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Adaptation planning: Transport & Infrastructure Rail Sector

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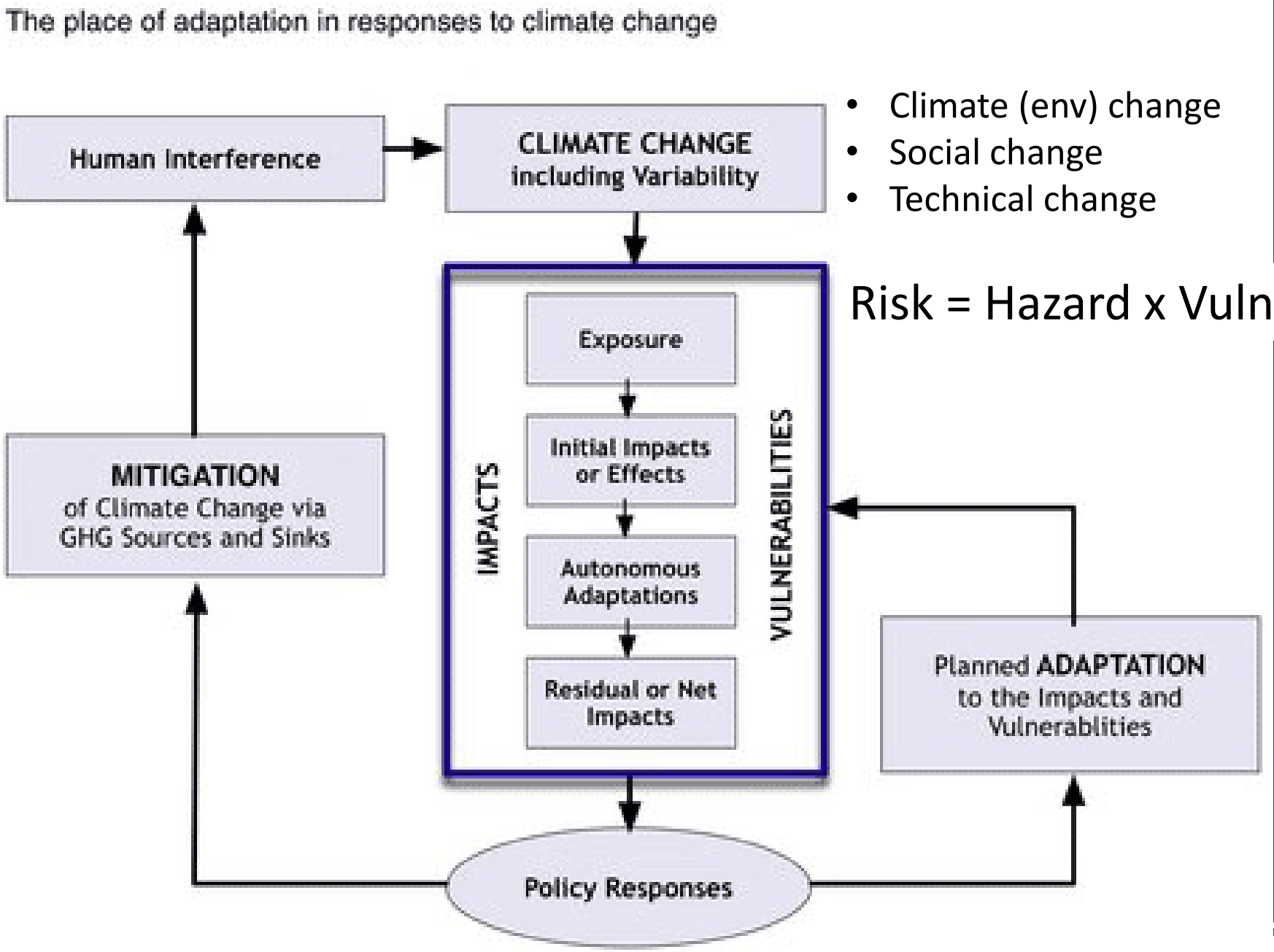
21st Century challenges

- Environmental impacts of development
  - Energy and carbon, water, air pollution
- Security, Social equality and access to resources
- Changing climate and natural hazards
  - Ukraine 2080 (compared to 1990)
  - 2-5°C temperature rise (summer) ±20% precipitation
    - Increasing summer dry periods
  - 3-8°C temperature rise (winter) +10/25% precipitation
    - Winter precipitation includes less snow, (but more freeze-thaw)

Policy Responses



- Climate (env) change
- Social change
- Technical change

Risk = Hazard x Vulnerability x Consequence

Mitigation insufficient or impossible

Adaptation is required

Transport is 'A difficult sector to adapt', having 'large secondary economic impacts' with 'regional and global consequences'

IPCC(2014) Impacts, Adaptation, and Vulnerability WGII report Ch8

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Context of Ukraine Rail Sector

- Long history (1850s through to today UZ working with DB)
- Extensive network ~27,000 km ~50% electrified
  - Diversity of infrastructure
  - 82% of freight and 50% of passenger transport
  - Challenges (before climate change)
    - Capacity, especially at critical locations
    - Balancing social and financial needs
    - Modernisation of infrastructure and rollingstock
      - Including electrification of existing lines

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Picture 26.9.2018 by Marek Graff

Understanding Risk

All of these are changing with time, along with society's idea of what is acceptable

Picture 24.9.2018 by Marek Graff

- Understanding Hazards
  - Climate/weather/geotechnical data
- Understanding Consequences
  - Technical (fail-safe)
  - Financial
  - Non-financial (social)
  - 'knock-on' consequential
- Understanding Vulnerability
  - Infrastructure of different ages
  - Different design standards
  - High interdependency of systems
  - Geographical distribution
  - Sensitivity to many variables and combinations of variables
  - Constant maintenance programme

How to address adaptation?

Learning lessons (Quant & Qual)

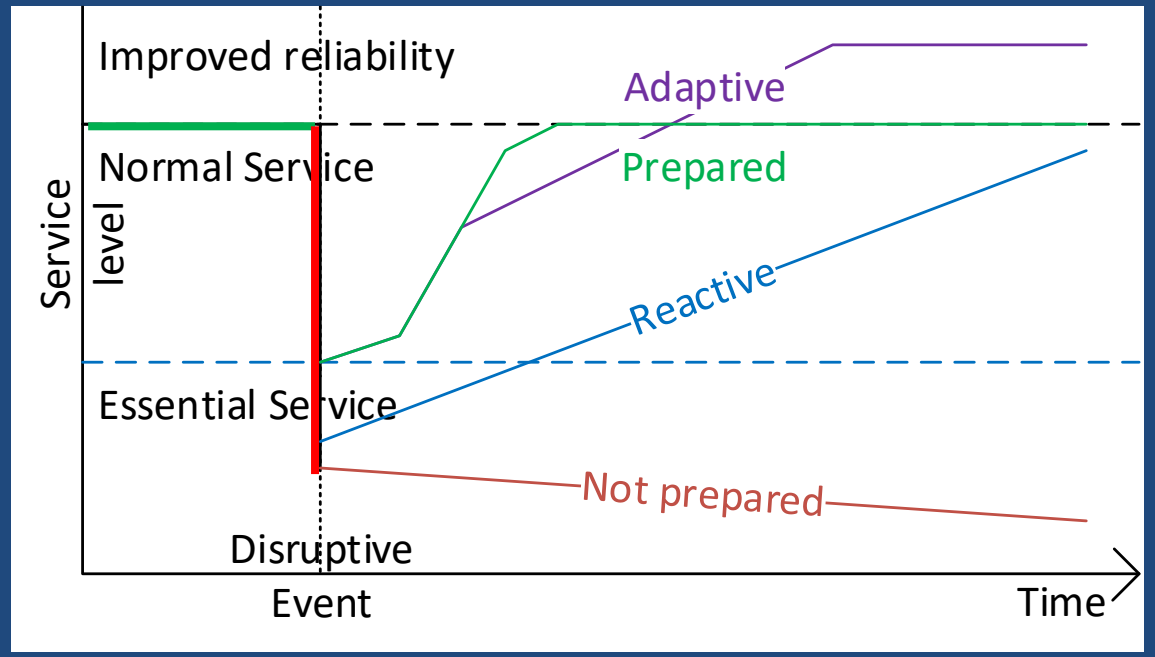
- From past events

MOWE-IT
MANAGEMENT OF **WEATHER** EVENTS IN THE **TRANSPORT** SYSTEM

- From other places (analogues)

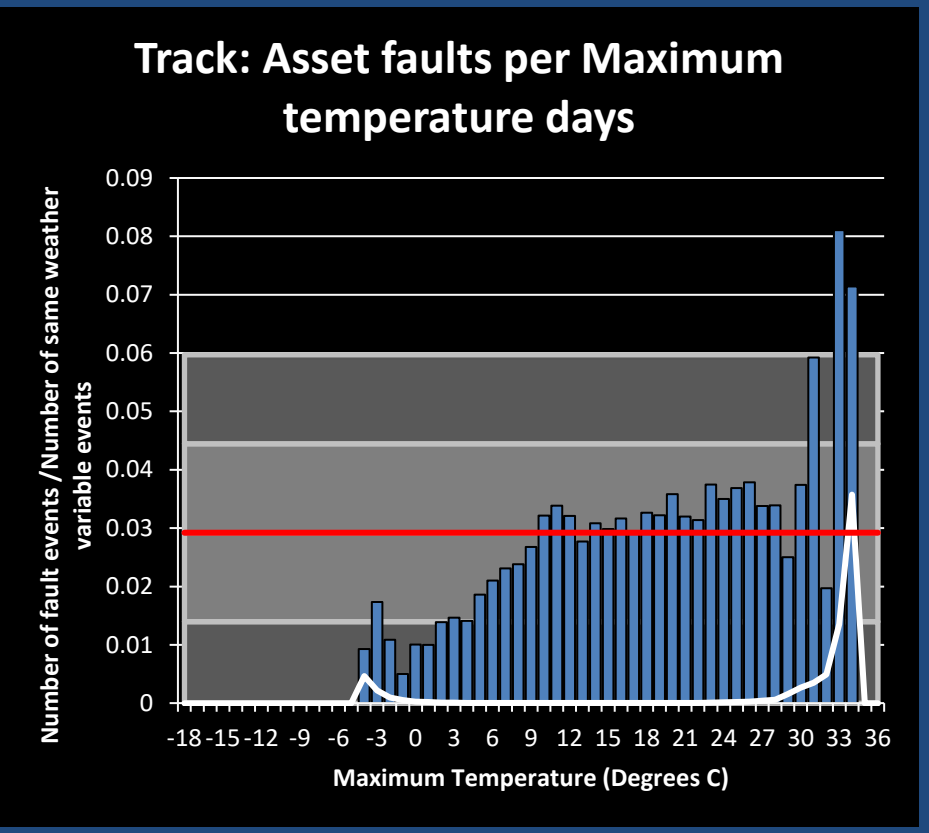
Assessing Vulnerability

- Interdependency
- Pathways to failure



- **Consider Pathways to Resilience**
  - Robustness (doesn't fail)
  - Redundancy (backup available)
  - Recovery (rapid return to service)

Learning from past events



- Routine events data
  - Known issues
  - e.g. track buckling
  - 'Unknown' issues
- Extreme events
  - Learning from others

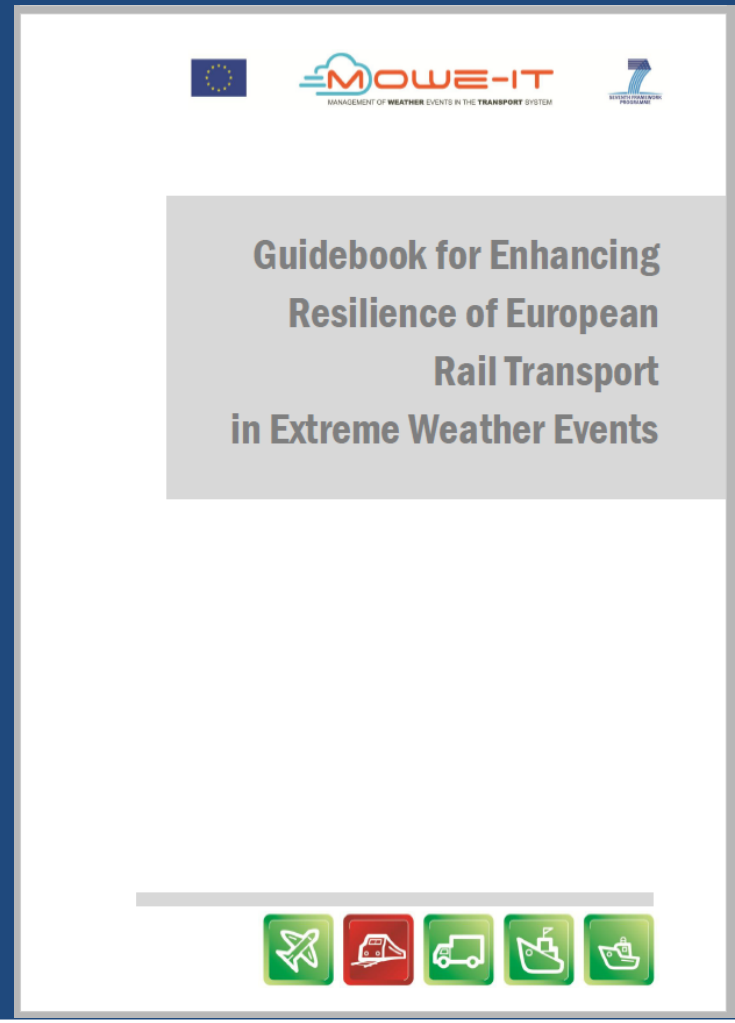


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Table 4 - Network wide delays to passenger and freight trains by detailed cause category 2012/13 (delay minutes) - data from Table 1.13 Network Rail (2013)

	Passenger Trains		Freight Trains		Combined Total	
Category	Delay Minutes	Delay per 100 track km	Delay Minutes	Delay per 100 track km	Delay Minutes	Delay per 100 track km
Points failures	468,164	0.10	107,705	0.29	575,679	0.11
Problems with trackside signs including TSR boards	20,684	0.00	2,349	0.01	23,010	0.00
Level crossing failures	85,592	0.02	13,427	0.04	99,275	0.02
TSR's Due to Condition of Track	27,383	0.01	39,428	0.11	66,823	0.01
Track faults (including broken rails)	639,031	0.13	130,310	0.35	770,344	0.15
Rolling Contact Fatigue	5,410	0.00	279	0.00	5,689	0.00
Reactionary delay to planned TSRs	92,651	0.02	15,473	0.04	108,660	0.02
Civil Engineering structures, earthworks & buildings	138,513	0.03	21,675	0.06	160,261	0.03
Other infrastructure	225,363	0.05	40,387	0.11	265,911	0.05
Track Patrols & related possessions	27,097	0.01	6,487	0.02	33,588	0.01
Possession over-run and related faults	141,158	0.03	37,267	0.10	178,395	0.03
Other possession related delay	50,204	0.01	5,850	0.02	59,778	0.01
Mishap – infrastructure causes	145,001	0.03	21,623	0.06	166,605	0.03

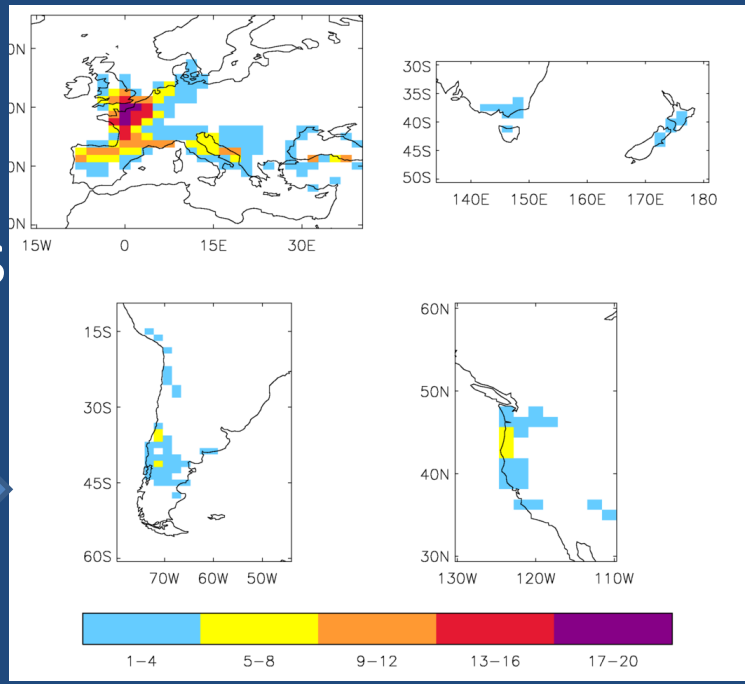
Metrics and performance

Note how generalisation can mask true causes

‘Track faults (including broken rails) ’ contains several reason codes and within each of these are several potential weather related failures from high or low temperatures, drought and/or excess precipitation.

Adaptation and Analogues

- As part of the ‘Tomorrow’s Railway and Climate Change Adaptation’ project
- Studied Results from 20 global climate models
  - Present day: 1971-2000 [“Baseline”]
  - Mid 21st century: 2035-2064
  - Late 21st century: 2070-2099
- Seeking areas that today have weather like the UK will have in future – and similar railway!



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What Adaptation planning looks like in Rail

- Rail Adapt was sponsored by UIC
- Workshops in London/Beijing
- 90 people / 50 organisations / 20 countries
- Informed by a background document

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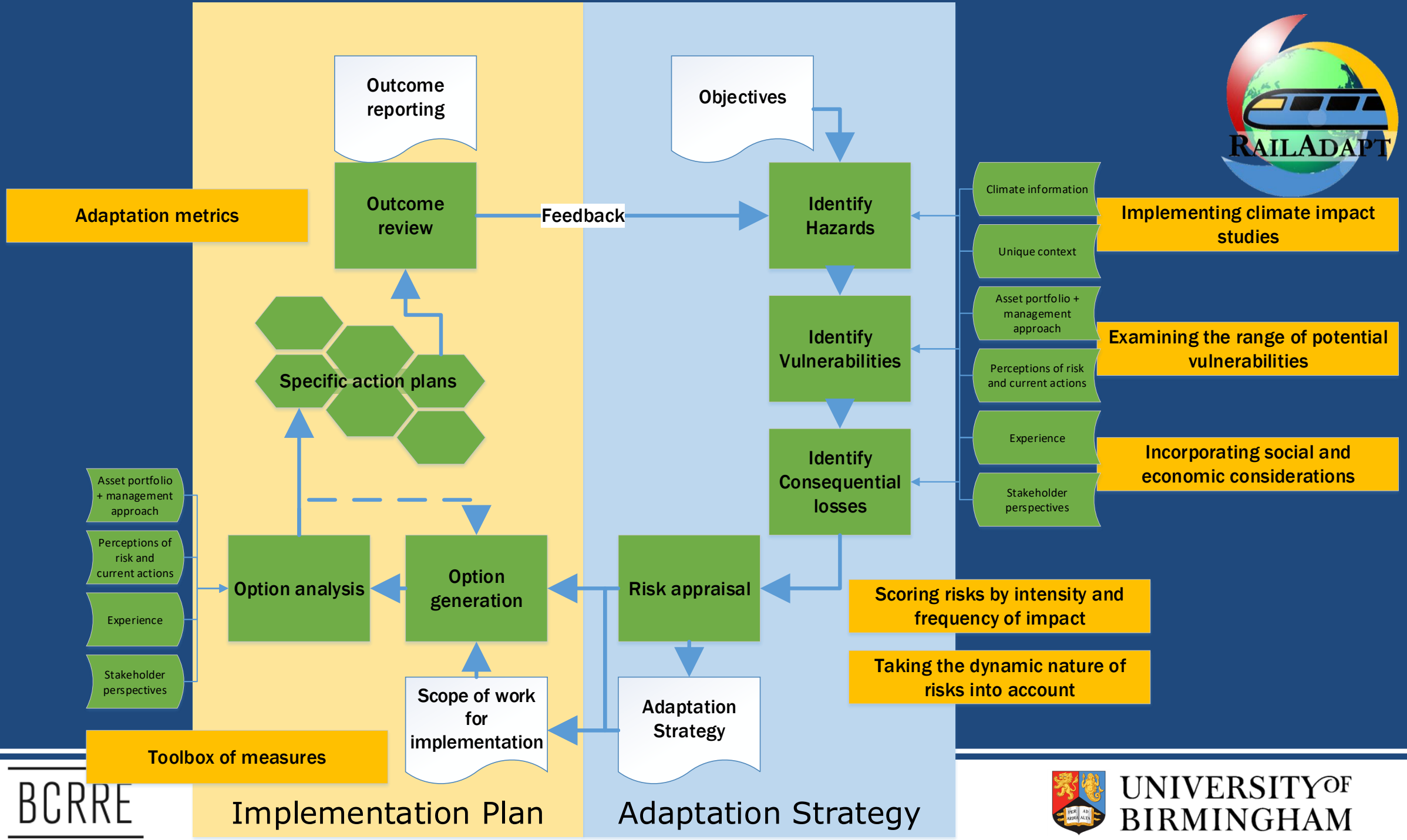
Principles

- Avoid reinvention (i.e. duplication)
  - Activities, processes, codes of practice etc.
- Link mitigation, adaptation, sustainable development
  - Mirroring common Sendai, Paris, SDG approaches
- Link broadly within an organisation
  - Avoid stand alone ‘department for adaptation’
- Link broadly outside an organisation
  - Mutual benefits and wider expertise
- In mobility field work across modes
  - e.g. Mutual support in times of disruption
  - e.g. Commonly certified contractors
- Adaptation is not a ‘project’ or ‘extra’
  - Needs to be iterative and business-as-usual



RAILADAPT

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Option examples

- New infrastructure
  - Design codes, standards and specifications for the future climate
  - Smart self-monitoring / repairing systems
- Existing short-life infrastructure
  - Enhanced recovery capability e.g. spare capacity
- Existing long-life infrastructure
  - Enhanced monitoring, inspection and renewal where necessary

Key messages

- Cross-sector and inter-agency working
- Strategy that enables various options
- Giving variety of potential responses
- Future requirements are:
  - Consistent evaluation techniques and metrics
  - Whole system modelling capturing disruption

http://uic.org/IMG/pdf/railadapt_final_report.pdf

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Weather and climate hazards and respective risks for railway infrastructures – ARISCC project

Factor	Effect	Impact on Railways/Assets
All listed factors/events will occur more often and their impacts will be more severe according to the existing climate models		
1. Temperature	**change of distribution patterns, higher average and maximum temperature**	
1.1 High temperatures and heat waves	overheating	infrastructure equipment
		rolling stock equipment
1.2 Sudden temp changes	tension	track buckling
1.3 Intense sunlight	overheating	track buckling, slope fires, signaling problems
1.4 Freezing and thawing cycles	soil erosion	damage to embankments, earthwork
2. Precipitation	**change of distribution patterns, more extreme events**	
2.1 Intense rainfall	soil erosion, land sides, flooding	damage to embankments, earthwork
2.2 Extended rain periods	slower drainage, soil erosion	other infrastructure assets, operation
2.3 Flooding: coastal, surface water, fluvial	landslides	drainage systems, tunnels, bridges
2.4 Drought	desiccation	earhworks desiccation
2.5 Snow and Ice	heavy snowfall, avalanches	restrictions/disruption of train operation
3. Wind	**change of distribution patterns, more extreme events**	
3.1 Storm/gale (inland)	higher wind forces	damage to installations, catenary
	uprooting of trees	restrictions/disruption of train operation
3.2 Coastal storms & sea level raise	Coastal flooding	embankments, earthwork, operation
4. Lightning strikes and thunderstorms	Overvoltage	catenary and signaling
5. Vegetation		vegetation management

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NATURAL RISKS	POTENTIAL EVENTS						
	Track	Power supply		Control Command and Signaling		Rolling stock	Operating
		Catenary	Substations	Signaling	Telecommunications		
High temperature	rail buckling	catenary dilatation	component heating			component heating	
						air-conditioning shutdown	
Low temperature / Frost	rail broken	catenary freezing	Components freezing			pantograph failure	
	switch malfunction					brake malfunction (hydraulic system)	
	ballast stones thrown (ice coming away from trains)					components damages by thrown ballast stones	
						doors freezing	
Snow / Avalanche	switch malfunction		components short-circuit (snow invasion)			snow packing	
	ballast stones thrown (snow coming away from trains)					components damages by thrown ballast stones	
	track covered by snow					components short-circuit (snow invasion)	
	snowdrifts					brake malfunction (snow between disk and pad), derailment	
	destruction	destruction		destruction		destruction	
						derailment	
Change of humidity or high humidity			components short-circuit (condensation)			components short-circuit (condensation)	
Strong wind		Short-circuits due to trees or branches which fall on the contact wire.				overturning	
Sand and dust	switch malfunction		sand/dust invasion into components			sand/dust invasion into components	
Heavy rain	Earthworks damages – Embankment collapses						
Flood, Tsunami	Destruction – Embankment collapses	destruction	destruction	destruction	destruction	destruction	Operating impossible
			short-circuits			short-circuits	
			no power supply from external providing				
Seashore corrosion	Embankment collapse	Rusty Components					
Fallen rocks	track destruction	catenary cut	substation damages	components broken or cable cut		derailment / overturning	
Seismic event	infrastructure destruction	destruction		components broken or cable cut		derailment / overturning	
		fire (short-circuit)	fire (short-circuit)	power supply loss			
			no power supply from external providing				
Surrounding fire		Some components can be burned					operating impossible
Salt injury	Rust	Rust				Rust	
		Reduction of electrical insulation performance				Reduction of electrical insulation performance	
Fallen leaves (for CR)	Slippery rails					Locking of wheels	
Thunderstorm	Embankment collapses - Destruction		Short-circuit No power supply from external providing				

Risk Matrix from UIC Systra report

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