



# Resilient Transportation Systems

Coping with  
today's and  
tomorrow's  
challenges



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# What is Resilience?

“... Ability of an organisation to **absorb and adapt** in an **changing environment**.”

“... Organizational resilience contributes to:

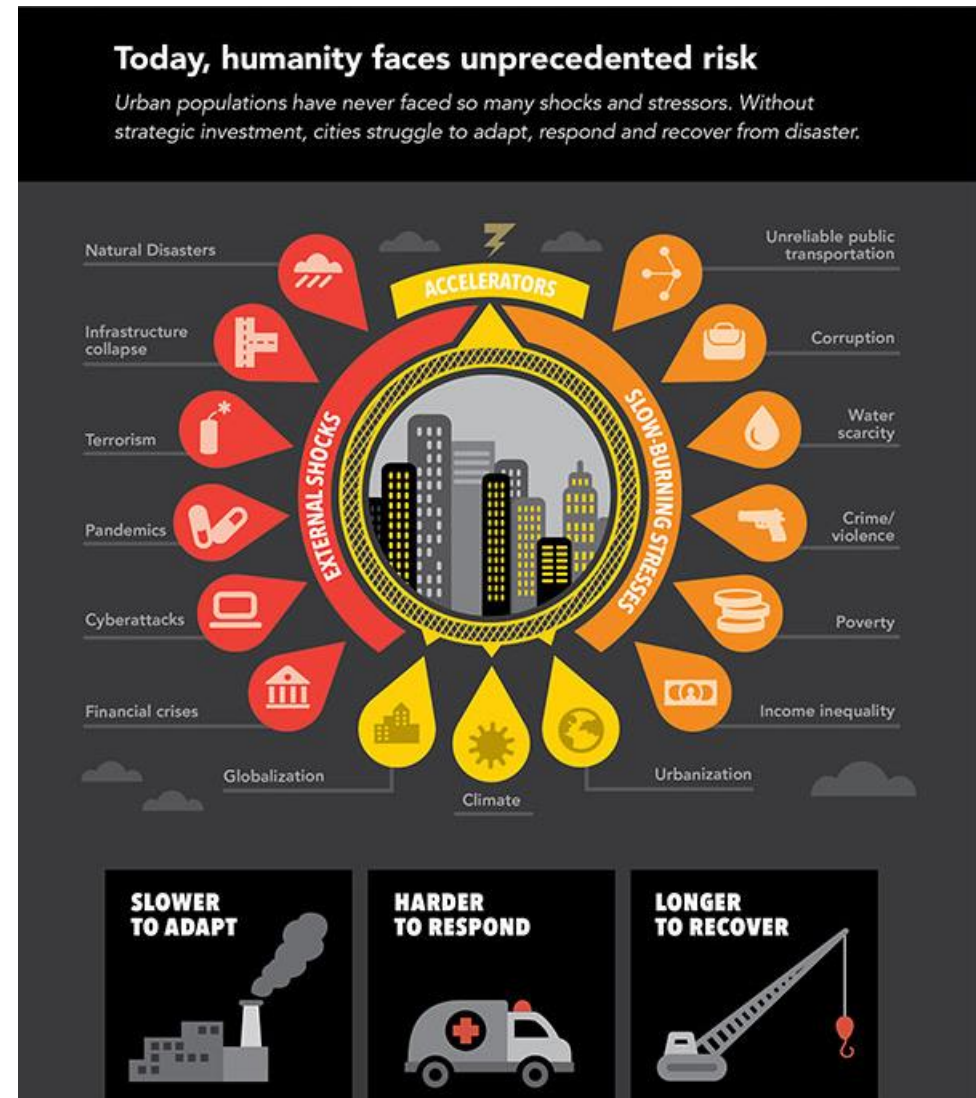
- An improved ability to anticipate and address **risks** and **vulnerabilities**;
- Increased **coordination and integration of management disciplines** to improve coherence and performance;
- A greater understanding of **interested parties and dependencies** that support **strategic goals, and objectives**.”

ISO 22316:2017

“How well we bounce”

*Professor Julia Black, LSE*

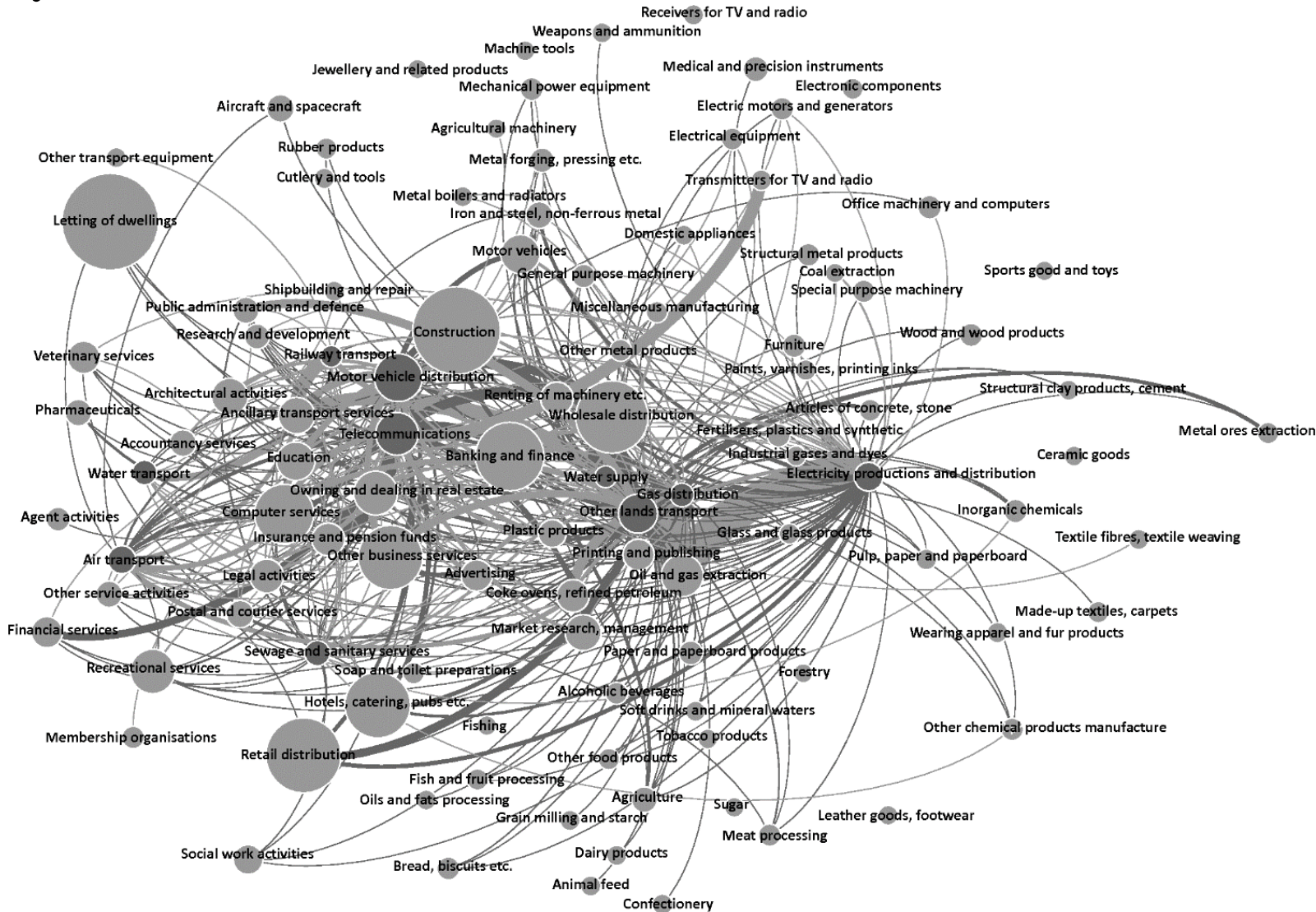
The ability of a system, community or society to anticipate, absorb, recover from and adapt to **shocks** and **stresses** in a timely manner.



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# What is Resilience?

- Our societies depend on near-seamless interaction of assets, services and people.
- Interdependencies and influences are exceedingly complex and fragile.
- Understanding Resilience needs a holistic, inclusive view not only systems- or asset-view
- Resilience considerations should not be limited by the primary function of the asset or system



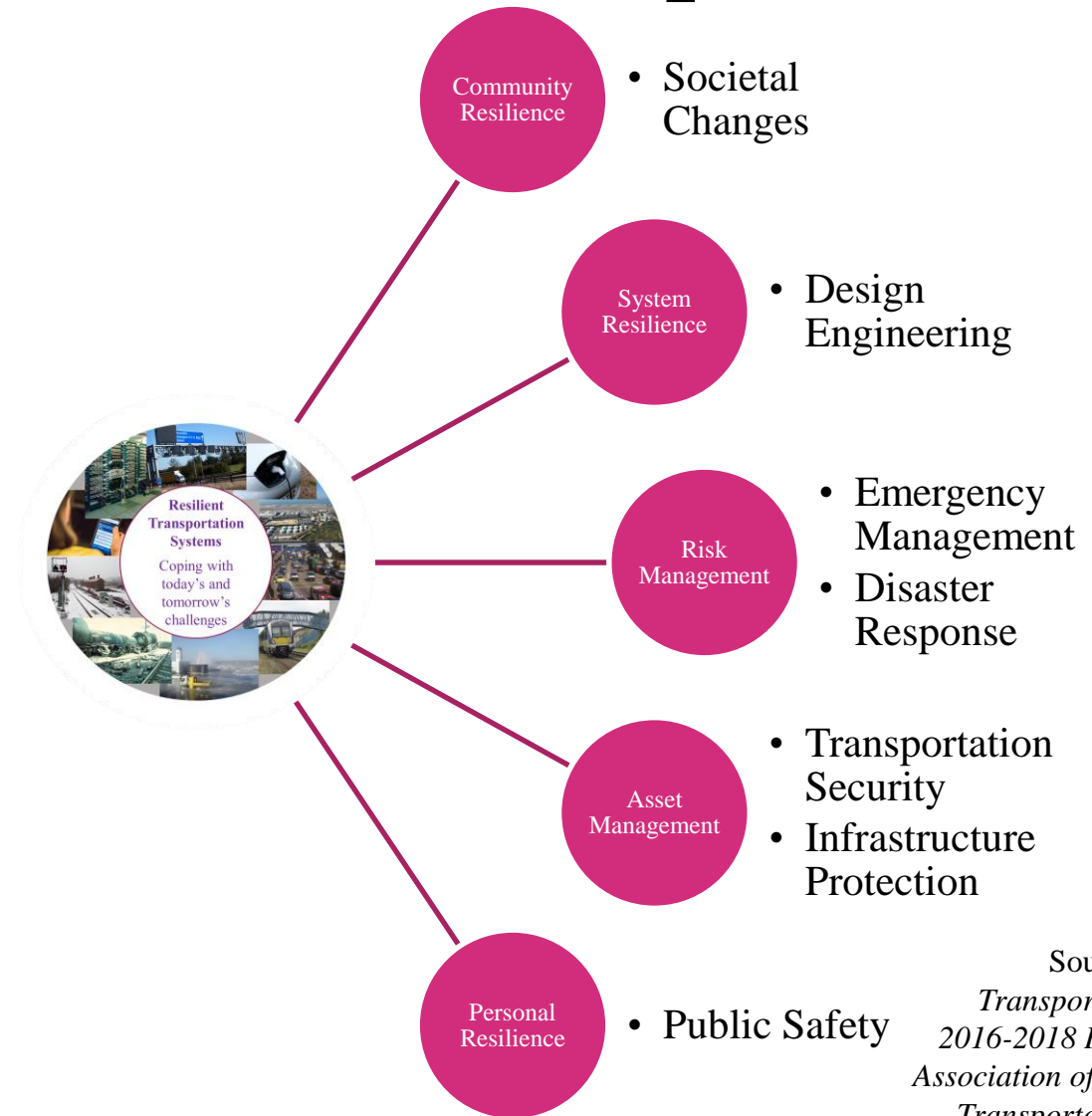
# Why is Resilience important for transportation systems?

- Where would we be without transportation?
  - Keeping societies connected and running
  - Securing economic prosperity and growth

- What are the events that can cause disruption of our transportation systems?

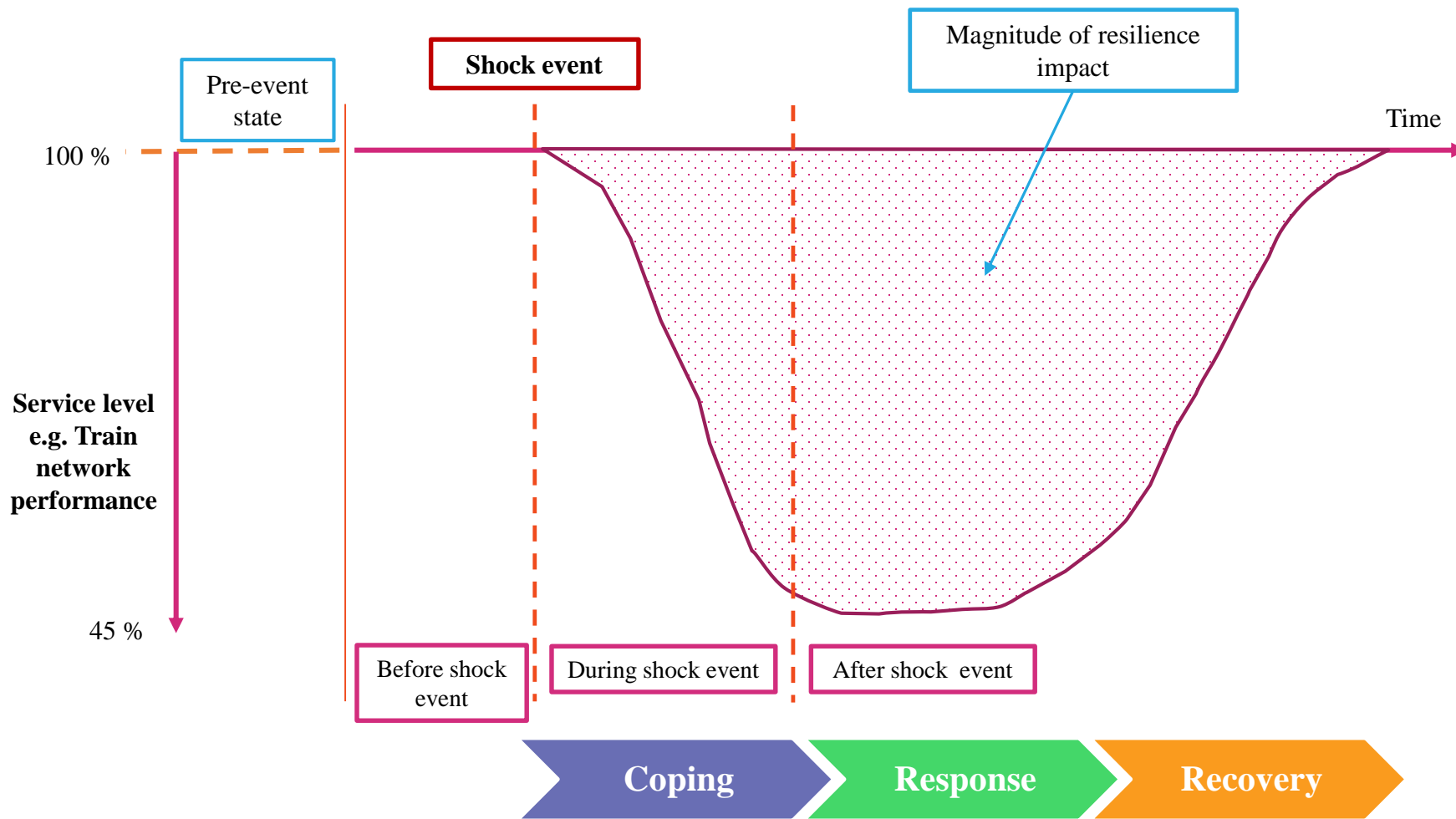
Shocks: extreme weather, power failures, malicious attacks, terrorism, transportation accidents

Stresses: legislation change, economic pressures, new technologies, customer behaviour



Source: *Understanding Transportation Resilience: A 2016-2018 Roadmap*, American Association of State Highway and Transportation Officials, 2017

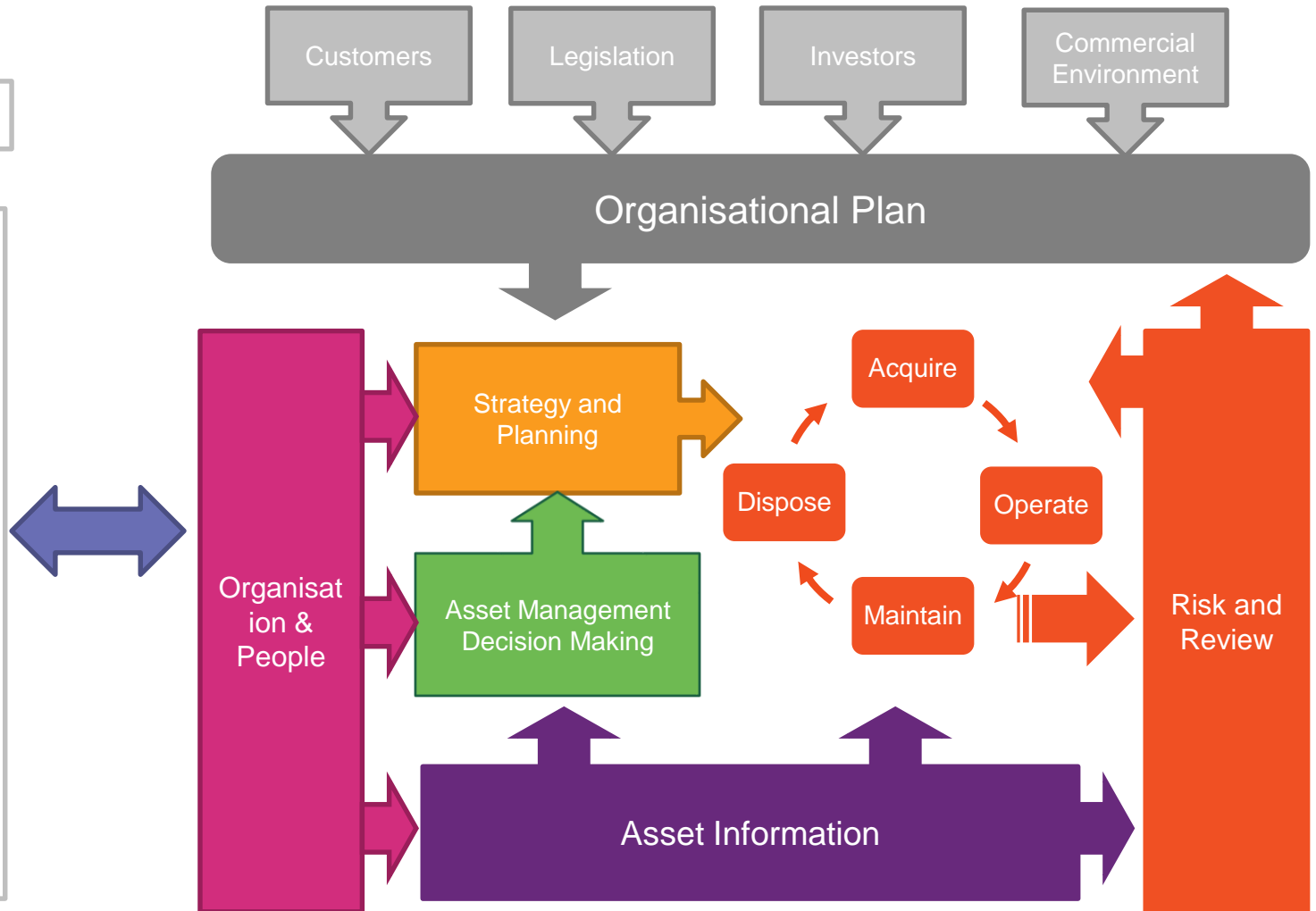
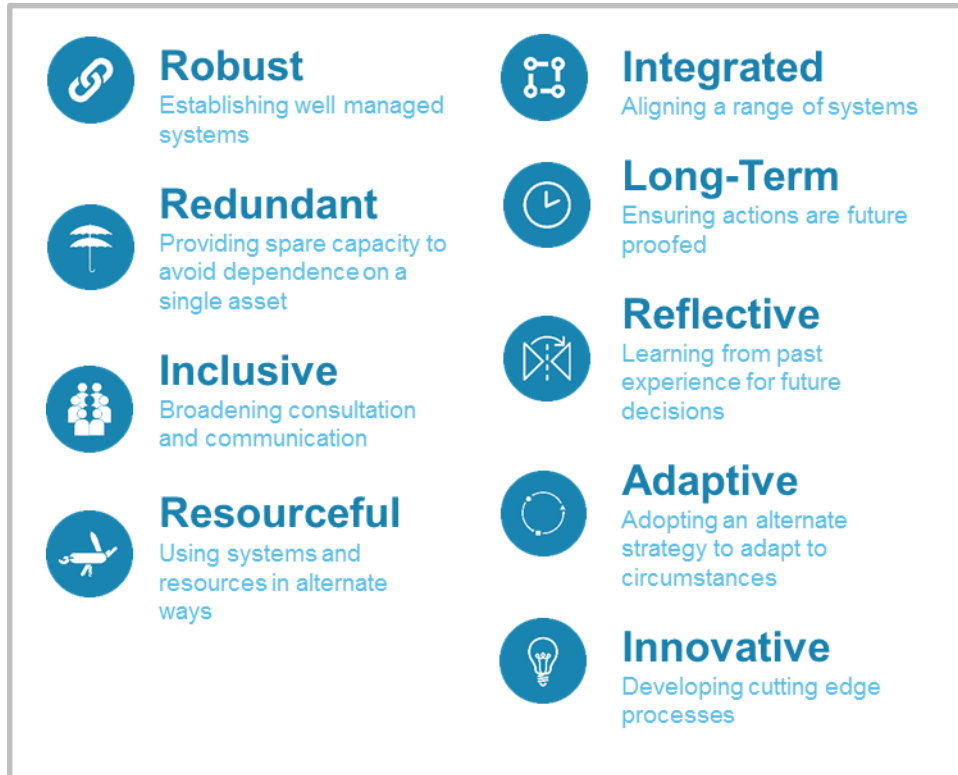
# Typical Resilience Timeline



Resilience maturity	Before	During	After
Awareness	2		
Preparedness	2		
Forewarning	3		
Robustness		3	
Coping		4	
Response		3	
Recovery			2
Resource availability			1
Surveillance			1
Learning from event			3

# Asset Management Anatomy and Resilience

## Holistic organisational resilience framework:



Source: *Asset Management - an anatomy*, The Institute of Asset Management (IAM), 2015

<https://theiam.org/knowledge/Knowledge-Base/the-anatomy/>

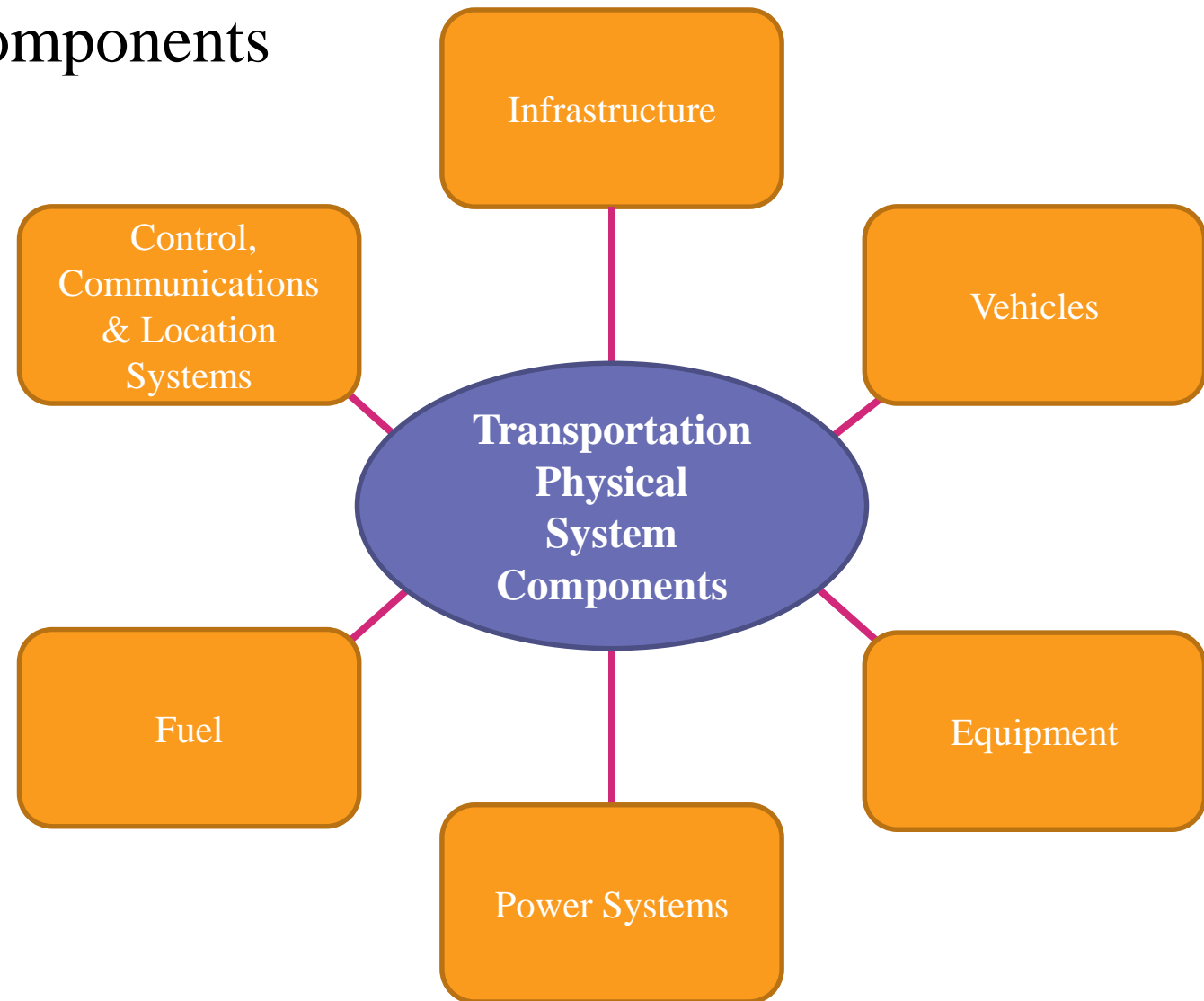
# AM Anatomy – Resilience Shocks / Stresses Mapping



Source: *Asset Management - an anatomy*, The Institute of Asset Management (IAM), 2015  
<https://theiam.org/knowledge/Knowledge-Base/the-anatomy/>

# Transportation System – Internal Components

- **Infrastructure:** Roads, tracks, stations, airports
  - **Vehicles:** Cars, bicycles, HGVs, ships
  - **Equipment:** Maintenance plants, loading cranes
  - **Power Systems:** Power plants, engines, living organisms (humans, animals)
  - **Fuel:** Petrol, diesel, electricity, renewable fuels
  - **Control, Communications & Location Systems:** Traffic monitoring, traffic control, GPS, data logging
- These internal components make the physical infrastructure of our transportation systems

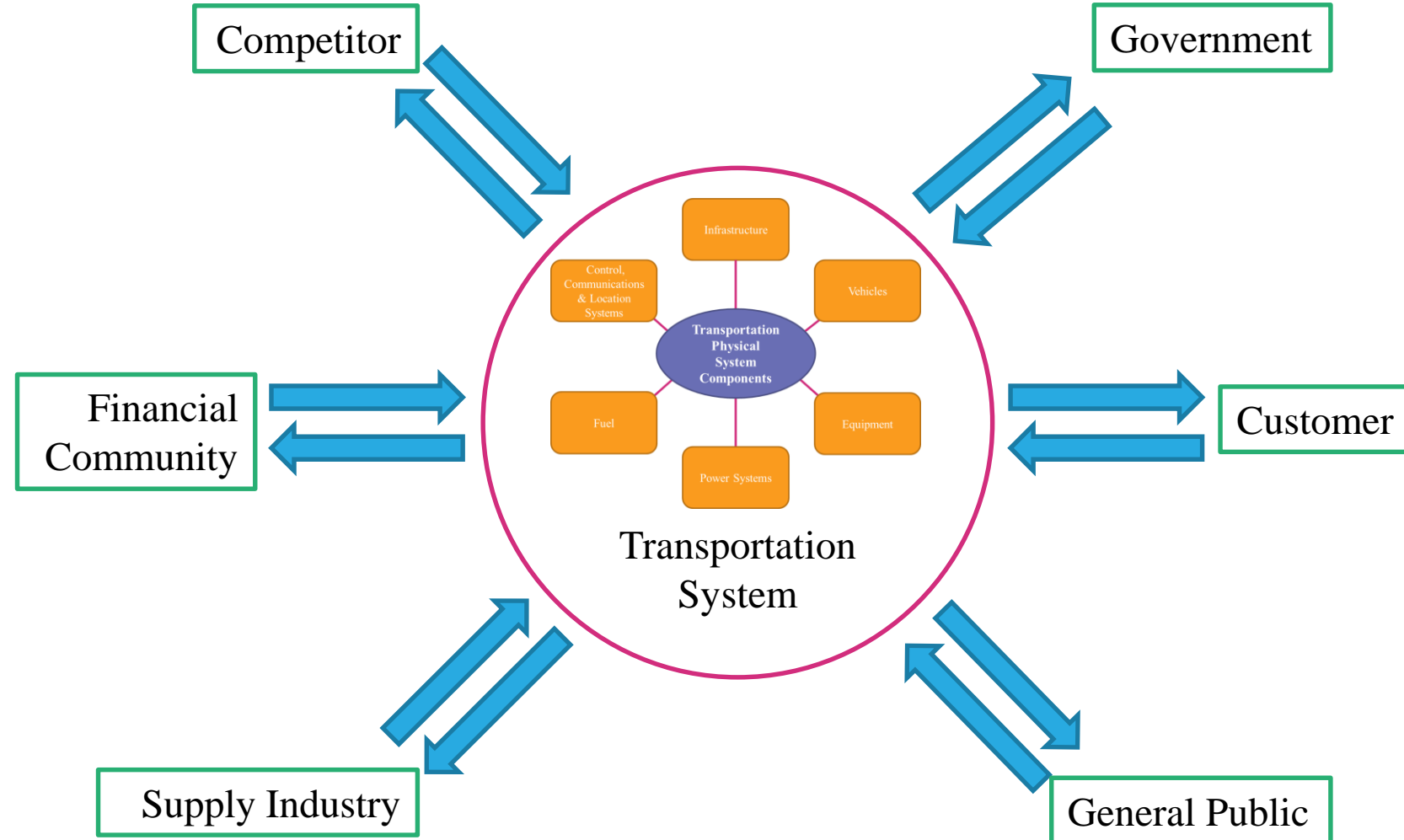


Source: *Resilience in Transportation Systems*, Tamvakis, Xenidis, 2012



# Transportation Systems – External Components

- External components common to every transportation system
- Building the framework of our systems
- Setting parameters of how we use transportation
- Defining how Transportation Resilience affects us in our lives



Source: *Resilience in transportation systems*, Tamvakis, Xenidis, 2012

# Testing Resilience – Three Examples for Shocks & Stresses

## Shock: Extreme Weather



- Storm Ophelia October 2017: €60m damages
- UK heatwave June 2017
- “The Big Freeze” 1962/63

## Stress: Electric Vehicles



- UK registration pure electric vehicles in 2017 up 33% from 2016; Petrol-Hybrids up 43%

## Shock: Brexit



- EU Membership Referendum 23 June 2016
- UK General Election 8 June 2017

# Testing Resilience – Three Examples for Shocks & Stresses

## Shock: Extreme Weather

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### Internal Systems Impact:

- Infrastructure damage to roads, tracks, ports and airports; disruption to services
- Damage to and loss of vehicles; no service until repair or replacement
- Power Systems might be interrupted; limited capacity for emergency response, repair and recovery
- Disruptions to fuel supply; limiting evacuation and emergency response efforts; potential for price increases
- Control & Communication Systems might be interrupted, damaged beyond repair; hindering effective emergency response, costly replacement

### External Systems Impact:

- Governments may be pressured for inadequate response mechanisms
- Lack of usability will deter customers leading to lost revenue
- Within general public, potential loss of live and access to places of work, lost production and cascading effects in globalised economy
- Supply Industry will become pressured to produce replacement parts and repair materials
- High insurance claims and losses will be felt in the financial community
- Competitors, if available will profit from disruption

# Testing Resilience – Three Examples for Shocks & Stresses

## Stress: Electric Vehicles

- UK registration pure electric vehicles in 2017 up 33% from 2016; Petrol-Hybrids up 43%



## Internal Systems Impact:

- Infrastructure requirement for increasing number of charging points
- Change in production of electric vehicles; high demand in specific products, i.e. batteries
- Power Systems experiencing higher demand of electricity; might not have additional capacity
- Traditional fuels will feel decreasing demand and price fluctuations
- Digitalisation and mobile technologies in electric vehicles will impact Control & Communication Systems

## External Systems Impact:

- Governments need to provide necessary legislation; incentives to adapt to new technologies
- Incentives may attract customers with low purchasing and running cost
- General public may benefit from lower emissions; disposal and sustainability of used batteries will remain a challenge
- Supply Industry will need to meet demand in materials and vehicles overall
- New markets and products might impact financial community
- Competitors, may profit from shorter travel distances and potential mixed-modal travel

# Testing Resilience – Three Examples for Shocks & Stresses

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### Internal Systems Impact:

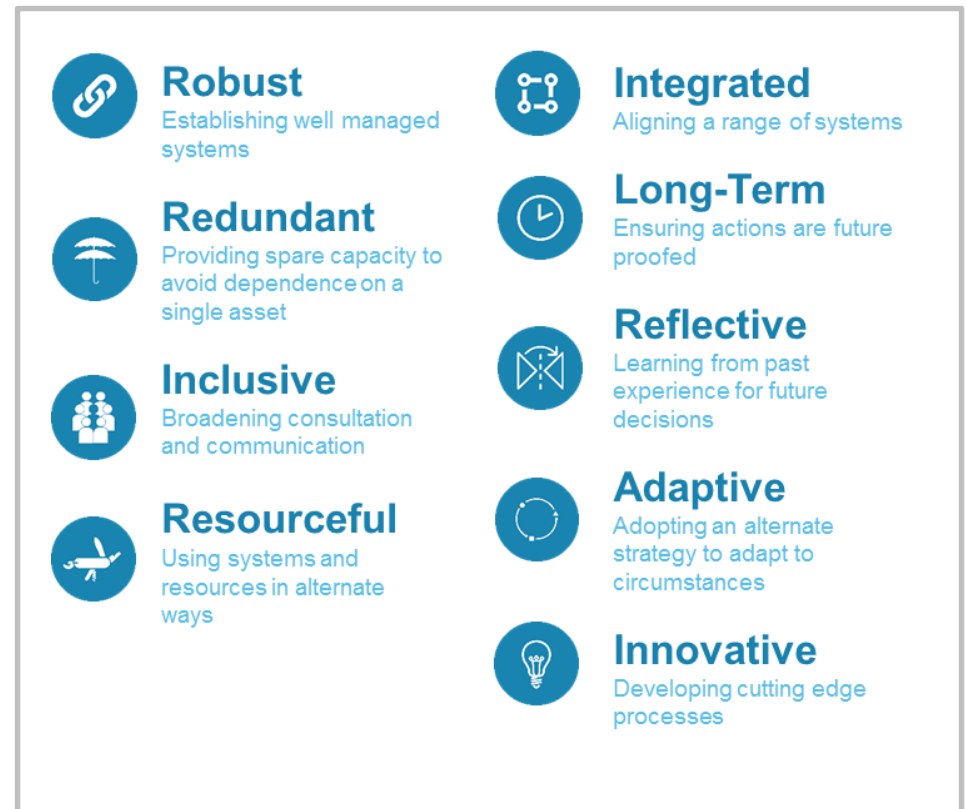
- Installation of border and customs controls will impact infrastructure; longer wait times affecting freight and travel
- Future trade agreements and tariffs may change usage of freight vehicles; less HGV, more ship traffic
- Fuel pricing might fluctuate due to tariffs and demand changes
- EU-wide developments in Control & Communication Systems may be impacted by legislation

### External Systems Impact:

- Governments need to consider trade and travel implications of new legislation and multi-national agreements
- Challenges to trade and travel outside of the UK might deter customers from transportation usage
- Supply Industry will need to reconsider production and supply chain arrangements in the face of tariffs
- Fluctuation in the markets has impacted financial community hesitation to invest and finance UK infrastructure projects
- Competitors, domestic travel and trade might increase, while international travel might decrease; car and train travel over air travel

# Transportation Resilience – Conclusions and Recommendations

- Take **holistic** view over asset- or systems focus
- What are the **acceptable levels of service**?
- What is the **disruption** to be avoided?
- Explore **interdependencies** of the internal systems and functions of the components
- Understand the **shocks and stresses** threatening the system as a whole, including cascading effects and multiple events scenarios
- Utilise new ways and possibilities in **data collection** and **analytics**
- Communicate with all internal and external **stakeholders** to achieve inclusive and acceptable solutions
- Extend planning **horizons** including future scenarios
- Understand interdependencies on a **national and global level** to prevent unexpected disruption
- Build **contingency** and **emergency response** plans, build capability to recover from impacts of national scale



# Thank you for your attention



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# Resources:

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