather
  - **500 million hours of delay** caused by limited visibility or slipperiness
- In the **UK**:
  - Average daily cost **£280 million** due to severe weather
  - Normal daily costs due to congestion are £60 million

In the EU

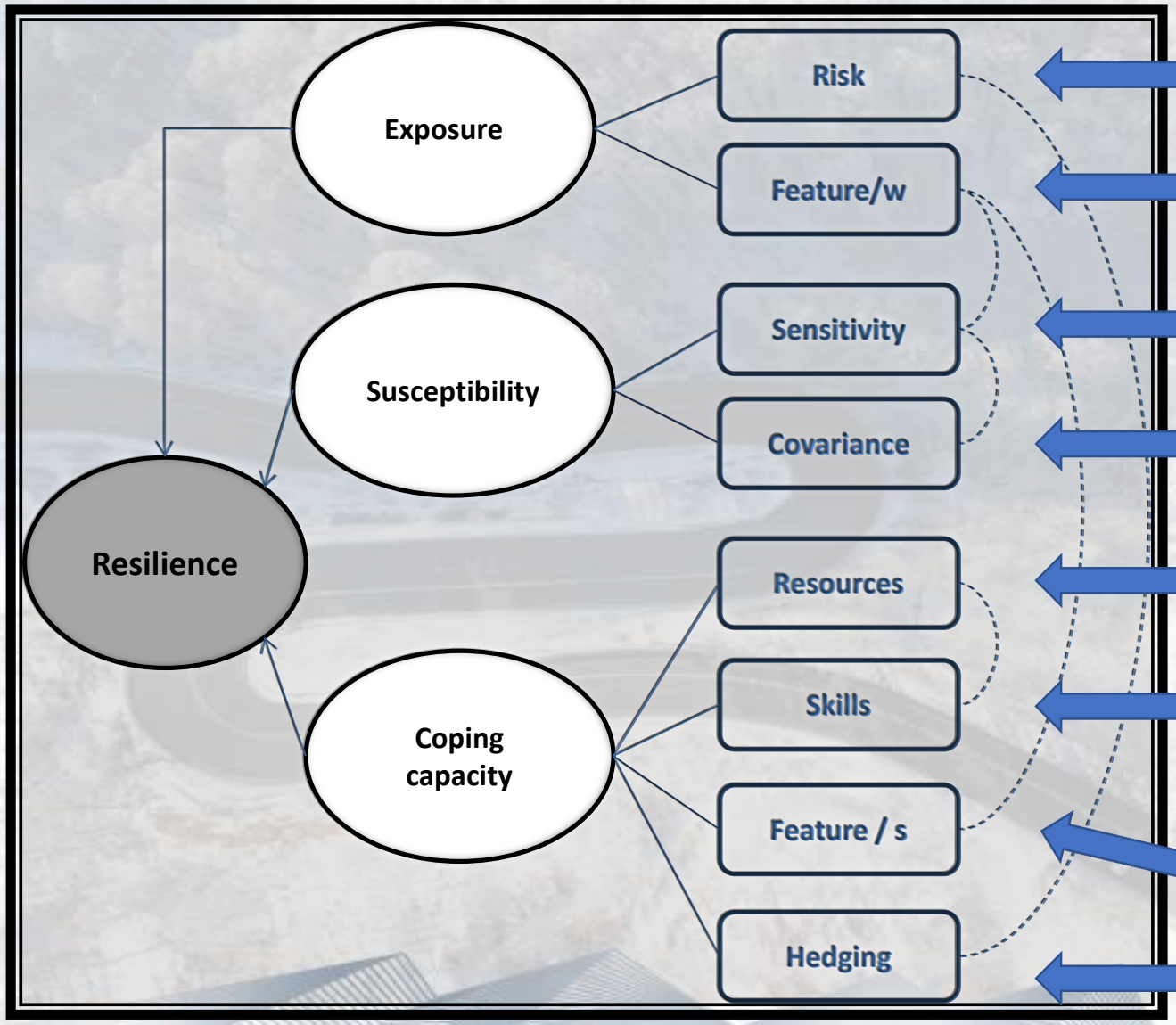
	Present costs due to extreme weather, including all phenomena (ca. 2010)				
	Accidents	Time costs	Infrastructure		Freight & logistics
			Physical infra	Maintenance	
Road	>10 bill.	0.5-1.0 bill.	ca. 1 bill.	ca. 0.2 bill.	1 – 6 bill.
Rail	>0.1 bill.	>10 mill.		>0.1 bill.	5 – 24 mill.
IWT	ca. 2 mill.	na	na	na	0.1 - 0.3 mill.
Short sea	>10 mill.	na	na	na	0.2 - 1 mill.
Aviation	na	>0.6 bill.	na	na	0.5 – 2.3 mill.
Light traffic	>2 bill.	-	na	na	-
TOTAL	>12 bill.	>1 bill.	ca. 1 bill.	>0.3 bill.	1-6 bill.
The EU-27 grand total more than 15 bill. € p.a.					

- ✓We need to identify and innovate in a systemic way the potential of different combinations of measures as adaptation and mitigation strategies
- ✓We need to estimate what kind of measures offer the best cost effectiveness

- ✓Potential for significant benefits for road operators, maintenance decision makers, road authorities and road users
- ✓better awareness and more proactive measures
- ✓reduced operational maintenance costs and lighter environmental footprint improvements in traffic safety and traffic management

$$Resilience = \frac{Coping\ capacity}{Exposure \times Susceptibility}$$

- **Coping capacity (“endurance / toughness”)**
  - the ability of people, organizations and systems, to use available skills and resources in order to face and manage adverse conditions, emergencies or disasters
- **Exposure (“weakness”)**
  - people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses
- **Susceptibility (“sensitivity”)**
  - the characteristics and circumstances of community, system or asset that make it susceptible to the damaging effects of a hazard



Probability of adverse event, e.g. probability of a storm

Outdated infrastructure component at the end of its technical service life or obvious poor quality

non-robust or unprotected components of the system

dependency on other system components or other systems (e.g. electricity power supply)

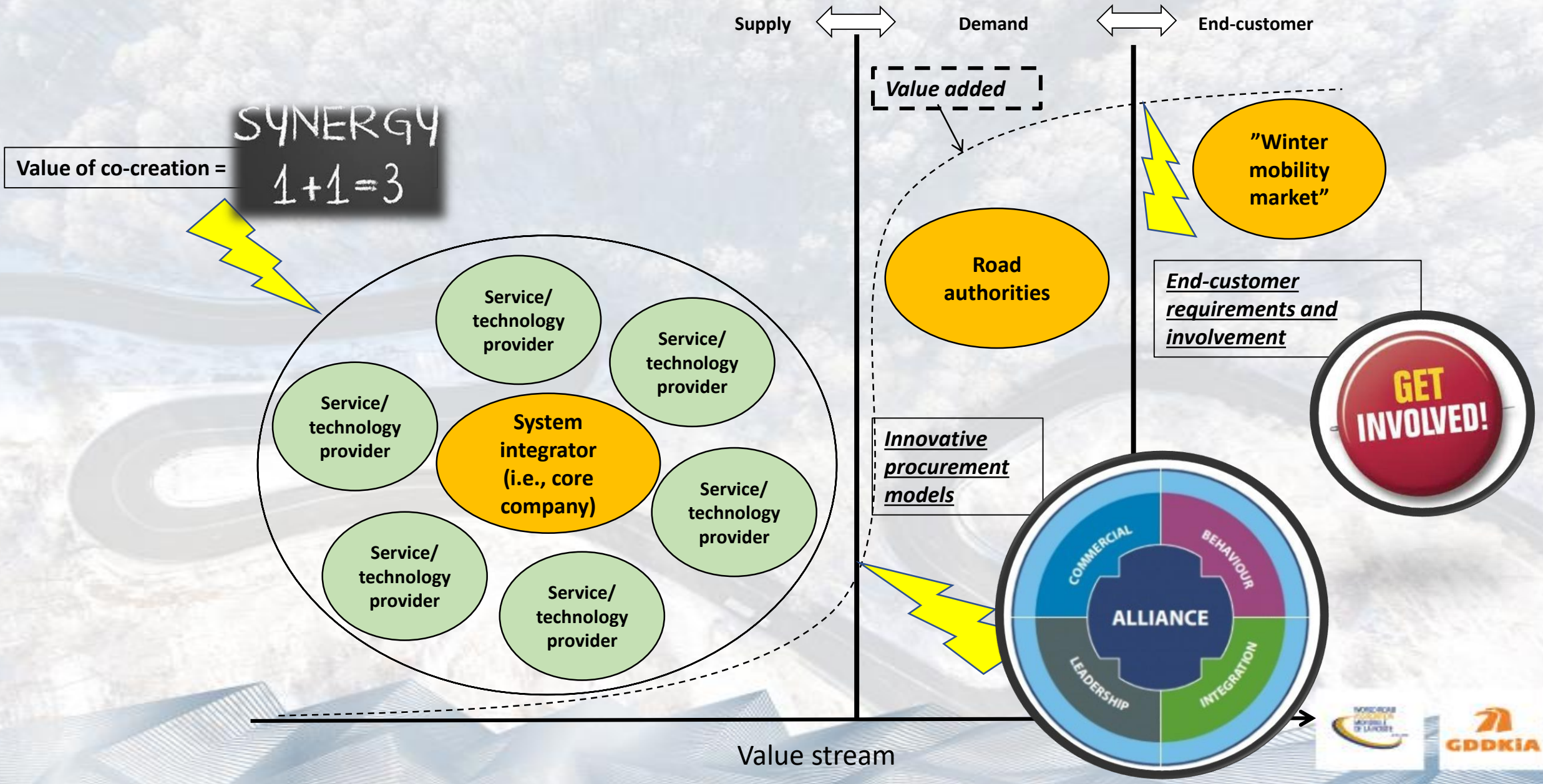
Availability and quality of repair equipment, budget adequacy

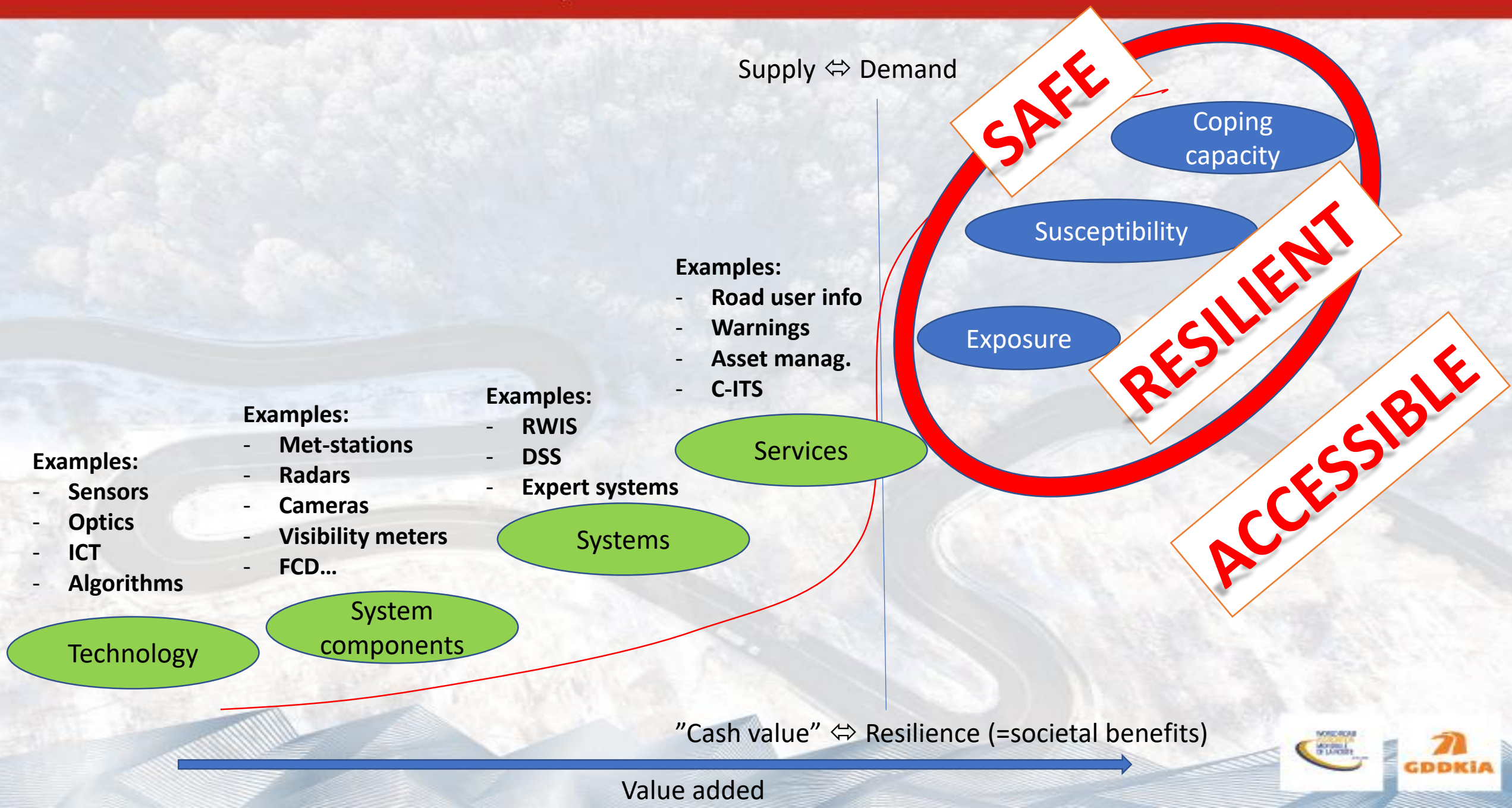
Trained maintenance and repair crews, sophistication of asset management strategies

Robust designs, engineering and design philosophy (e.g. use of safety multipliers or factors)

Hedging => protective structures, insurance.

Source: Leviäkangas P, Aapaoja, A (2015) Resilience of transport infrastructure systems. CSID Journal of Sustainable Infrastructure Development, Vol. 1, pp. 80-90.


Supply
Demand
End-customer
Value added
SYNERGY
1+1=3
Value of co-creation =
Service/ technology provider
Service/ technology provider
Service/ technology provider
System integrator (i.e., core company)
Service/ technology provider
Service/ technology provider
Service/ technology provider
Road authorities
”Winter mobility market”
End-customer requirements and involvement
GET INVOLVED!
Innovative procurement models
COMMERCIAL
BEHAVIOUR
ALLIANCE
LEADERSHIP
INTEGRATION
Value stream


Supply ⇔ Demand
SAFE
Coping capacity
Susceptibility
Exposure
RESILIENT
ACCESSIBLE
Examples:
- Road user info
- Warnings
- Asset manag.
- C-ITS
Services
Examples:
- RWIS
- DSS
- Expert systems
Systems
Examples:
- Met-stations
- Radars
- Cameras
- Visibility meters
- FCD…
System components
Examples:
- Sensors
- Optics
- ICT
- Algorithms
Technology
”Cash value” ⇔ Resilience (=societal benefits)
Value added

Integrated winter road maintenance = Increased Resilience

Context and issue	Opportunity
Clarifying the roles and responsibilities of different actors	**Real-time info** **guidelines** If road users h to suitable act
Proper and efficient use of maintenance vehicles and C-ITS	Possibility of collected data Easier to **reas** during activiti Easier to take
Real-time location and awareness of maintenance vehicles	It is possible to **direct** entire **maintenance** vehicle fleet to focus on areas where the driving conditions are the most difficult Possible to **redefine priority** ro Possibility to **inform the move**
Correct timing of maintenance activities	D a B

SAFETY AND RELIABILITY

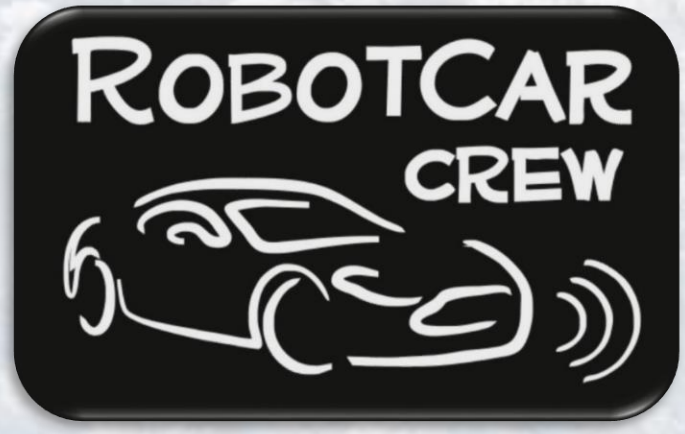
PROACTIVENESS AND ENVIRONMENT FOOTPRINT

ACCESSIBILITY

ENHANCED TRAFFIC MANAGEMENT

SUMMARY: Benefits – road info and maintenance services

- Providing weather and road weather information to **road users** in Finland reduced the number and severity of accidents:
  - **€16 - €32 million benefits** with current services
  - Additional €16 - €32 million with more advanced services
- Benefits in **maintenance**:
  - **€2.7 million total** consisting of reduced need for materials, less unnecessary operations, and fewer belated operations
- **Weather information to pedestrians and bicyclists** would provide significant benefits:
  - Savings of €49 - €73 from reducing slipping accidents by services targeted to end-users
  - Savings of €120 million from reduced slipping accidents by services targeted to maintenance operators
- Benefits for maintenance **operators**
  - **Proactivity**: reduced need of personnel and materials
  - **Anti-icing** has lowered snow and ice control costs by 10-50%



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