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Transport Infrastructure Ireland

Transport Infrastructure Ireland

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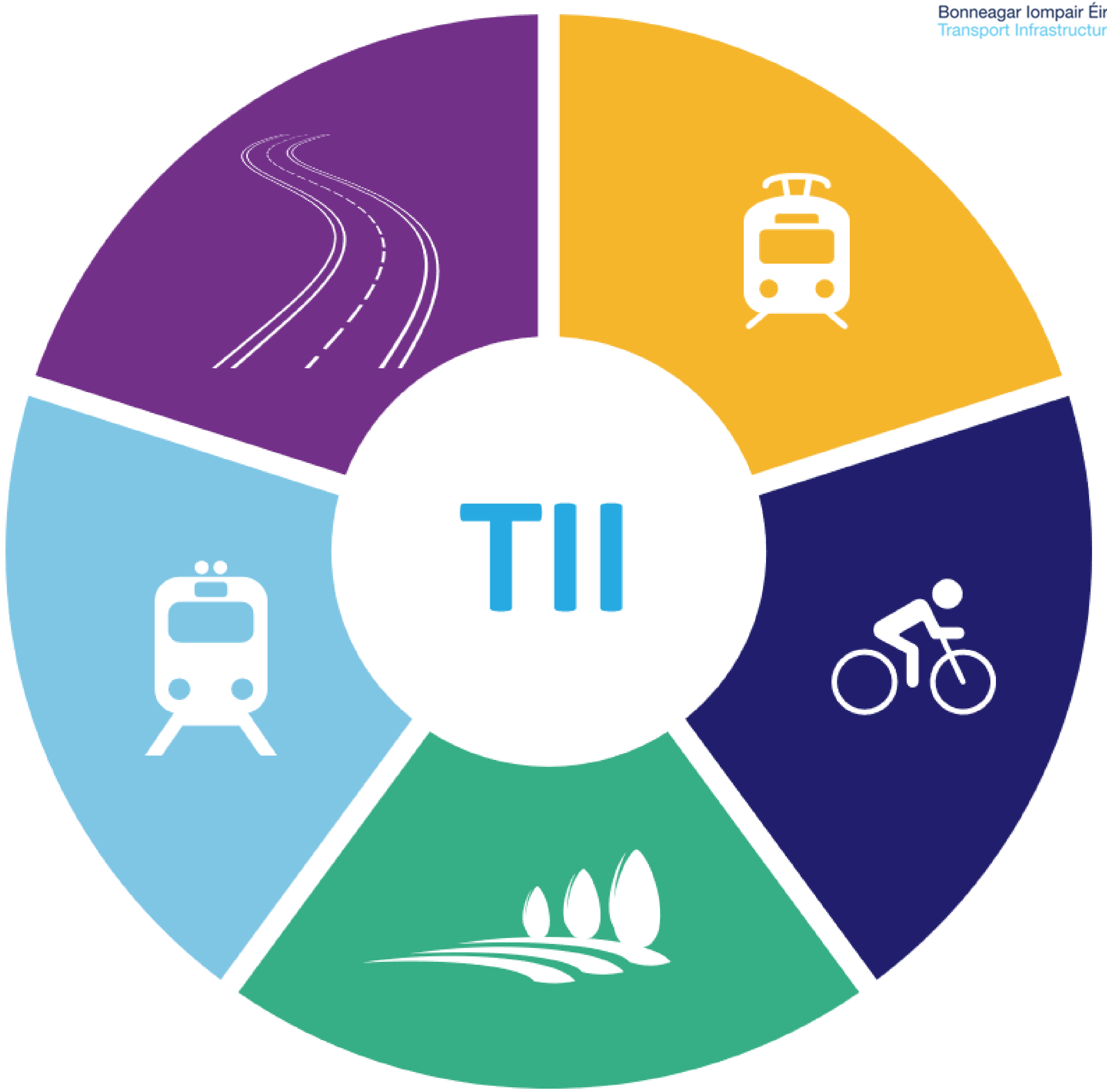
Deighton User Conference – June 2024

Agenda

- *Agency Overview*
- *Challenges Faced*
  - *TII Carbon Reduction / Climate Change Resilience*
- *TII Asset Management*
  - *Current / Future Assets*
- *dTIMS in TII*
  - *TII’s journey with dTIMs since 2011*
  - *Challenges & Solutions*
  - *Latest Enhancements to PMS*
  - *Deterministic V Probabilistic Modelling*
  - *How dTIMS impacts our network*
- *Q&A*



Road Network – Assets Managed

TII has been **leading the development of the Major Interurban Road Network** across the country, connecting Ireland's major cities for the past 25 years.

Across **5,314km** of national roads, TII manages:

Carriageway & Earthworks
assets worth
€ 14.1 billion

5314 km roads
1200 km is high quality motorway and dual carriageway

Drainage & Ducting
assets worth
€2.5 billion

600 km urban positive drainage
1200+ km designed drainage
(filter, carrier, kerb and gulley)

Bridges, Walls and Structures
assets worth
€ 4.2 billion

3400 structures,
700 gantries

Land
assets worth
€ 5.2 billion

14000 hectares

Tunnels & Major Structures
assets worth
€ 1.9 billion

3 x tunnels
(1 x bored
2 x immersed tube)

Traffic Systems, Signs and Markings
assets worth
€ 0.4 billion

600 traffic signals
130,000 road signs

Street Lighting
assets worth
€ 0.2 billion

42,000 streetlights

Footpaths and Cycleways
assets worth
€ 0.1+ billion

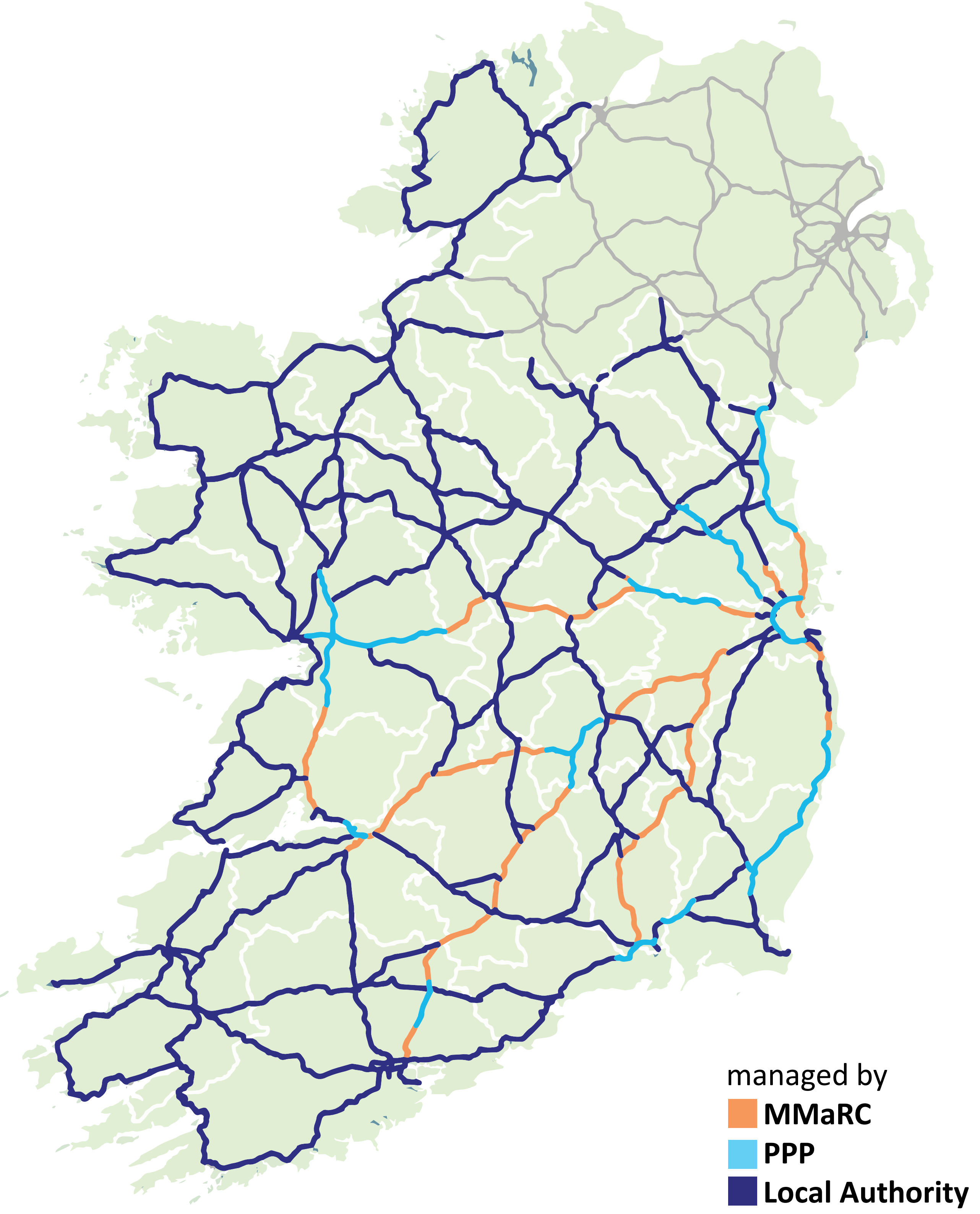
1000+km of footpaths,
200+ km cycleways

Gross Replacement Cost of TII Road Network

€31 billion

GRC

*Other Ancillary Assets not shown such as buildings, depots, ITS, safety barriers, other street furniture, utilities and accommodation works total c . € 2.4bn



National Cycling Network

- TII is leading the development of an ambitious new **National Cycle Network** for Ireland
- The proposed National Cycling Network will span **3,500km**, linking over 200 cities, towns, and villages across Ireland

Greenways Network

- TII plays a pivotal role in the development and enhancement of the **Greenways Network** in Ireland.
- On behalf of the Department of Transport, we are investing **€60m a year in greenways** until 2030.
- We are supporting local authorities to deliver more than **200km of greenways** as part of the National Cycle Network and a further **100km of recreational greenways**. TII funded **70+ Greenway Projects in 2023.**

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Challenges Faced

TII Carbon Reduction and Climate Change Adaptation and Resilience

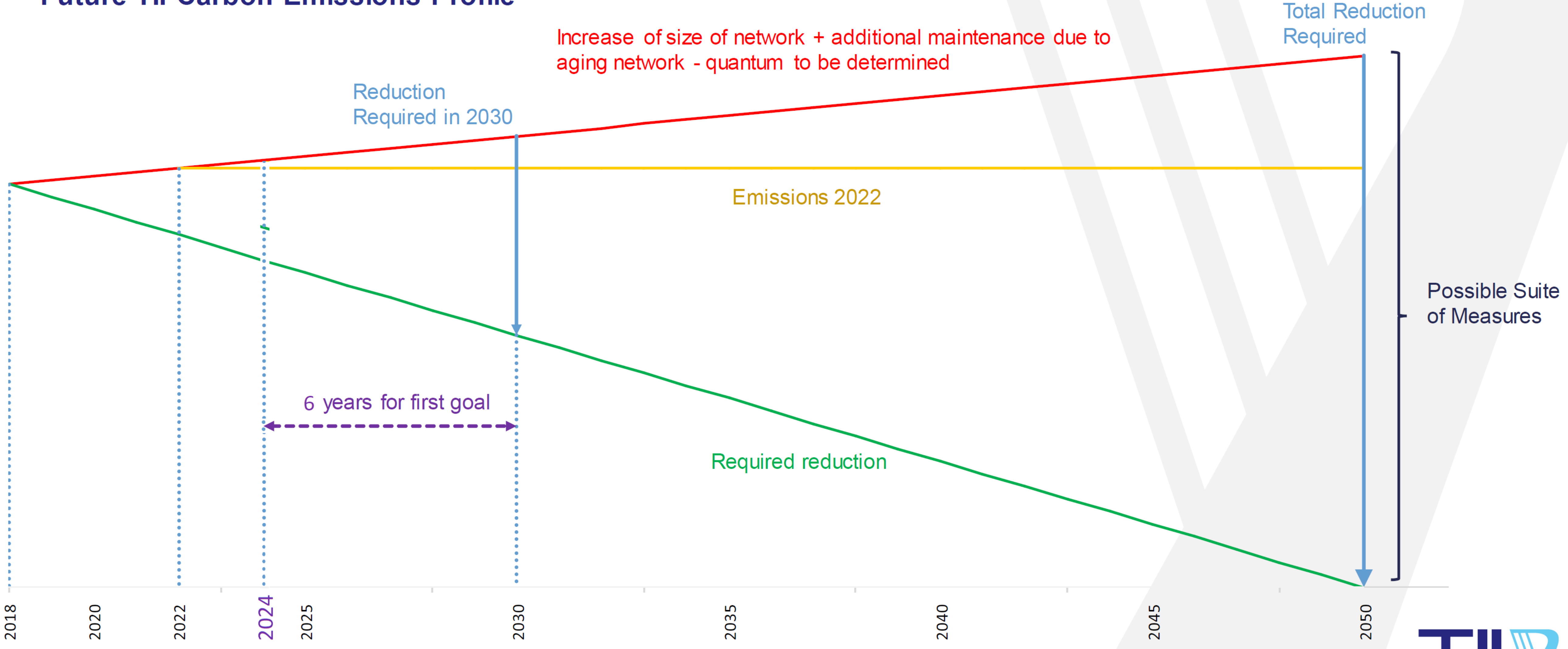
Carbon Reduction

Table 1 TII's seven strategic objectives for climate adaptation

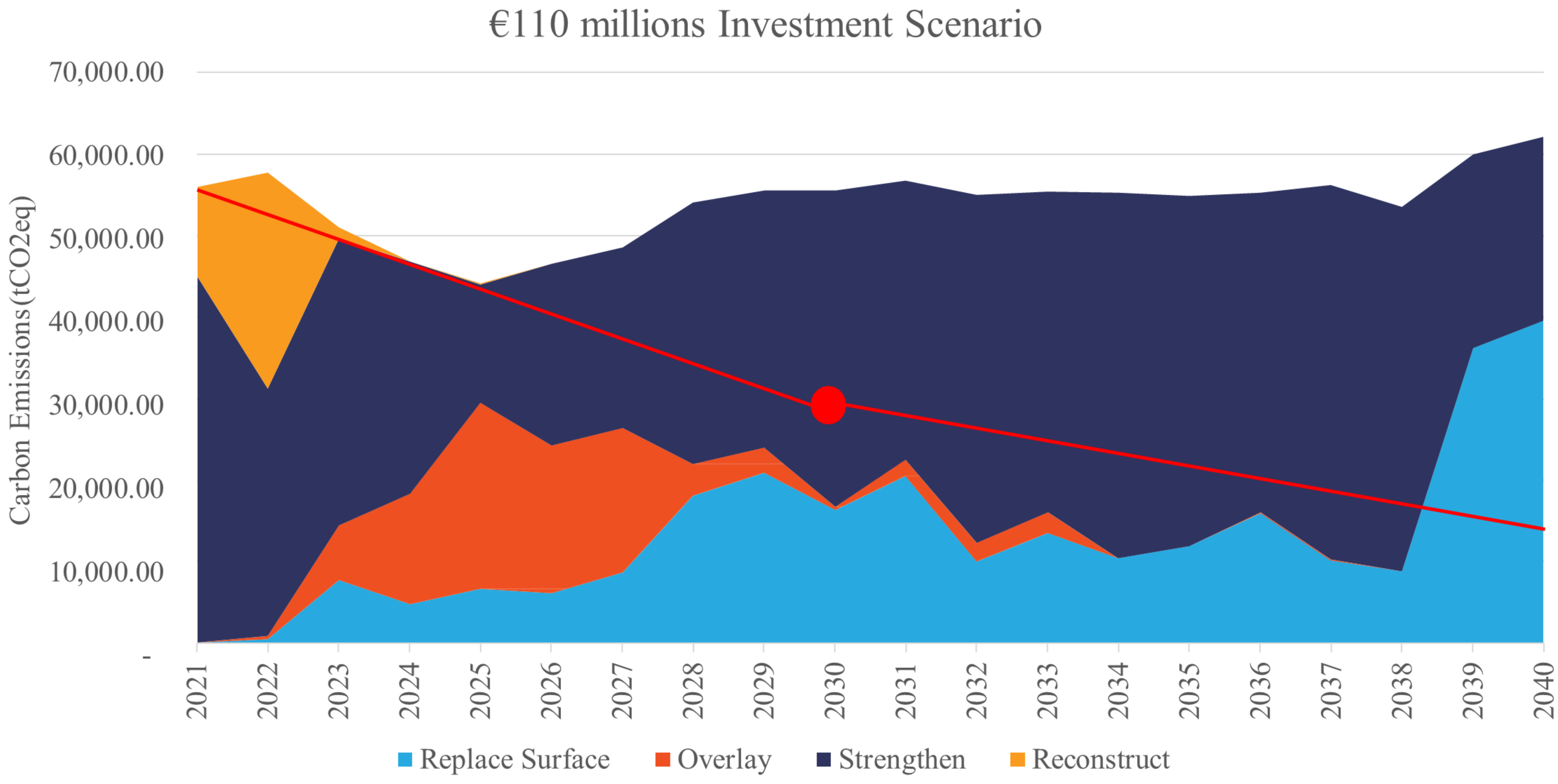
TII's seven climate adaptation strategic objectives	
1	Observe fewer network disruptions during climate-related events.
2	Rapidly recover from any climate-related events.
3	Have a robust, flexible, and equitable organisation that responds effectively during climate events.
4	Enhance the climate resilience of lifeline roads in order to maintain community accessibility.
5	Engage with the wider adaptation efforts across Ireland through partnerships and wider research.
6	Embed climate adaptation within TII's operations, policies, and procedures in order to ensure a safe and resilient network.
7	Adopt a low-carbon approach in TII's designs, standards, and processes when considering climate adaptation, while also considering wider social and environmental benefits.

Pavement and Carbon

Future TII Carbon Emissions Profile



Carbon Emissions from Pavement Renewal Works

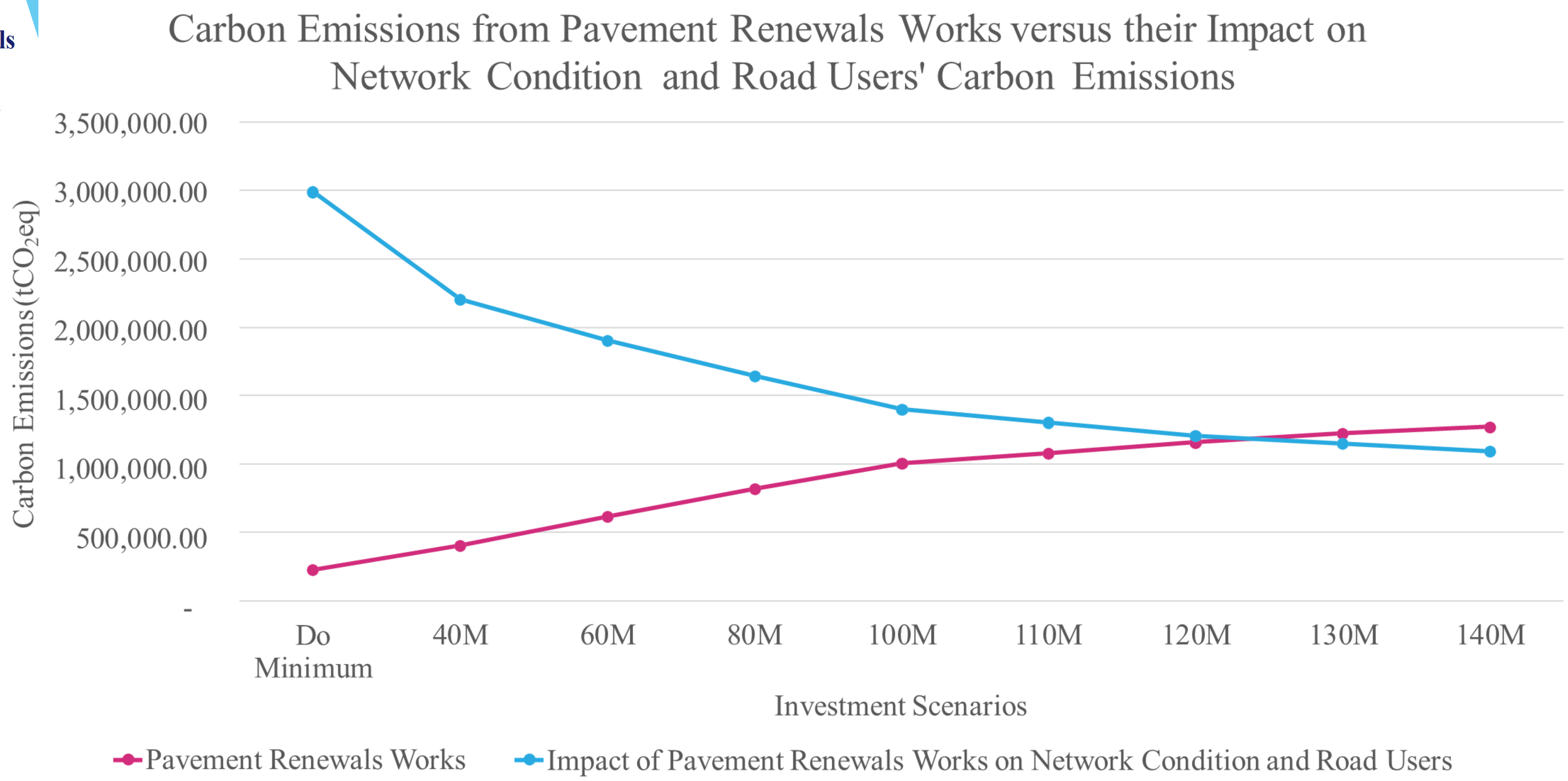


Carbon Emissions (CO2eq) Analysis

TII Pavement Renewals Business Case

Pavement Renewals Programme 2023 - 2027

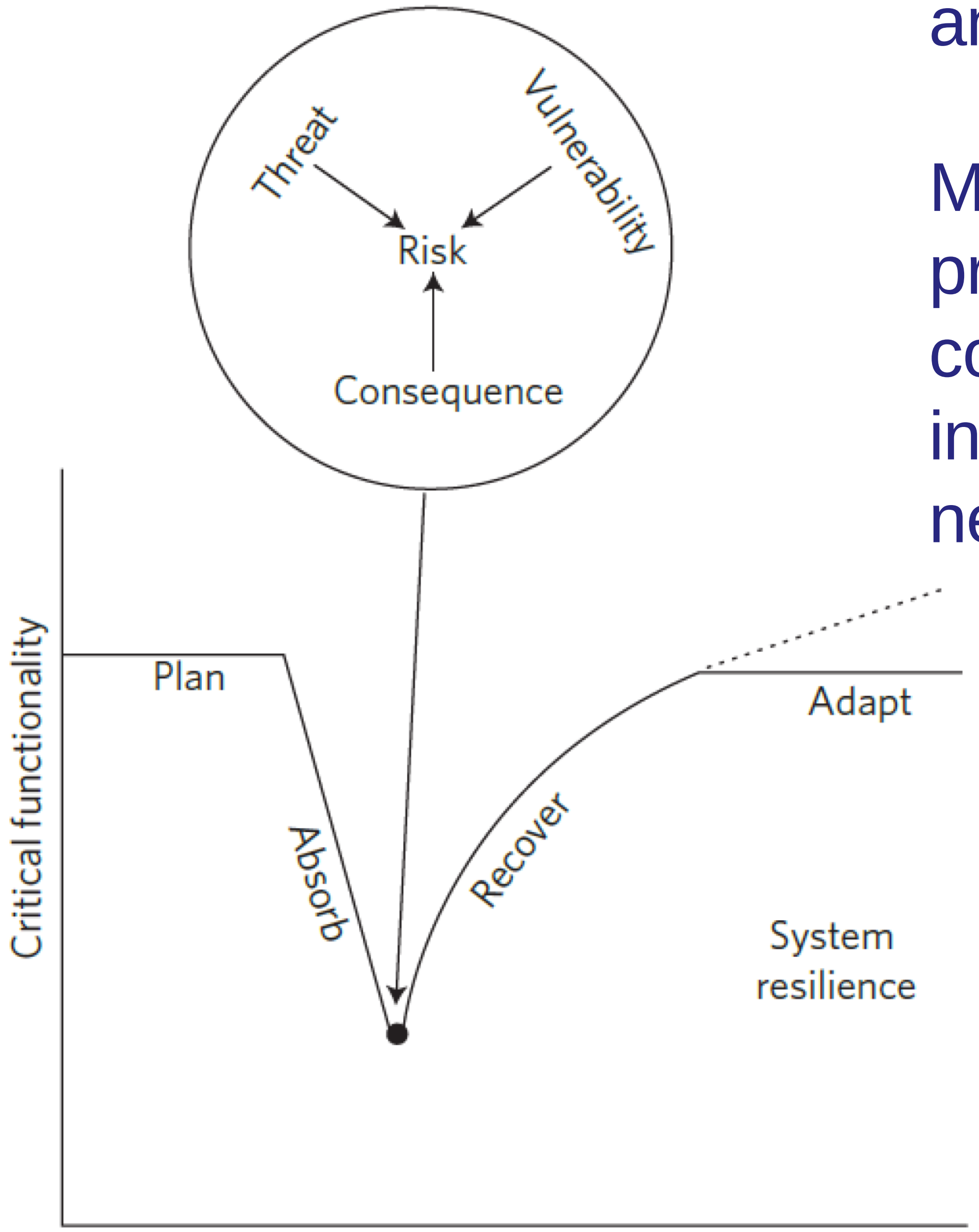
July 2023
(Issue 1)



Climate Change Resilience and Response

Resilience
The coping capacity or ability of a system or network to absorb, recover and adapt to an adverse event.

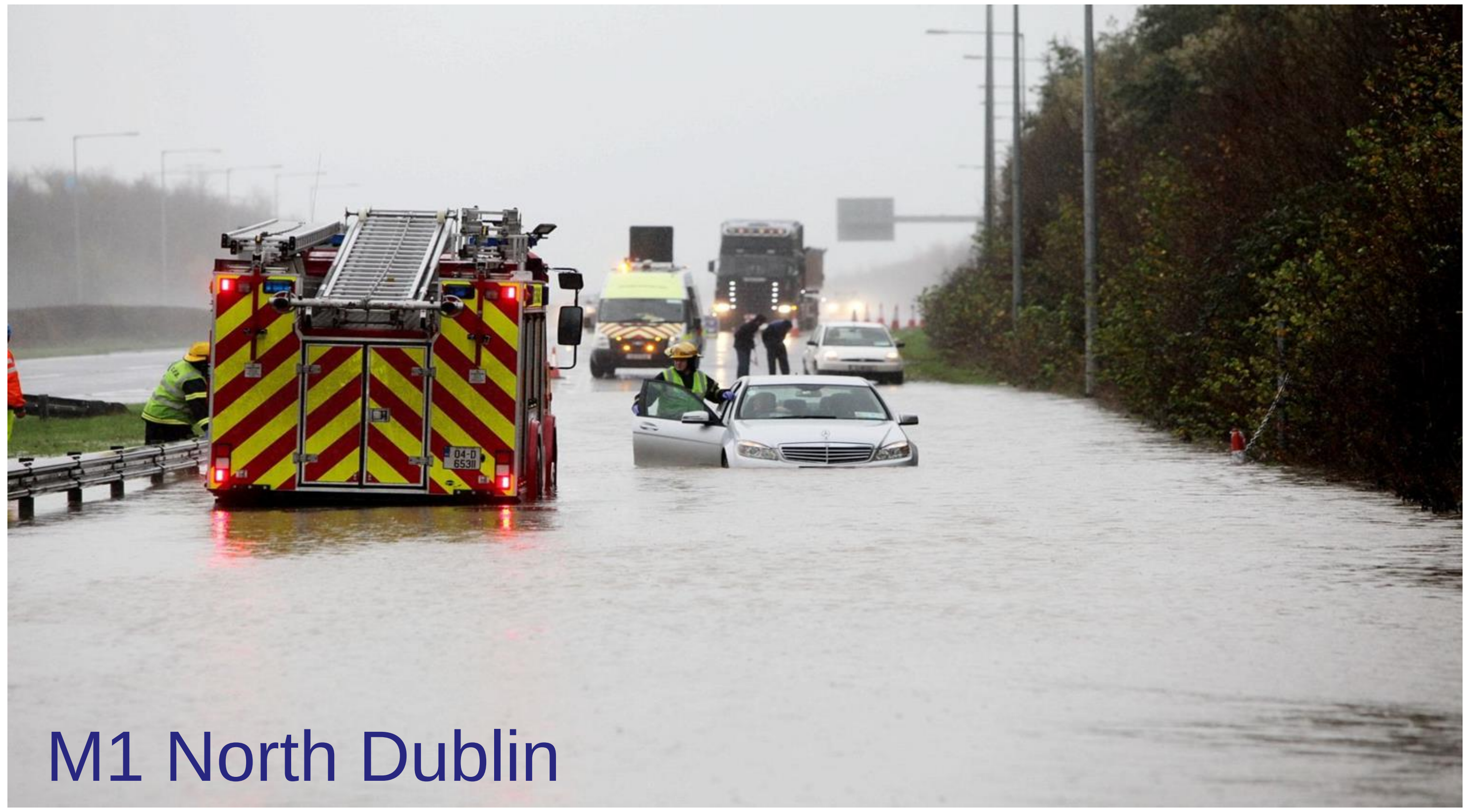
Minimising impacts on services provided to road users and communities through the restoration of initial conditions or the adoption of a new operating scenario



A resilience management framework including risk analysis as a central component (Linkov et al., 2014)

The Impact of Climate Change on the National Road Network

- More frequent and intense adverse climatic events?
- Safety?
- Disruption?
- Cost?
- Robust Infrastructure?
- Robust Operations?



M1 North Dublin

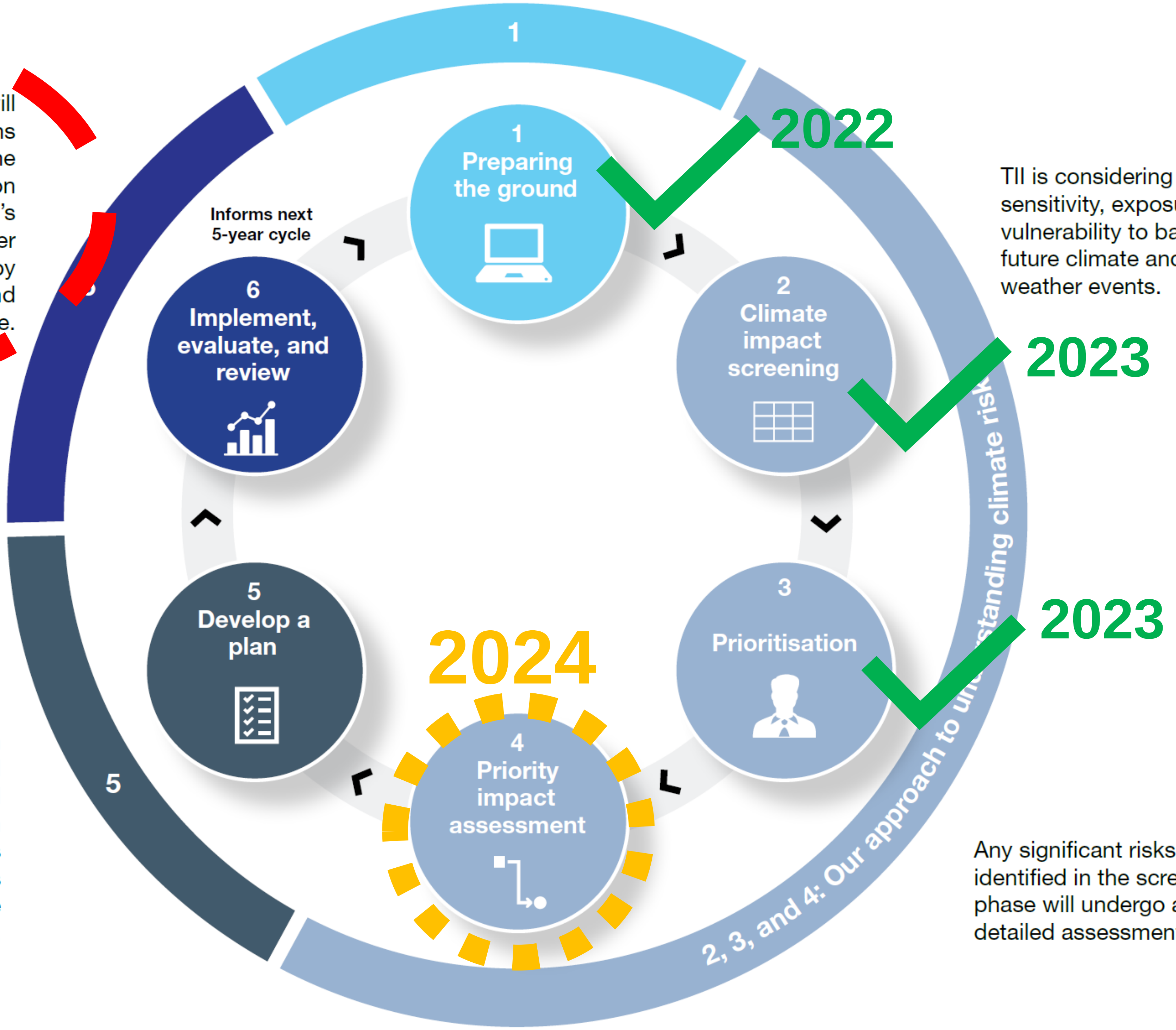
TII Climate Change Adaptation Strategy

TII has distributed responsibility for screening climate impacts across the organisation, to ensure that the Climate Adaptation Strategy is informed by those with the most relevant technical expertise.

Over the next five years TII will implement the adaptation actions and measures outlined within the Climate Adaptation Implementation Plans. TII will monitor the plan's progression, as well as consider how effective the measures are by setting up a process to evaluate and review performance.

This Climate Adaptation Strategy and its implementation will be owned by a sponsor at the senior leadership level.

Climate adaptation implementation plans will be produced which will outline the adaptation actions and measures being taken to address the risks outlined in the previous stages.



TII is considering assets' sensitivity, exposure, and vulnerability to baseline and future climate and extreme weather events.

Any significant risks identified in the screening phase will undergo a detailed assessment.

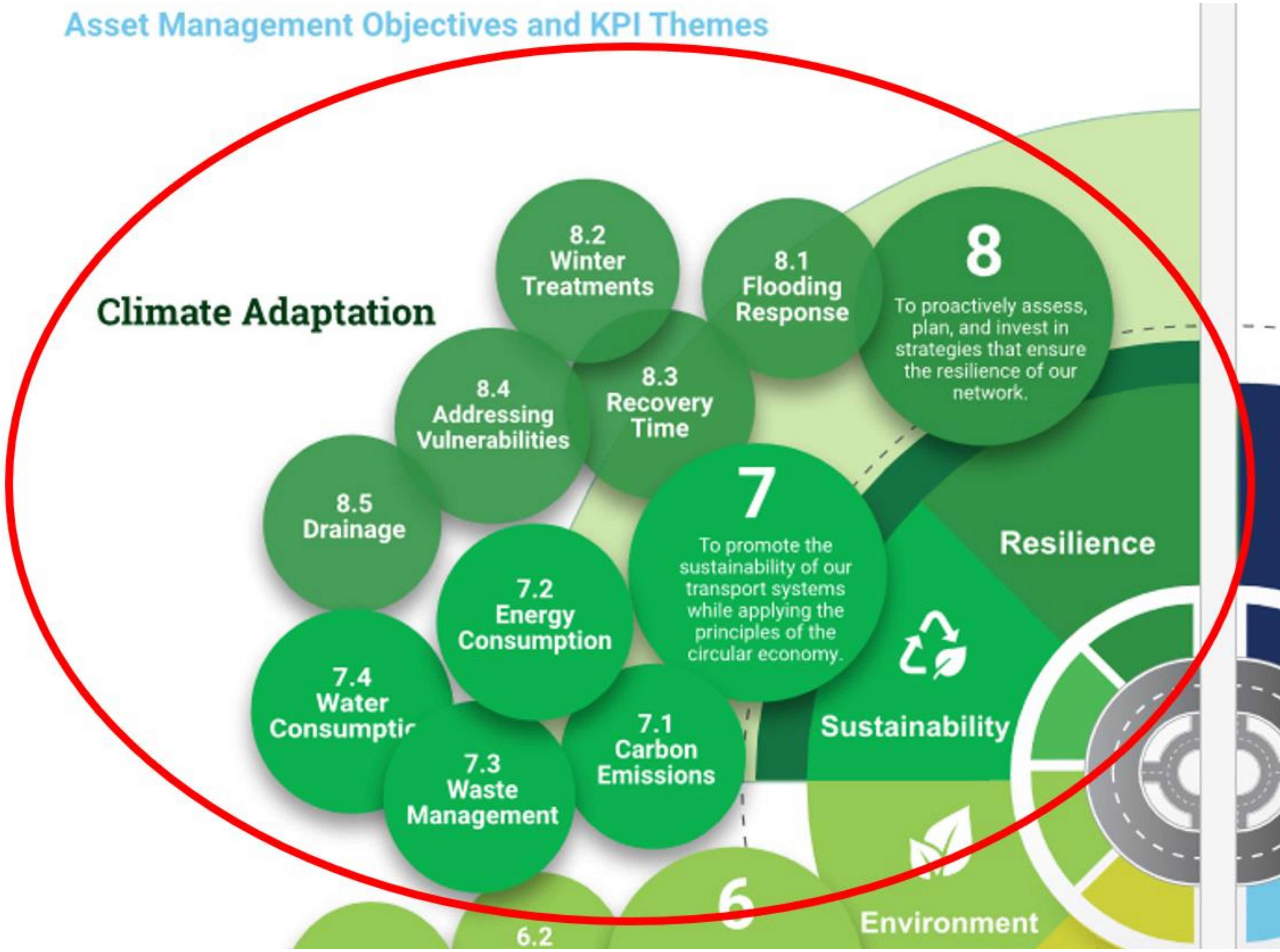
Figure 1 TII's climate adaptation approach, adapted from the Sectoral Planning Guidelines for Climate Change Adaptation [13]

Priority Impact Assessment

PLANNING, DESIGN, CONSTRUCTION, MAINTENANCE AND OPERATION

- FORWARD PLANNING
- RESPONDING TO DISRUPTIVE OR EMERGENCY SITUATIONS
- APPROPRIATE INVESTMENT DECISIONS
- LEVEL OF SERVICE NOW AND IN THE FUTURE
- SHORT TERM RISKS
- LONG TERM RISKS

PIARC 2023R28EN4

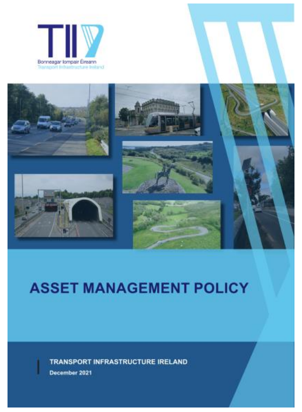


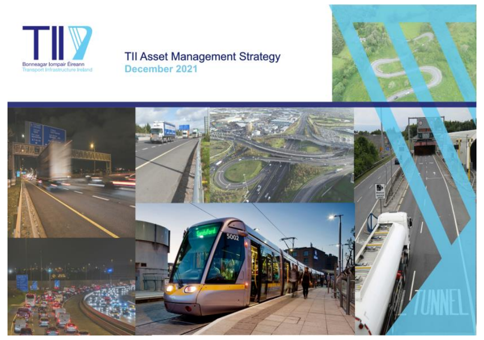
TII Asset Management

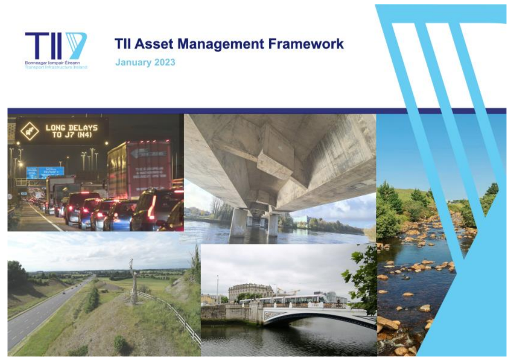
TII Statement of Strategy 2021-2025

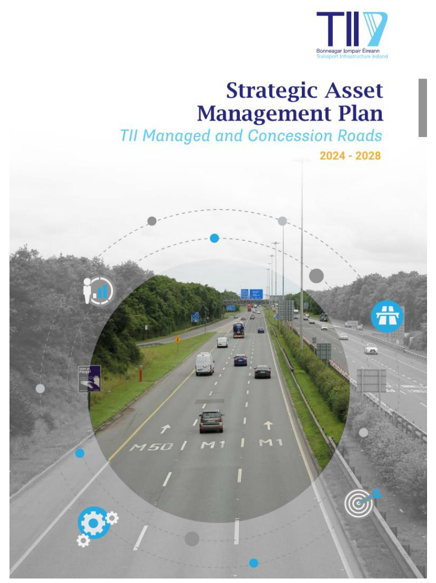
Goals	Strategic Objectives
Existing Infrastructure Operate, maintain and extend the life of national roads and light railway infrastructure to ensure the safety and efficiency of our transport networks, ensure appropriate management of environmental resources and contribute to the transition to a low-carbon and climateresilient society.	1. Maintain and change existing infrastructure to reduce transport-related deaths, injuries and risks. 2. Extend the life and optimise the use of our transport infrastructure, to minimise the need to build new infrastructure. 3. Maintain our transport systems to ensure they are safe, resilient and available for use. 4. Introduce measures to support the reduction of carbon and other emissions in our operations. 5. Support use of emerging technologies such as connected co-operative and automated mobility. 6. Provide the information that our customers need.

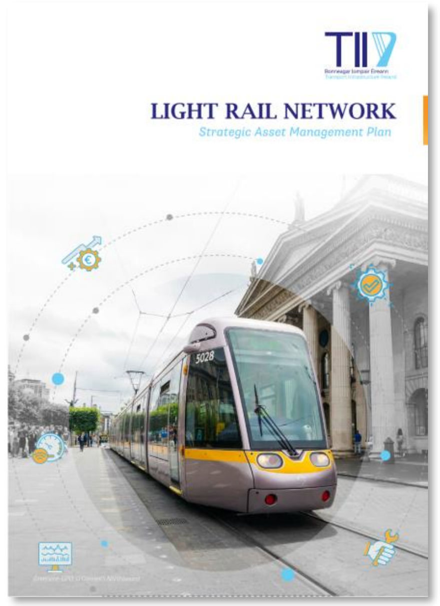
TII Asset Management Structure – Line of Sight

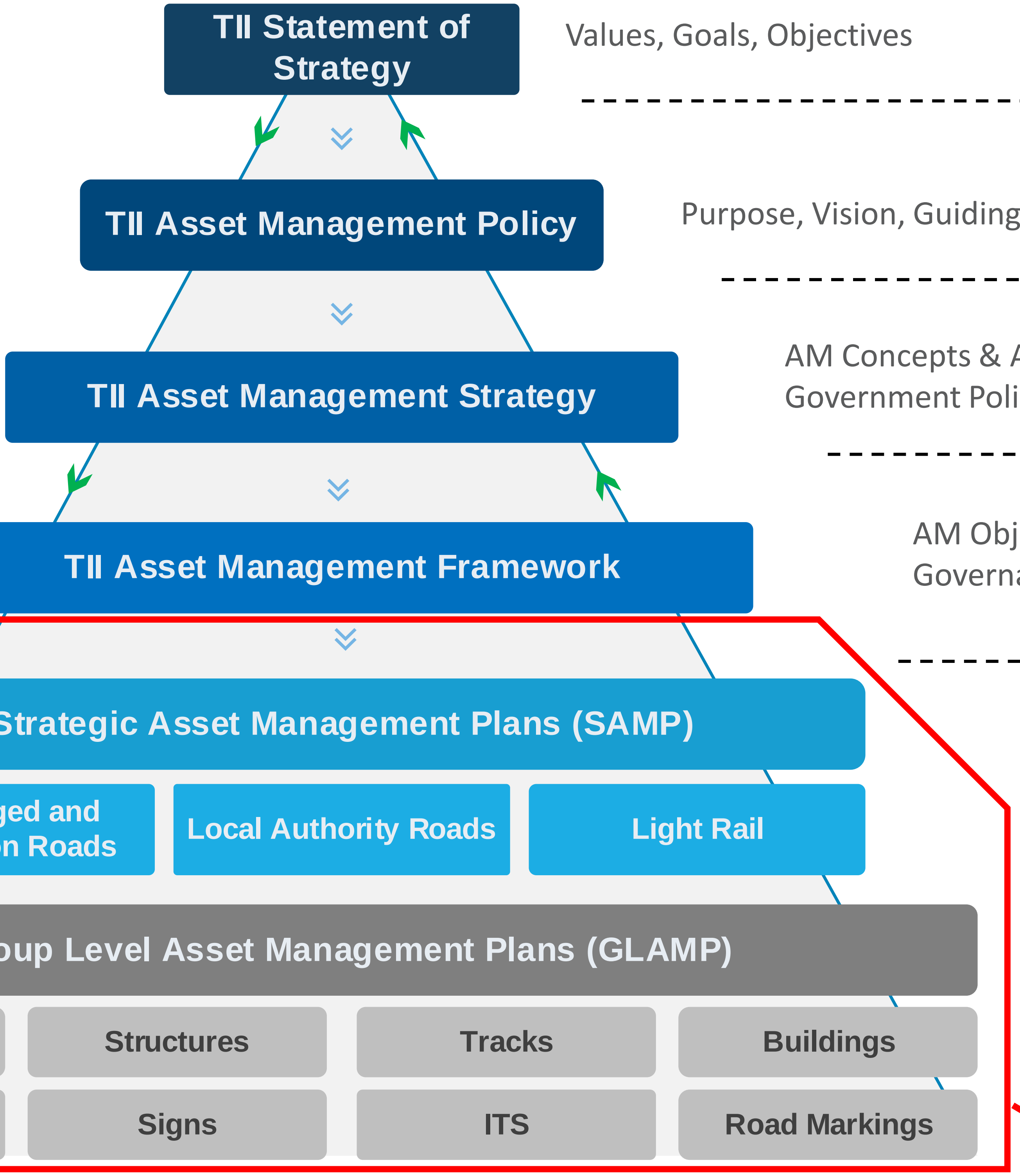












Values, Goals, Objectives

Purpose, Vision, Guiding Principles

AM Concepts & Alignment with TII and Government Policies & Strategies

AM Objectives, Data and Systems, Governance

- Develop collaboratively with input from stakeholders
- Review of current state of assets
- Gap analysis and improvement plan

Examples from roads and light rail. Detailed Performance Measures and KPIs

dTIMS is a key lever in delivering our overall Strategic and Group Level Asset Management Objectives.

Asset Management Policy, Strategy, Framework published to
www.tii.ie/assetmanagement

*"Assets will be managed in a sustainable manner through the development, implementation, and maintenance of an asset management approach that is risk-based and **data-driven**, enabling us to make informed decisions throughout the life of our assets"*

TII's Journey in Asset Management

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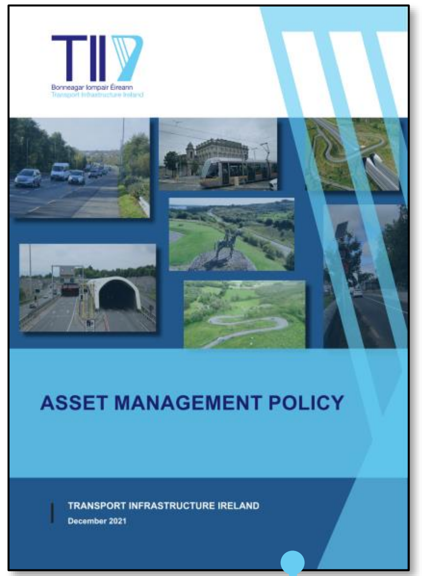
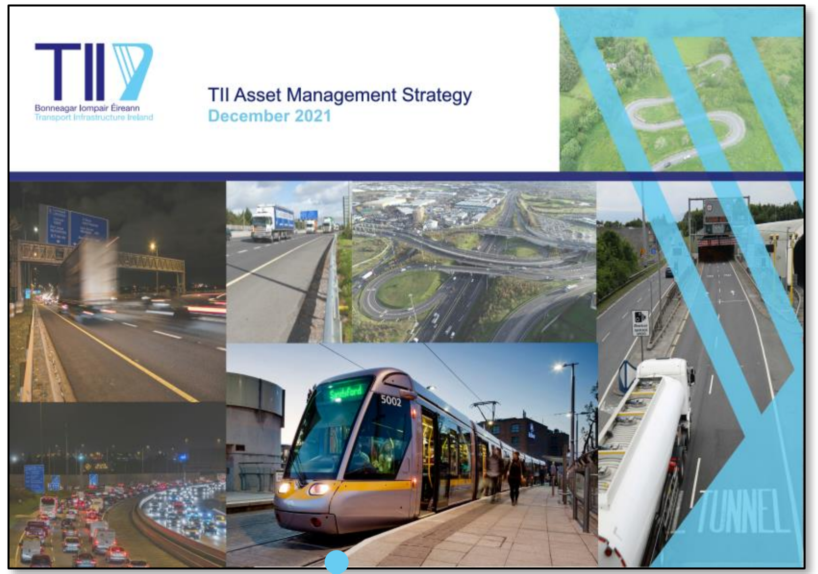
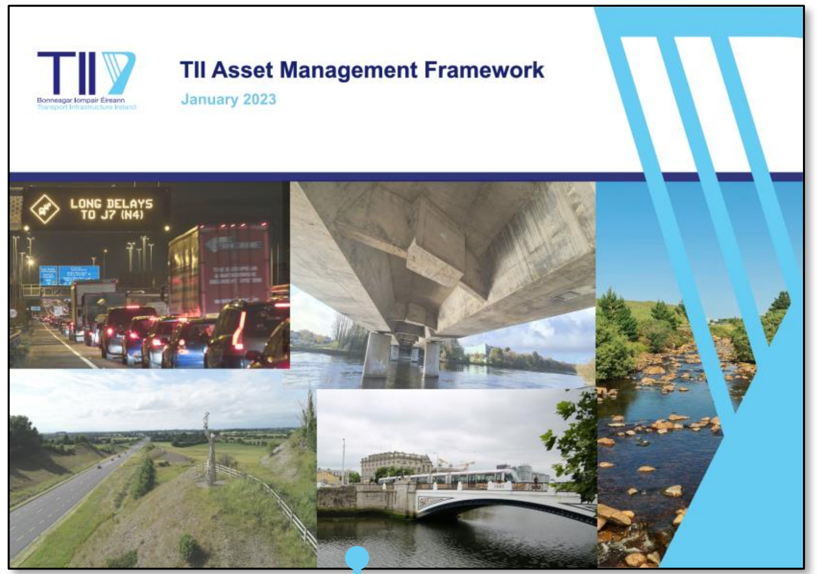
AM Policy



AM Strategy



AM Framework



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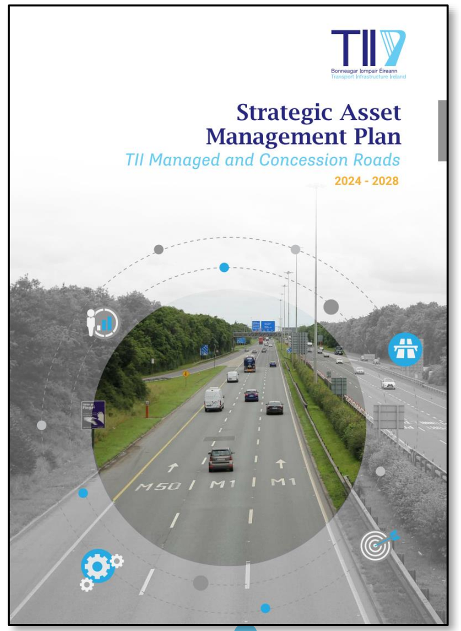
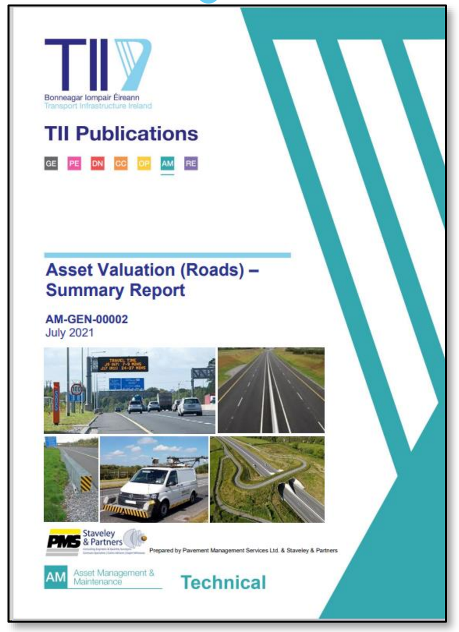
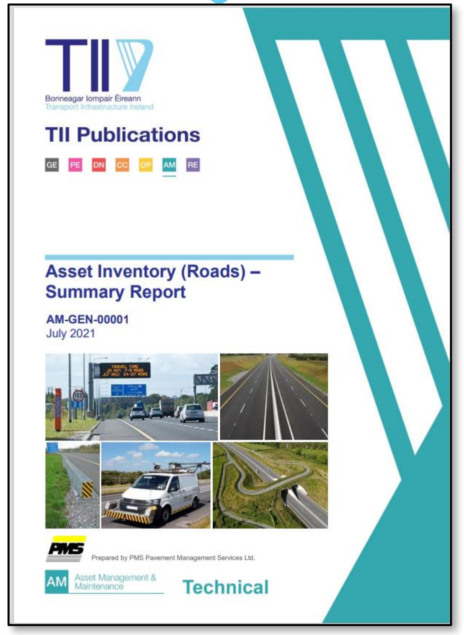
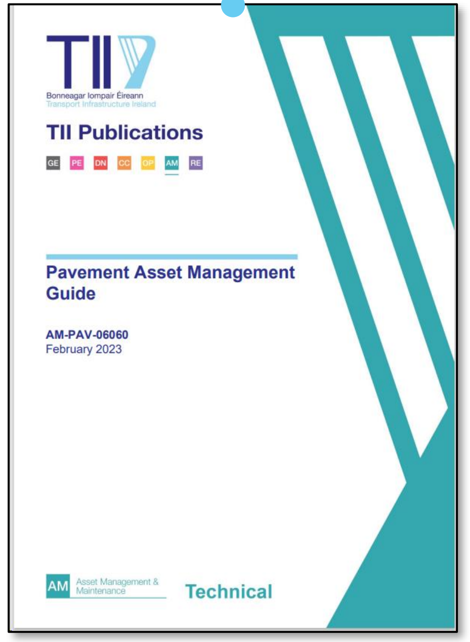


July 2021 — Dec 2021 — Jan '23 — Feb '23 — June '23 — July '23 — Dec '23

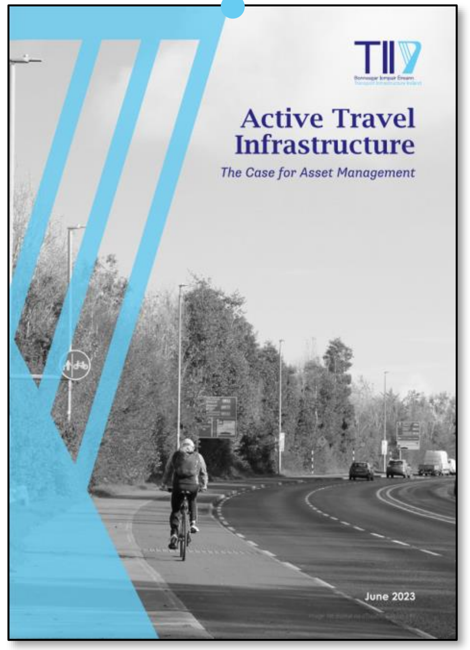




Asset Inventory & Valuation (Roads)



Pavement Asset Management Guide



Active Travel Asset Management Case

Pavement Renewals Business Case 2023-2027

TII Asset Management Objectives

Safety

To ensure transport networks that are secure and safe for all

Reliability

To ensure consistent and predictable journeys for the movement of people and goods across all modes

Condition

To maintain, preserve, and extend the useful life of our transport assets

Maximising Value

To plan, build, operate, and maintain the transport system, through collaboration and appropriately targeted investment choices

Customer

To balance the diverse needs of our customers, achieving the best possible outcomes in terms of system quality and effectiveness

Sustainability

To promote the sustainability of our transport systems while applying the principles of the circular economy

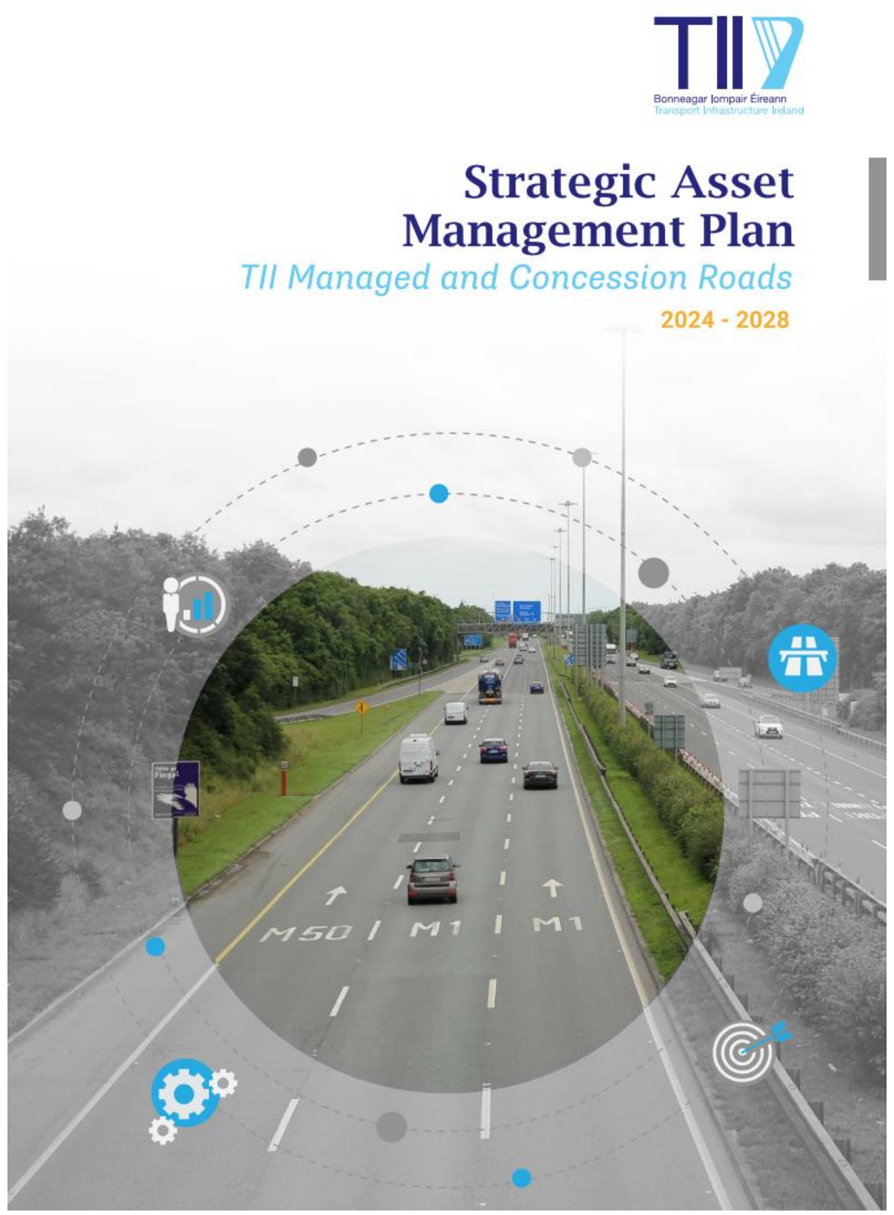
Environment

To provide efficient and effective transport systems with positive environmental benefits

Resilience

To proactively assess, plan, and invest in strategies that ensure the resilience of our network

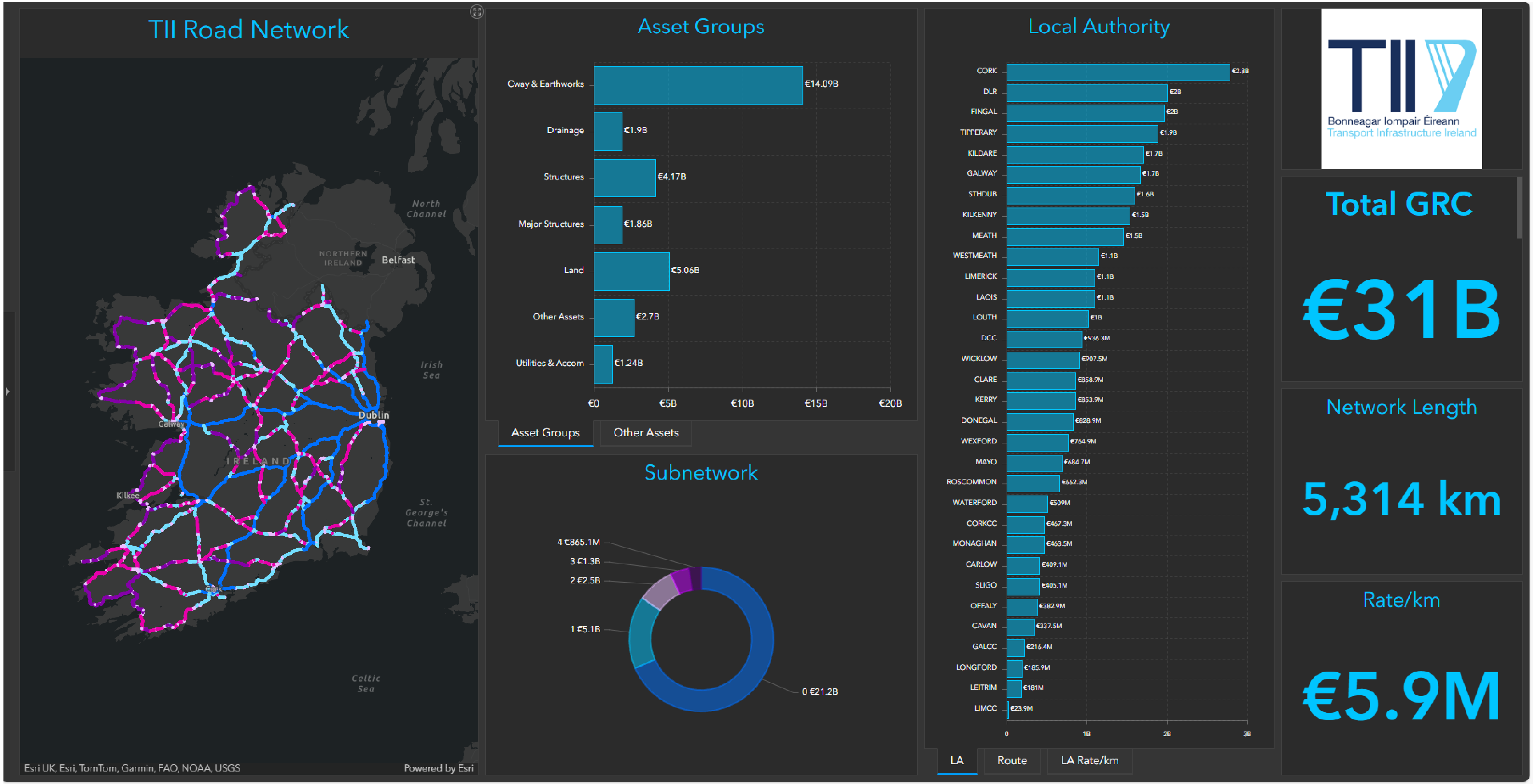
Strategic Asset Management Plan – 2024 - 2028
TII Managed and Concession Network



CONTENT

4 5

Asset Valuation



Asset Valuation – Managed Network

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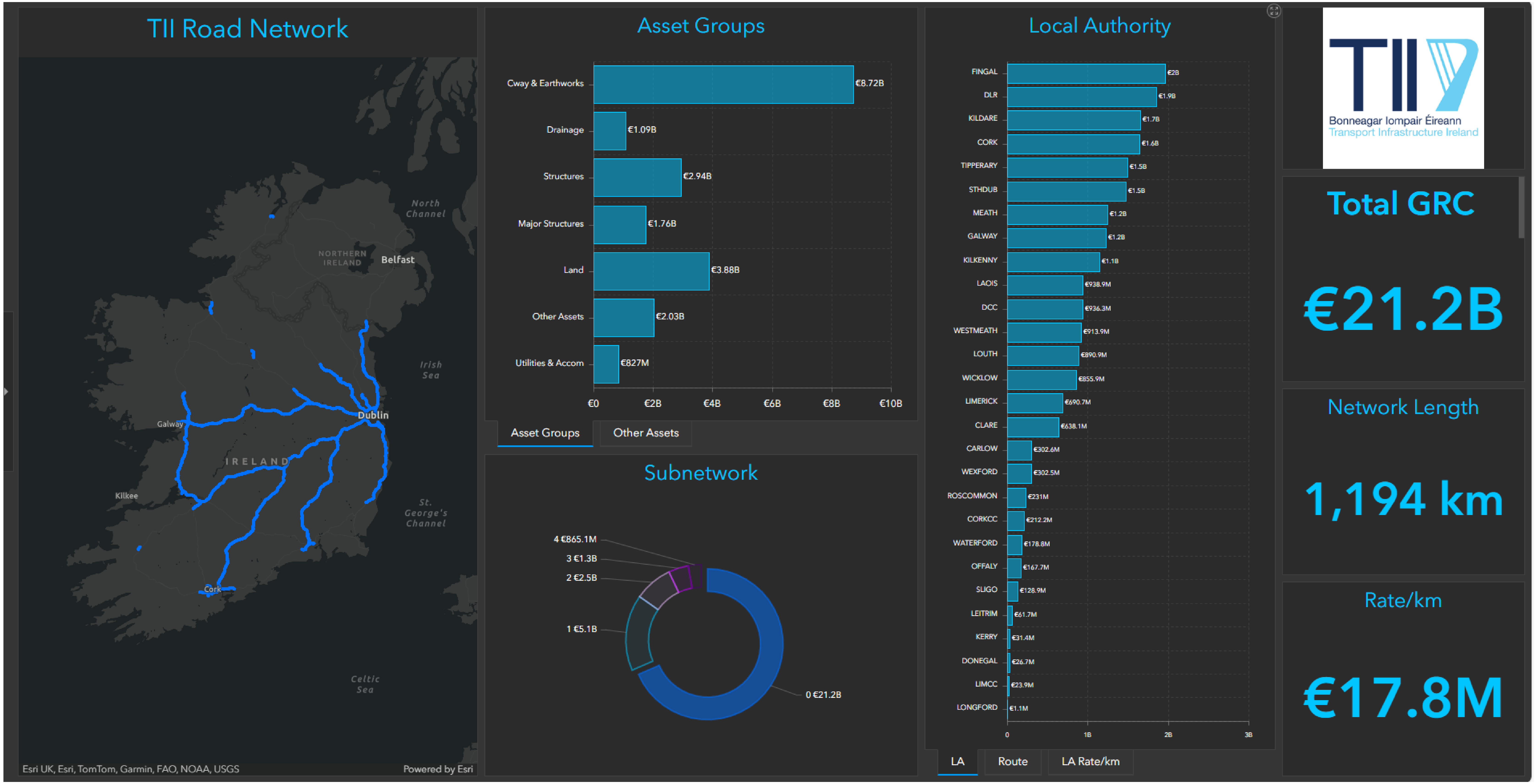

Snapshot of TII Managed and Concession Network

1. Land & Earthworks

Total Area Land of c. **9,000 ha** with Embankments (Fill vol **64 million m^3** and Cut vol **84 million m^3**)

2. Pavements

Almost **1,350** Centerline-km with **237** Interchanges and Paved Area of more than **30 million m^2**

3. Structures

1,282 Road Bridges, **54** Foot Bridges, **71** Retaining Walls, and **1,500** Culverts, with Total Deck Area over **870,000 m^2**

4. Drainage Systems

Over **1,950 km** Linear Drainage Systems with more than **69,000** Drainage Point Items, and **520** Attenuation Areas

5. Fencing & Noise Barriers

More than **2,500 km** Boundary Fencing / Noise Barrier, and c. **2,500 km** Safety Barrier

6. Pedestrian & Cycle Facilities

156km of Pedestrian/Cycle Facilities, and over **700km** of Kerbing

7. Road Lighting, Traffic Signs & Markings

15,000 Road Lighting Columns, **28,300** Traffic Signs, and more than **8,300 km** of Road Markings

8. Intelligence Transport Systems (ITS)

More than **1,225** Traffic Signals, **272** VMS, **1539** ERTs and over **2,750** Other ITS assets

9. Toll Plazas

16 Toll Plazas with Canopy Area **8,500 m^2** and **128** Traffic Lanes

10. Depots & Buildings

26 Depots with Land Area **23 ha** and Buildings with Total Floor Area more than **25,500 m^2**

11. Winter Service Facilities

106 Winter Service Fleet, **363** Other Vehicles/Plants, and over **110,000 Tonnes** Salt Storage and **270,000 litres** Fuel Storage Facilities

12. Staffing

454 Full-time and **179** Part-time Personnel

Asset Management Objectives and KPI Themes

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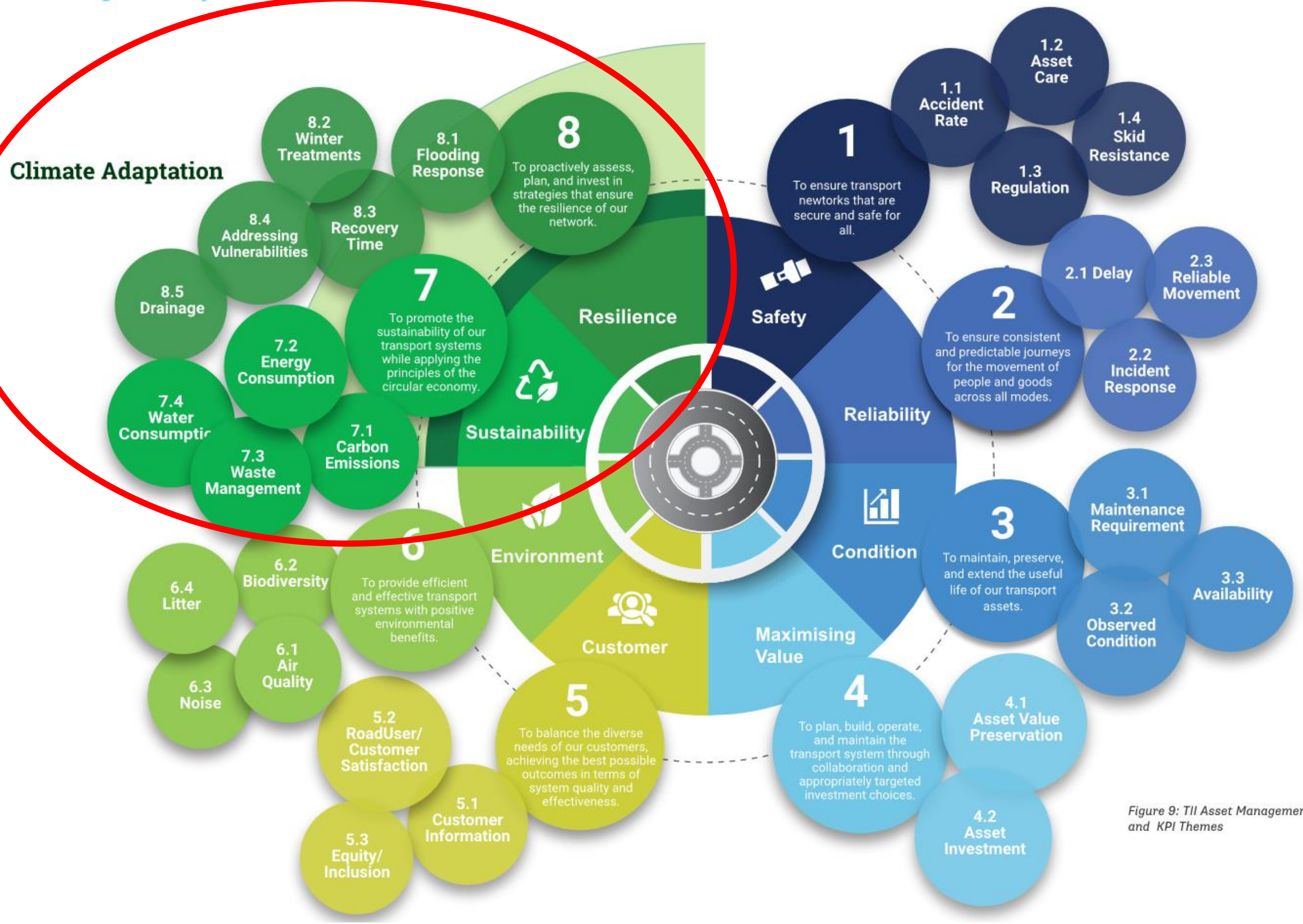


Figure 9: TII Asset Management Objectives and KPI Themes

Carbon Reduction, Climate Adaptation and Asset Management

- Sustainability objective: Key Performance Indicators relating to **Carbon Emissions, Energy Consumption, Waste Management and Water Consumption** on the managed motorway network are introduced
- Resilience objective, KPIs relating to **Flooding Response, Drainage, Winter Maintenance, Addressing Vulnerabilities and Recovery Time** have been developed

Climate Adaptation

AM Objective	Potential Metrics (Present)	Potential Metrics (Future)
Sustainability	• Scope 1 CO_2 emissions rel. to baseline • Scope 2 CO_2 emissions rel. to baseline • Maintenance fleet converted to EV (%) • Reduction in total energy consumed • Proportion of lighting that is LED • Percentage of water from collected rainfall • CO_2 emissions associated with the • maintenance fleet	• kWh of energy generated through own renewable sources
Resilience	• Number of reported flooding incidents • Percentage of winter service treatments in compliance with required timescale • Percent carriageway length not susceptible to carriageway surface water problems	• Lane Closure duration due to flooding • Time to restore minimum required performance level after disruption • Percent of investment addressing identified vulnerabilities

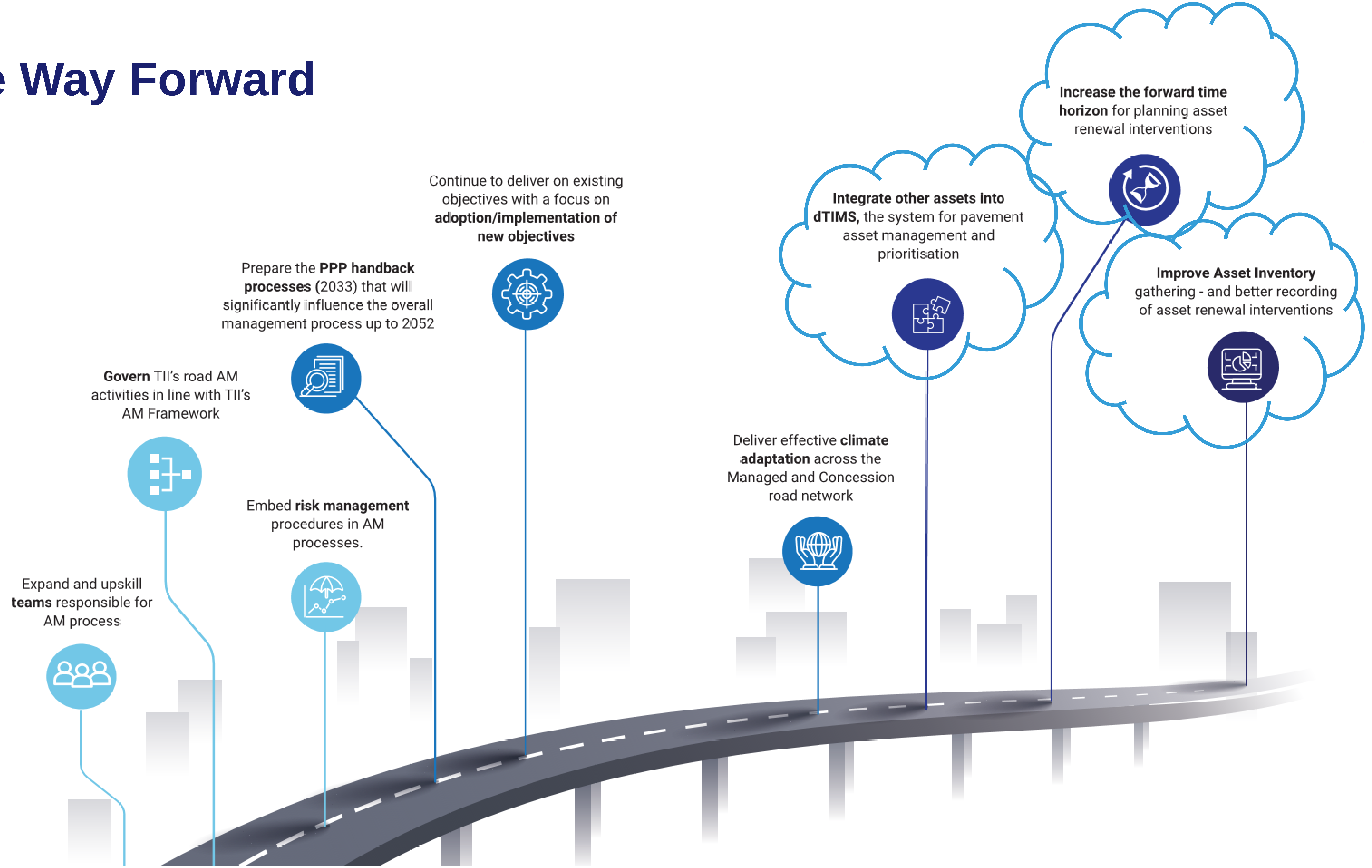
Summary of Improvement Actions

Areas	Actions	Climate	Sustainability	Risk
Pavement	Review and update trigger levels and KPIs, integrating whole-of-life analysis with a focus on embedded carbon.	✓		
	Consider expanding annual condition inspections to assess additional lane characteristics.			✓
	Monitor the composition of bituminous binders to ensure future achievement of surface lifespans.			✓
	Evaluate the feasibility of replacing bituminous binder with bio binders for carbon reduction, considering longevity effects.	✓		✓
	Innovatively use rejuvenators on the MMaRC and PPP networks to extend effective surface life.		✓	
	Consider increased use of high PSV recycled aggregate in surface layers for sustainability and circular economy benefits.		✓	
	Continue to develop innovative tests for aggregate skid resistance to expand sources of high skid resistance aggregates.		✓	
Structures	Develop a costed asset renewal programme for bridge components to secure funding for life cycle interventions.			✓
	Implement periodic repainting of steel bridge elements to prevent corrosion and maintain structural integrity.			✓
	Prepare for bridges' handover from PPP to direct TII management. Develop policies and allocate resources for maintenance transfer, including assessment timing and funding.			✓
	Establish a separate management structure for large-span cable-stayed structures from inspection through post-handover maintenance.			✓
	Implement dTIMS bridge management software for prioritised repair and rehabilitation, enabling long-term forecasting under varied funding scenarios.			
	Conclude research on probabilistic-based bridge performance modelling, using the EIRSPAN database for lifecycle cost analysis of road network structures.			

Areas	Actions	Climate	Sustainability	Risk
Geotech Assets	Implement Asset Management concepts for geotechnical assets, including slopes, embankments, walls, and unstable subgrades, to effectively measure and manage life-cycle risk, performance, and investment.		✓	✓
Intelligent Transport Systems (ITS) Assets	Evaluate emerging tolling technologies within the evolving landscape of telematics and Intelligent Transportation Systems (ITS)..		✓	✓
	Periodically review the necessity of maintaining a network of roadside telephones in a mobile phone-saturated environment.			
	Regularly review asset lifespans, adopting maintenance approach reflecting technological advancements and power sources.			✓
	Continuously reassess Variable Messaging Systems (VMS), especially regarding ongoing developments in Connected Autonomous Vehicles (CAV) technology.			
	Continue developing and utilising degradation models in the Asset & Fault Management System (AFMS) to guide timely and cost-effective interventions for TII's ITS equipment.			✓
Drainage and Hidden Assets	Map and classify current drainage assets, including gullies, channels, chambers, drains, and pipes, for climate adaptation purposes.	✓	✓	✓
	Perform vulnerability mapping and establish a programme to address high-risk areas identified in the assessment.	✓	✓	✓
	Evaluate existing culvert capacity considering future rainfall predictions.	✓	✓	✓
	Assess the risk of Bridge Scour under present and anticipated climatic conditions.	✓		✓
	Formulate a Bridge Scour Mitigation Programme as needed, which may include retrofitting measures for existing bridges.	✓		✓
	Develop comprehensive ducting mapping, including location and capacity details over time, to support effective asset management.	✓		✓

Areas	Actions	Climate	Sustainability	Risk
Biodiversity	Develop a biodiversity accounting metric for new projects and track progress on project-specific biodiversity enhancements.		✓	
	Establish the biodiversity baseline of the entire TII Network using the biodiversity accounting metric.		✓	
	Implementation of targeted research, mitigation, and, where applicable compensation.		✓	
	Identification and mitigation, where feasible, of priority species collision hotspots on the existing road network.		✓	
	Eradicate, control and prevent the spread of Invasive Alien Species on new projects and the existing network.		✓	
Asset Management Information & Systems	Integrate asset age and condition information from TII systems like dTIMS and EIRSPAN/dTIMS with selected outputs from MMaRC and PPP databases, and maintenance contractors.		✓	
	Establish automated processes with FME technology for seamless integration across systems, enhancing data analysis capabilities.			✓
	Expand MapRoad system use to MMaRC contracts for easy recording and geo-referencing of detailed project information. Encourage PPP operators to adopt same approach.			✓
	Capture geo-referenced and detailed records of maintenance and renewal activities for various asset types on a routine basis.		✓	
	Develop a standardised coding system for all assets, potentially aligning with TII Specifications for Road Works Series, for detailed expenditure breakdown by asset type.			
	Prioritise data types to be collected and consider establishing different "tiers" for assets based on their importance and impact.			✓
Lifecycle Planning	Develop a holistic cost-benefit analysis approach, considering factors beyond the asset's lifespan, such as safety, traffic delays, and embodied carbon.			
	Incorporate costs related to embodied and emitted carbon directly resulting from road construction or maintenance, including road user effects from these activities.	✓		✓
	Endeavour to minimise all relevant and quantifiable costs over the asset life cycle while maintaining the required performance.	✓		✓

The Way Forward



dTIMS is a key lever in delivering our Strategic Asset Management Objectives.

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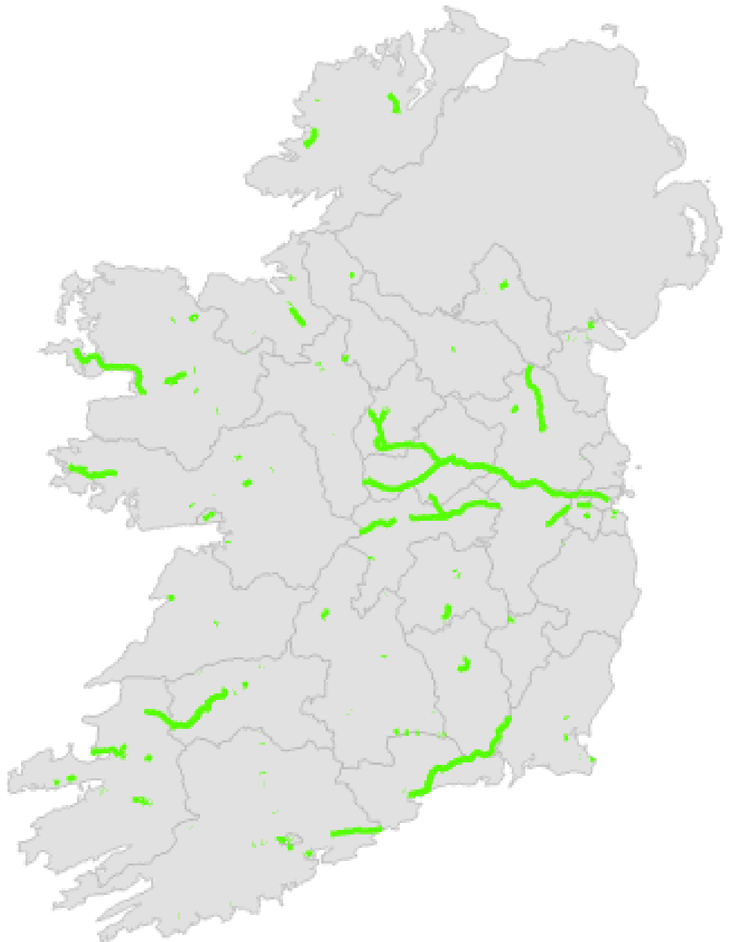
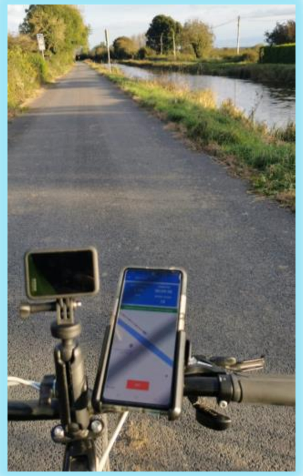
Future Assets in dTIMS

Transport Infrastructure Ireland: Active travel

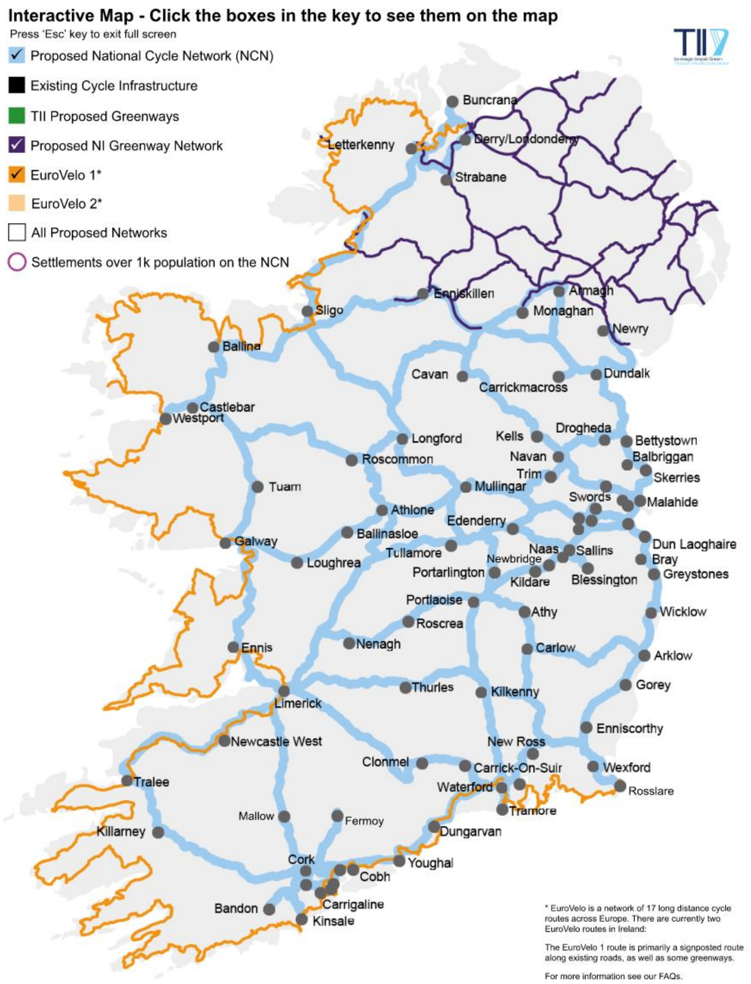
Existing



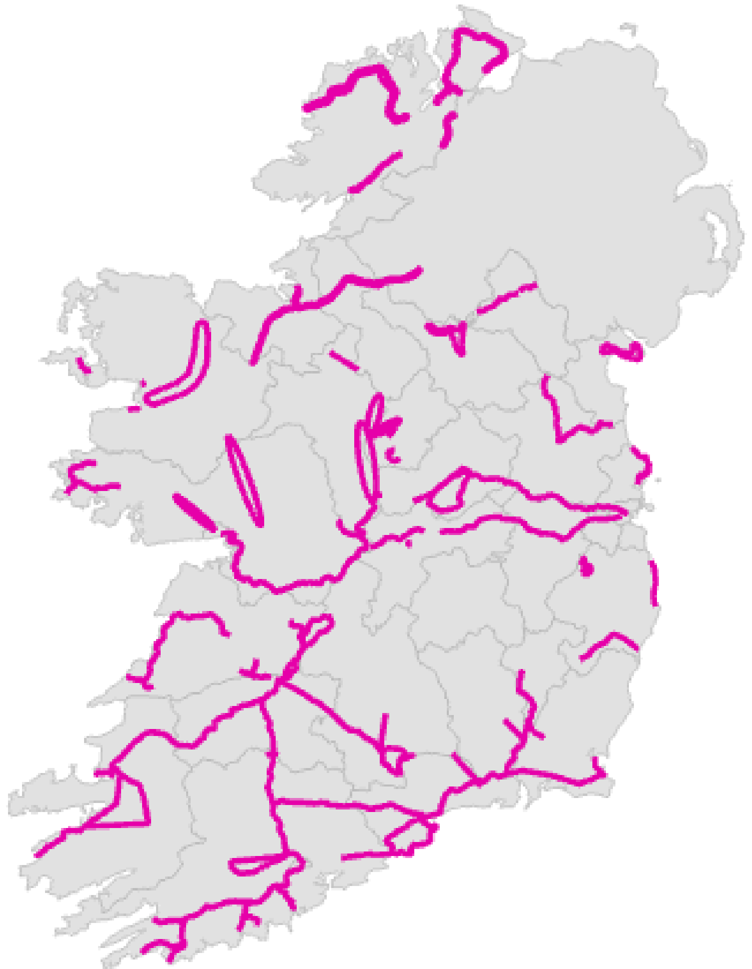
c.900 km Cycleways/Greenways



Planned



National Cycle Network c.3500km



Greenways c. 2500km

R&D / Innovations in Data Collection & Condition Assessment:

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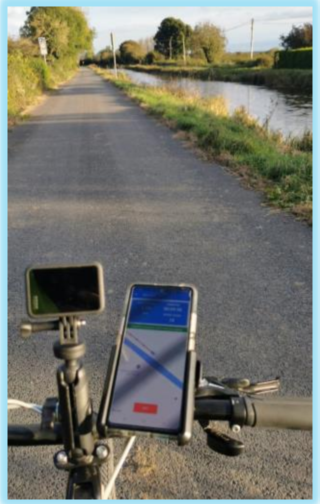
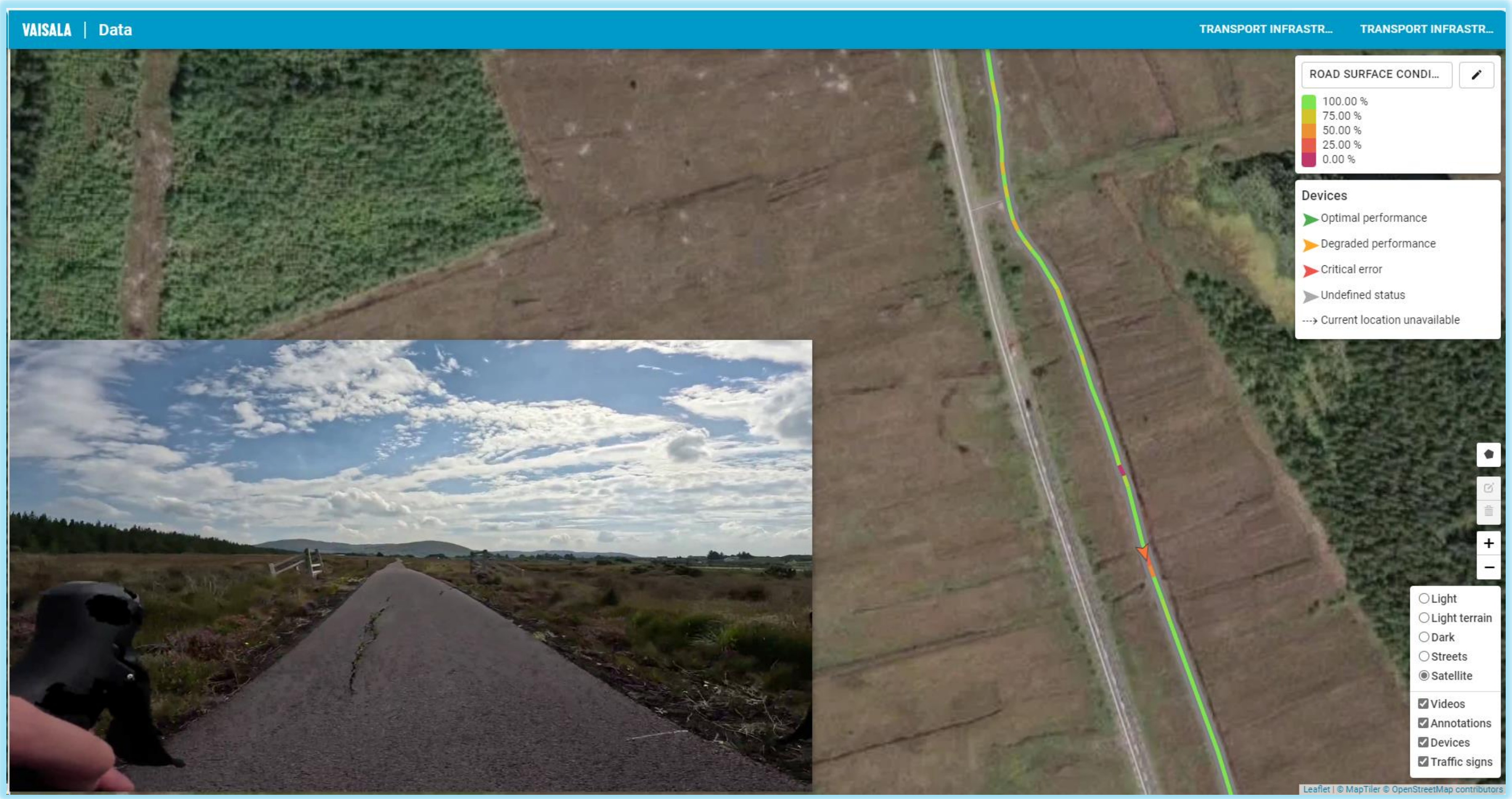
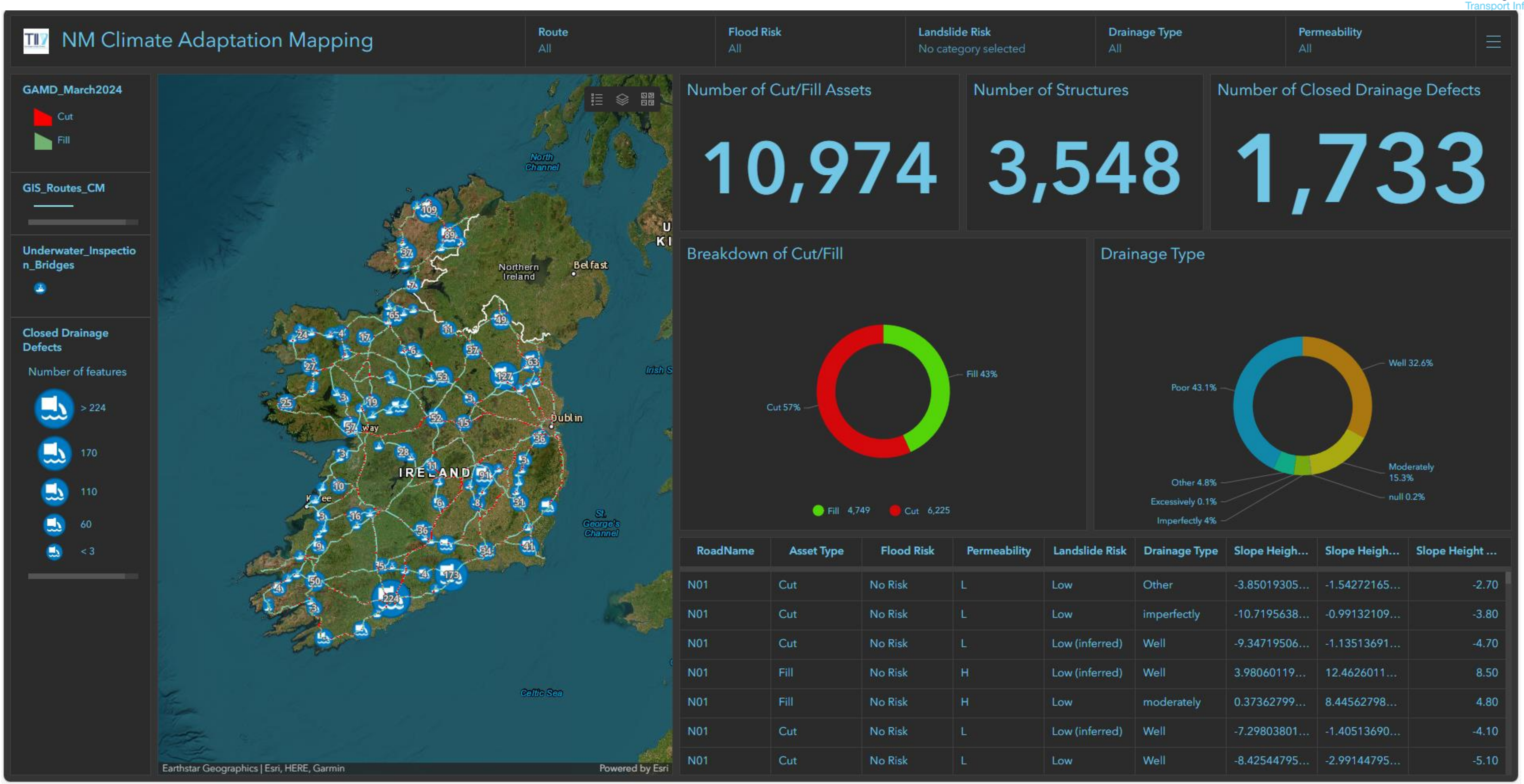
- R&D / Innovations in Data Collection & Condition Assessment:
- **Current**
  - ESRI AGOL Field Maps Collector App
  - GoPro Georeferenced Video data collection – UbiPIX
  - Vaisala Road AI App
  - MapRoad – Inventory and Data Capture
- **Future**
  - VivaCity AI Sensor
  - Trial Xenomatics - Xenobike – LiDAR.



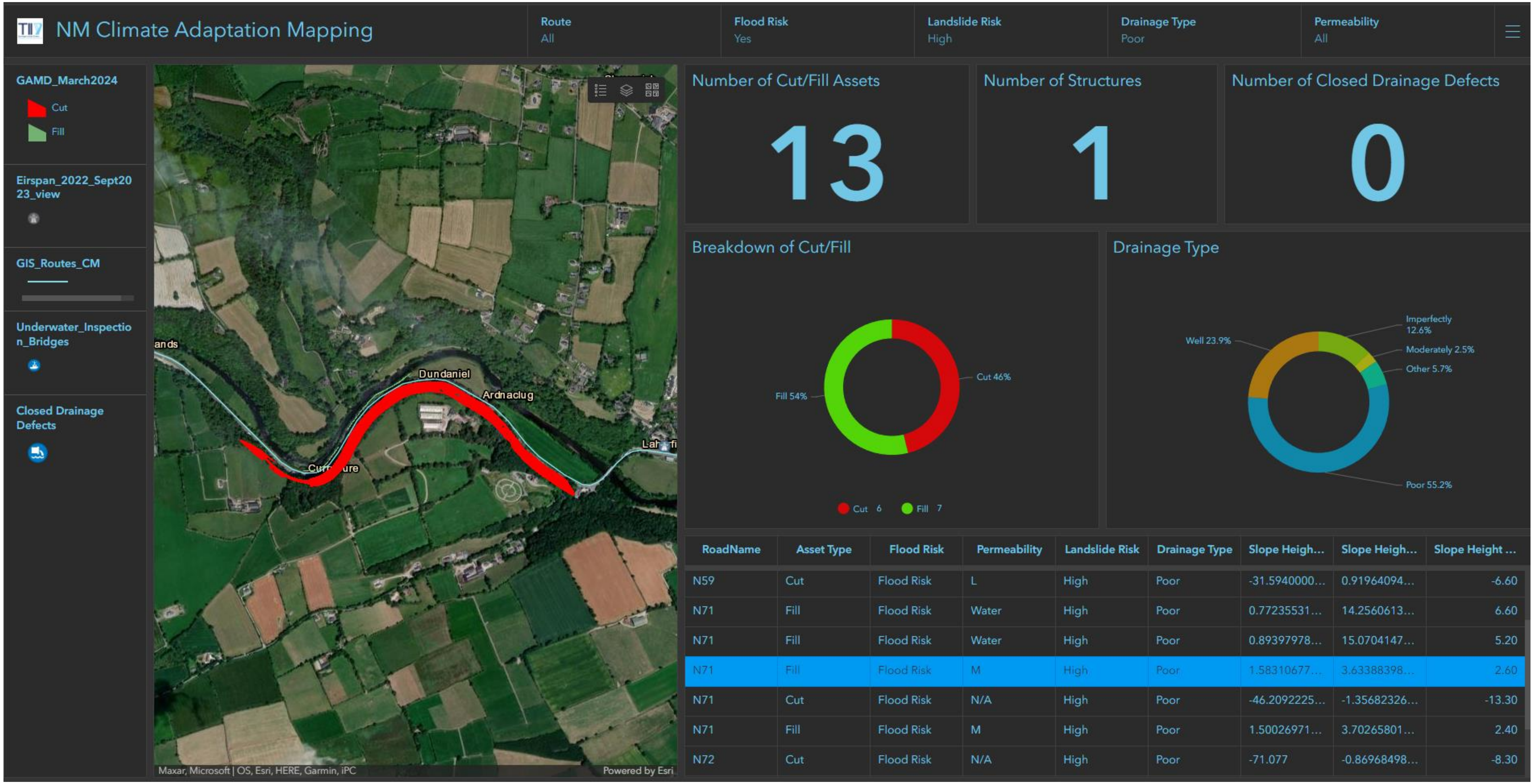


Drainage / Geotech Assets – Climate Adaptation



RoadName	Asset Type	Flood Risk	Permeability	Landslide Risk	Drainage Type	Slope Heigh...	Slope Heigh...	Slope Height ...
N01	Cut	No Risk	L	Low	Other	-3.85019305...	-1.54272165...	-2.70
N01	Cut	No Risk	L	Low	imperfectly	-10.7195638...	-0.99132109...	-3.80
N01	Cut	No Risk	L	Low (inferred)	Well	-9.34719506...	-1.13513691...	-4.70
N01	Fill	No Risk	H	Low (inferred)	Well	3.98060119...	12.4626011...	8.50
N01	Fill	No Risk	H	Low	moderately	0.37362799...	8.44562798...	4.80
N01	Cut	No Risk	L	Low (inferred)	Well	-7.29803801...	-1.40513690...	-4.10
N01	Cut	No Risk	L	Low	Well	-8.42544795...	-2.99144795...	-5.10

Drainage / Geotech Assets – Climate Adaptation



RoadName	Asset Type	Flood Risk	Permeability	Landslide Risk	Drainage Type	Slope Heigh...	Slope Heigh...	Slope Height ...
N59	Cut	Flood Risk	L	High	Poor	-31.5940000...	0.91964094...	-6.60
N71	Fill	Flood Risk	Water	High	Poor	0.77235531...	14.2560613...	6.60
N71	Fill	Flood Risk	Water	High	Poor	0.89397978...	15.0704147...	5.20
N71	Fill	Flood Risk	M	High	Poor	1.58310677...	3.63388398...	2.60
N71	Cut	Flood Risk	N/A	High	Poor	-46.2092225...	-1.35682326...	-13.30
N71	Fill	Flood Risk	M	High	Poor	1.50026971...	3.70265801...	2.40
N72	Cut	Flood Risk	N/A	High	Poor	-71.077	-0.86968498...	-8.30

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dTIMS in TII

Background to dTIMS in TII

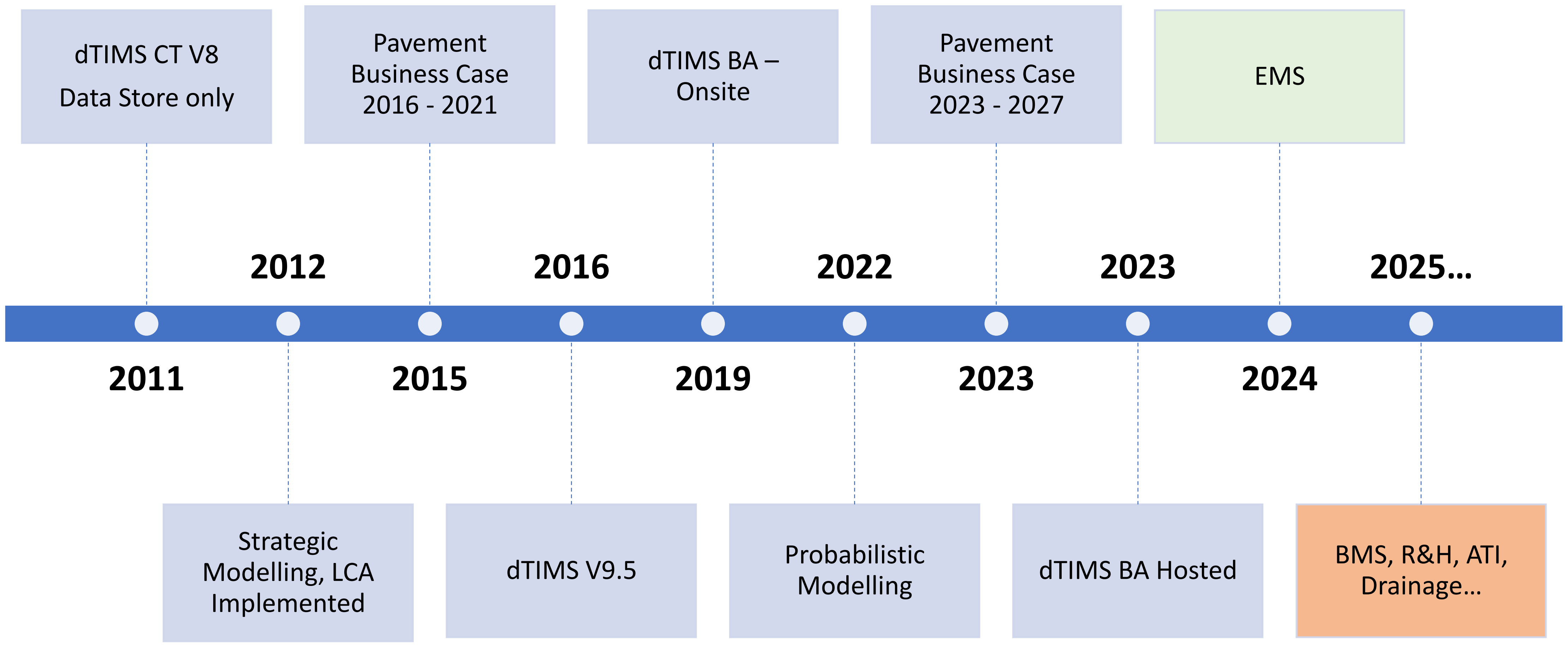
- Repository for historic and current condition
- Ability to forecast future condition and apply LCA/LCCA process on each road section
- Define Custom deterioration curves
- Propose maintenance strategies

- Support existing asset management
- Support existing decision processes

- Define Multiple Budget Scenarios
- Optimise Recommendations

Background to dTIMS in TII

- Tender process was initiated in 2010.
- Deployment as a data repository completed in 2011
- Strategic modelling configured and tested in 2012-2013
- dTIMS has been used to generate multi-annual pavement maintenance programs since.



Challenges – Diverse National Road Network

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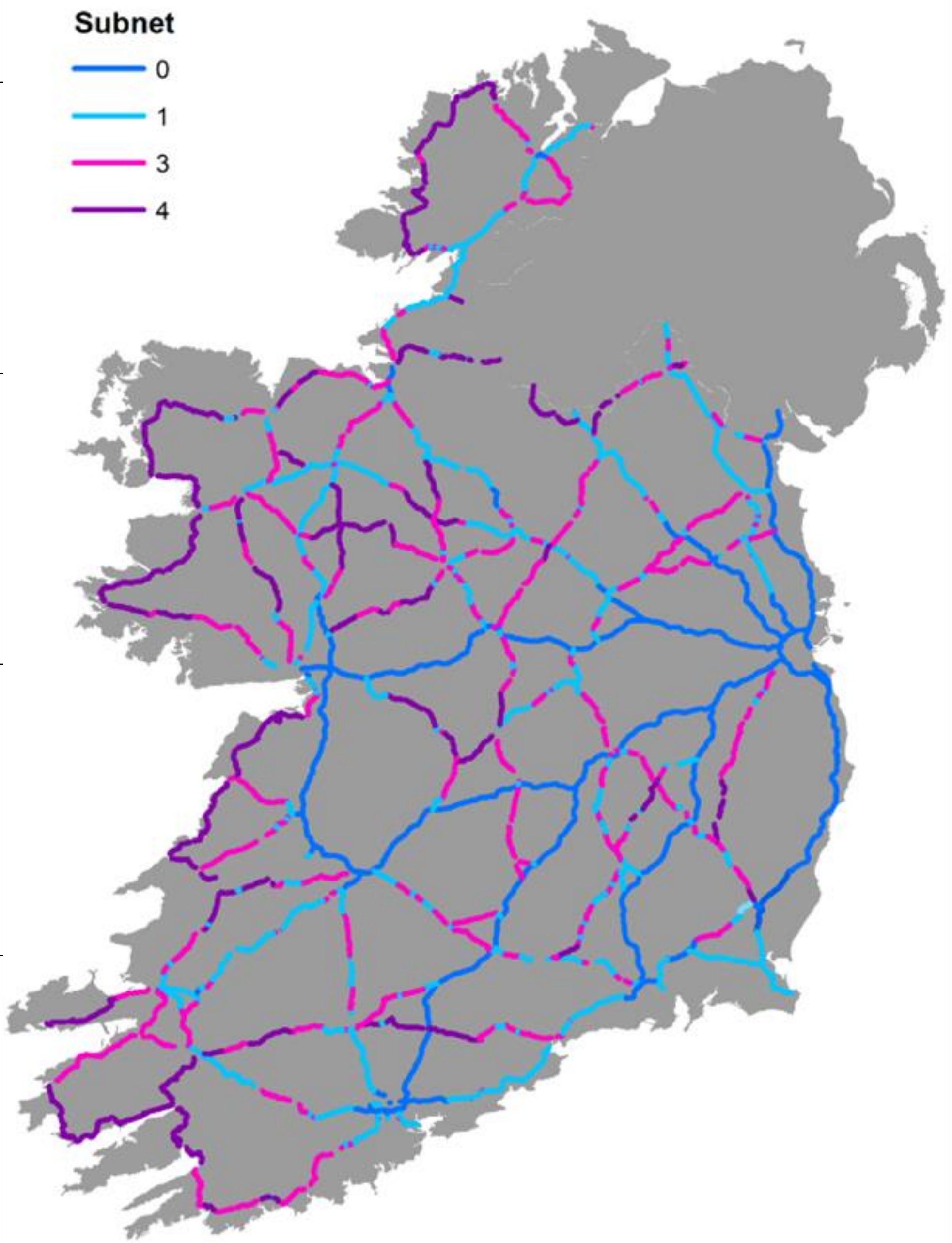
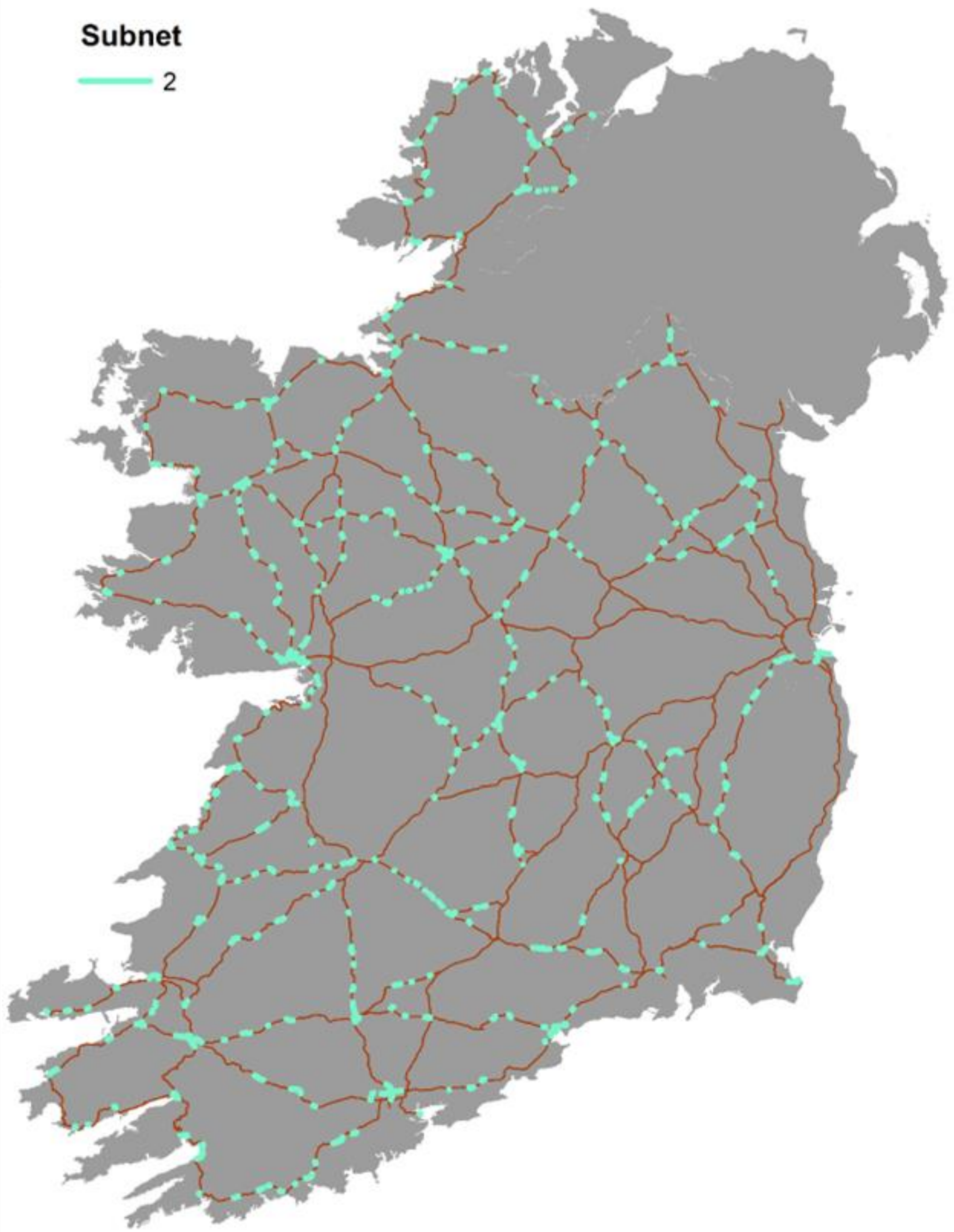
- TII operates a very diverse network. There are major variations in:
  - Pavement Structure
  - Traffic Levels
  - Alignment
  - Drainage Characteristics
- TII addressed this by breaking the Overall Network into into 5 Subnetworks. Subnetworks display internally consistent characteristics and behaviour.

Subnetworks

Subnet		Classification	Length (km)	% Of Network
0	Motorway + Dual Carriageways	High speed, high volumes pavement, made up of Motorway and Dual Carriageway sections of the network.	1200	23%
1	Engineered Single Carriageway	Typically carry reasonably large volumes of traffic and are identified by the presence of hard shoulders adjacent to the carriageway.	1200	22%
2	Urban Roads	Low to medium speed, typically short sections through towns that are not bypassed, also includes longer sections within the cities and larger towns where National Roads start and end.	700	13%
3	Legacy Pavement - High Traffic	Legacy subnetwork, typically constructed without formal geometric or pavement design. Typically carries traffic volumes less than 10,000 AADT.	1300	24%
4	Legacy Pavement - Low Traffic	Legacy subnetwork, typically constructed without formal geometric or pavement design. Typically carries traffic volumes less than 5000 AADT.	950	18%





Subnetwork Configuration in dTIMS

Subnetworks are Defined differently in terms of:

- Currently
  - Condition class thresholds
  - Rates of deterioration
  - Treatment Triggers
  - Treatment Costs
  - Treatment Effects/Resets

Parameter	Subnet	Class 1 - Very Good	Class 2 - Good	Class 3 - Fair	Class 4 Poor	Class 5 Very Poor
IRI	0	1.5	2	2.5	3	>3
IRI	1	2	2.5	3	3.5	>3.5
IRI	2	3	4	5	7	>7
IRI	3	2.7	3.2	4	5	>5
IRI	4	3	4	5	7	>7
LPV3	0	1	2	3	4	>4
LPV3	1	1	2	3	4	>4
LPV3	2	2	4	7	10	>10
LPV3	3	2	3.5	5	7	>7
LPV3	4	2	4	7	10	>10
RUT	0	3	5	6	9	>9
RUT	1	3	5	6	9	>9
RUT	2	4	6	9	15	>15
RUT	3	4	6	9	15	>15
RUT	4	4	6	9	15	>15

Subnetwork Configuration in dTIMS

Subnetworks are Defined differently in terms of:

- Currently
  - Condition class thresholds
  - Rates of deterioration
  - Treatment Triggers
  - Treatment Costs
  - Treatment Effects/Resets

Name	Treatment	Objective	Trigger Treatments are triggered at the Fair (F), Poor (P) or Very Poor (VP condition classes)	Unit Rates by Subnet (square metre)				
				0	1	2	3	4
Replace Surface	Surface Dressing, microsurfacing, thin surface overlay, plane & replace, thin surface (includes pre-treatments)	Sealing of pavement surface, improving skid resistance, roughness and rutting.	IRI OR LPV OR RD = F	€ 25	€ 25	€ 5	€ 25	€ 12.5
Overlay	Inlay 50-100mm, overlay up to 100 mm, Base/binder patching (includes pre-treatments)	Increase Strength, retard aging, improve or restore surface characteristics, improve or restore functionality	(IRI OR LPV OR RD = P) **OR** (RD = VP)	€ 90	€ 90	€ 95	€ 80	€ 60
Strengthen	Inlay 100-200 mm, overlay up to 200 mm	Increase Strength, retard aging, improve or restore surface characteristics, improve or restore functionality	(IRI OR LPV OR RD) = VP	€ 110	€ 110	€ 115	€ 95	€ 70
Reconstruct	Full depth reconstruction (> 200 mm). Reconstruction of sub-base	Increase capacity and pavement strength to provide a long life pavement	(IRI OR LPV = VP) **AND** (RD = VP)	€ 175	€ 160	€ 150	€ 130	€ 120

Subnetwork Configuration in dTIMS

Subnetworks are Defined differently in terms of:

- Currently
  - Condition class thresholds
  - Rates of deterioration
  - Treatment Triggers
  - Treatment Costs
  - Treatment Effects/Resets
- In Development
  - Treatment GWP Costs
  - Strategy Delay GWP Costs

Treatment	Parameter	Subnet				
		0	1	2	3	4
Replace Surface (relative)	IRI	-0.5	-0.5	-0.5	-0.5	-0.5
	RD	-2	-2	-2	-2	-2
	LPV	-0.5	-0.5	-0.5	-0.5	-0.5
	Cumulative Traffic	Current Cumulative Traffic x 0.1				
Overlay	IRI	1.2	1.7	2.2	2.2	2.5
	RD	2	2	3	3	4
	LPV	0.8	0.8	1.2	1.2	1.2
	Cumulative Traffic	0	0	0	0	0
Strengthen	IRI	1	1.4	2	2.2	2.2
	RD	2	2	3	3	4
	LPV	0.8	0.8	1.2	1.2	1.2
	Cumulative Traffic	0	0	0	0	0
Reconstruct	IRI	1	1.4	2	2.2	2.2
	RD	2	2	3	3	4
	LPV	0.8	0.8	1.2	1.2	1.2
	Cumulative Traffic	0	0	0	0	0

Subnetwork Configuration in dTIMS

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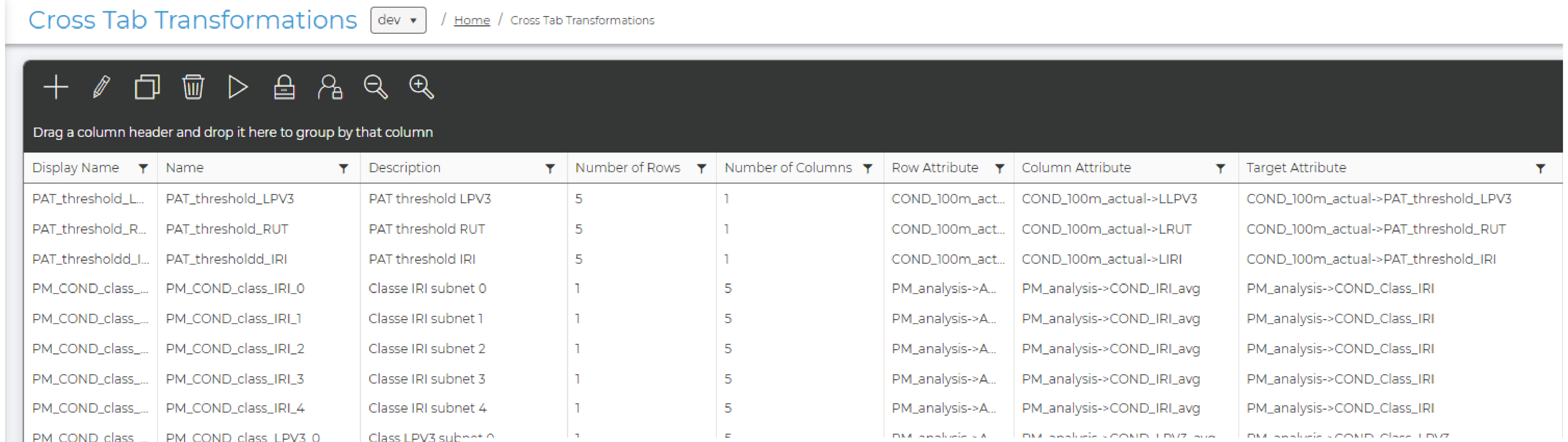
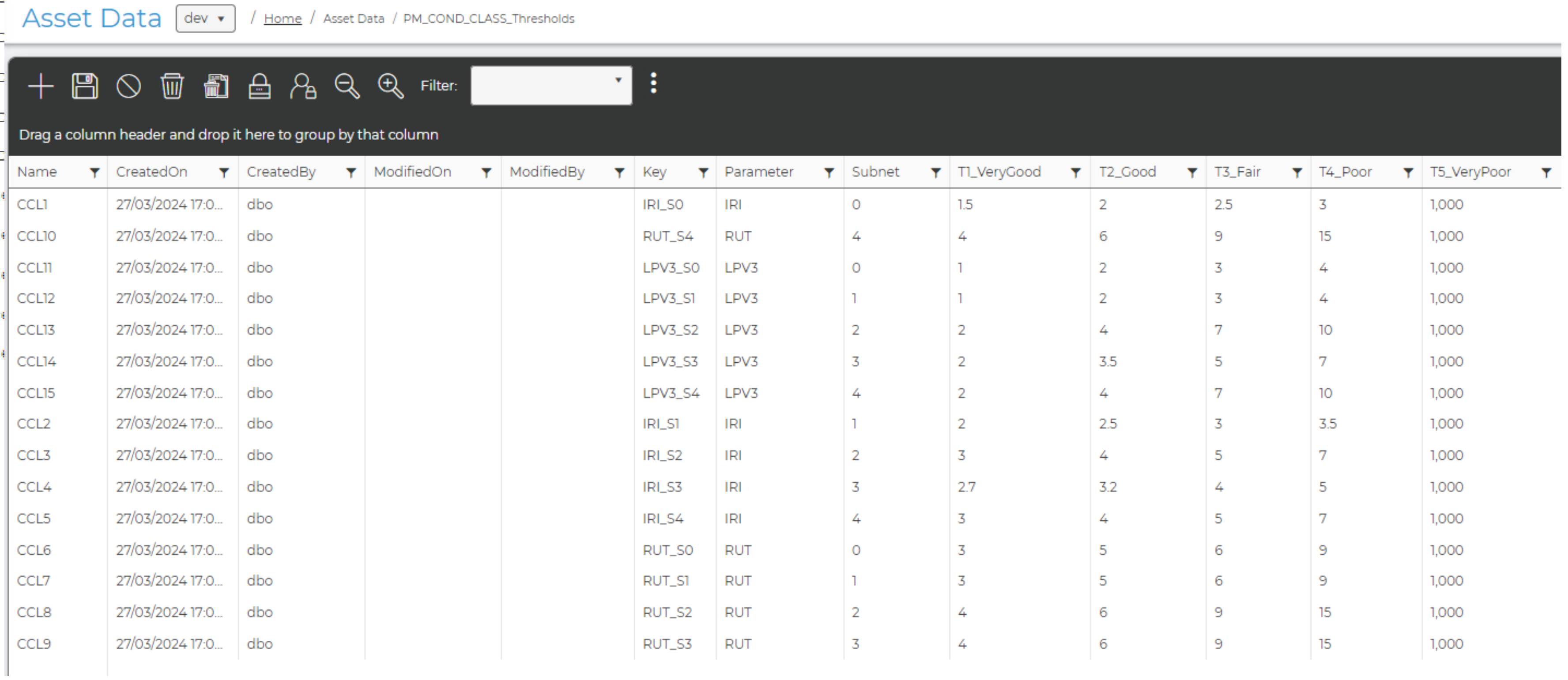
- Using a combination of Lookup Tables, CrossTab Transformations and Analysis Filters TII's pavement asset management processes could be captured and replicated in dTIMS

- The additional analysis tools available in dTIMS (Cross Asset Optimisation, SAM etc) enabled more nuanced approaches to maintenance strategy selection and optimisation than was previously available



Display Name	Name	Description	Number of Rows	Number of Columns	Row Attribute	Column Attribute	Target Attribute
PAT_threshold_L...	PAT_threshold_LPV3	PAT threshold LPV3	5	1	COND_100m_act...	COND_100m_actual->LLPV3	COND_100m_actual->PAT_threshold_LPV3
PAT_threshold_R...	PAT_threshold_RUT	PAT threshold RUT	5	1	COND_100m_act...	COND_100m_actual->LRUT	COND_100m_actual->PAT_threshold_RUT
PAT_thresholdd_I...	PAT_thresholdd_IRI	PAT threshold IRI	5	1	COND_100m_act...	COND_100m_actual->LIRI	COND_100m_actual->PAT_threshold_IRI
PM_COND_class_...	PM_COND_class_IRI_0	Classe IRI subnet 0	1	5	PM_analysis->A...	PM_analysis->COND_IRI_avg	PM_analysis->COND_Class_IRI
PM_COND_class_...	PM_COND_class_IRI_1	Classe IRI subnet 1	1	5	PM_analysis->A...	PM_analysis->COND_IRI_avg	PM_analysis->COND_Class_IRI
PM_COND_class_...	PM_COND_class_IRI_2	Classe IRI subnet 2	1	5	PM_analysis->A...	PM_analysis->COND_IRI_avg	PM_analysis->COND_Class_IRI
PM_COND_class_...	PM_COND_class_IRI_3	Classe IRI subnet 3	1	5	PM_analysis->A...	PM_analysis->COND_IRI_avg	PM_analysis->COND_Class_IRI
PM_COND_class_...	PM_COND_class_IRI_4	Classe IRI subnet 4	1	5	PM_analysis->A...	PM_analysis->COND_IRI_avg	PM_analysis->COND_Class_IRI
PM_COND_class_...	PM_COND_class_LPV3_0	Class LPV3 sub...					
PM_COND_class_...	PM_COND_class_LPV3_1	Class LPV3 sub					
PM_COND_class_...	PM_COND_class_LPV3_2	Class LPV3 sub					
PM_COND_class_...	PM_COND_class_LPV3_3	Class LPV3 sub					
PM_COND_class_...	PM_COND_class_LPV3_4	Class LPV3 sub					
PM_COND_class_...	PM_COND_class_RD_0	Class RD subn					
PM_COND_class_...	PM_COND_class_RD_1	Class RD subn					
PM_COND_class_...	PM_COND_class_RD_2	Class RD subn					
PM_COND_class_...	PM_COND_class_RD_3	Class RD subn					
PM_COND_class_...	PM_COND_class_RD_4	Class RD subn					

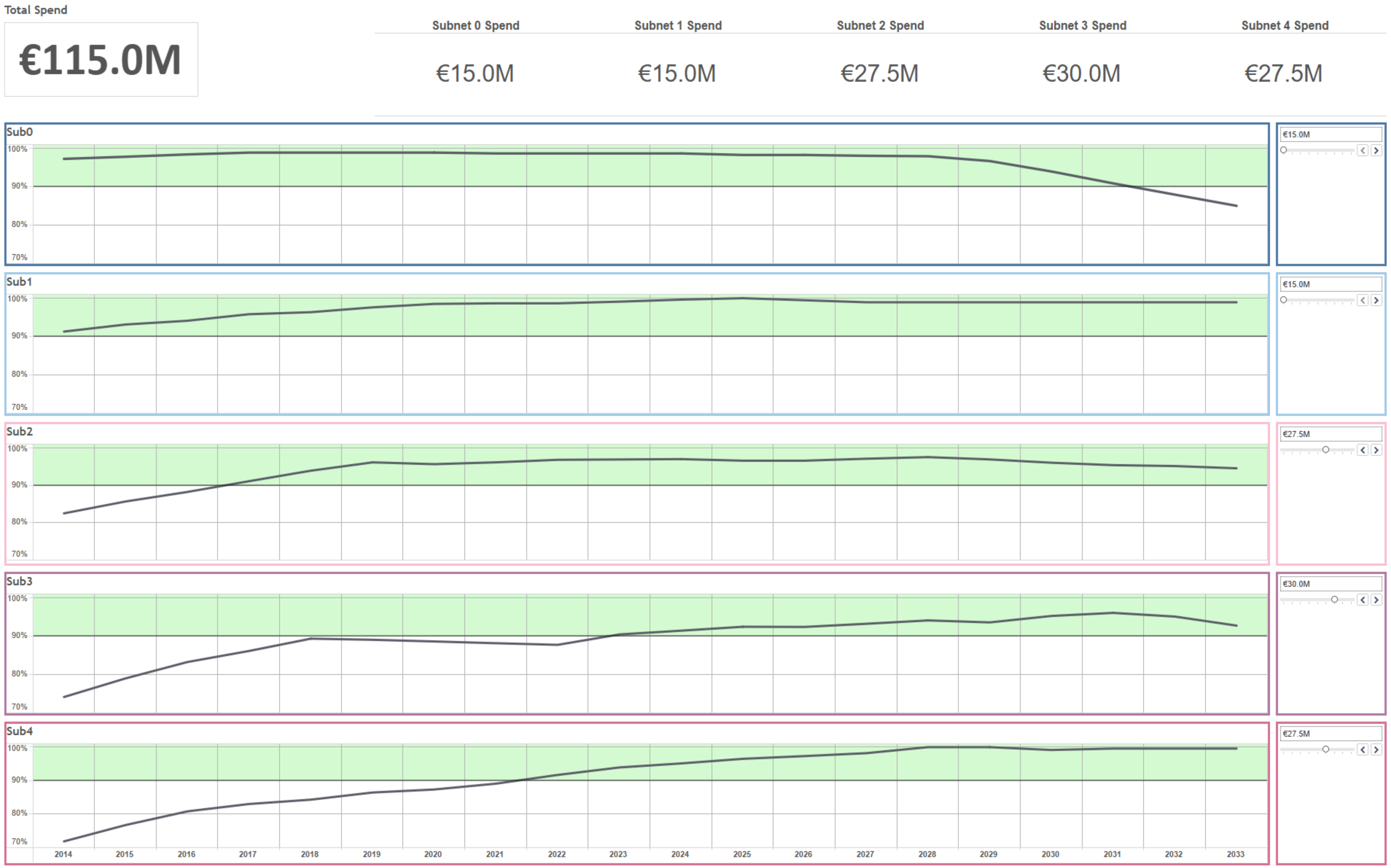


Name	CreatedOn	CreatedBy	ModifiedOn	ModifiedBy	Key	Parameter	Subnet	T1_VeryGood	T2_Good	T3_Fair	T4_Poor	T5_VeryPoor
CCL1	27/03/2024 17:0...	dbo			IRI_S0	IRI	0	1.5	2	2.5	3	1,000
CCL10	27/03/2024 17:0...	dbo			RUT_S4	RUT	4	4	6	9	15	1,000
CCL11	27/03/2024 17:0...	dbo			LPV3_S0	LPV3	0	1	2	3	4	1,000
CCL12	27/03/2024 17:0...	dbo			LPV3_S1	LPV3	1	1	2	3	4	1,000
CCL13	27/03/2024 17:0...	dbo			LPV3_S2	LPV3	2	2	4	7	10	1,000
CCL14	27/03/2024 17:0...	dbo			LPV3_S3	LPV3	3	2	3.5	5	7	1,000
CCL15	27/03/2024 17:0...	dbo			LPV3_S4	LPV3	4	2	4	7	10	1,000
CCL2	27/03/2024 17:0...	dbo			IRI_S1	IRI	1	2	2.5	3	3.5	1,000
CCL3	27/03/2024 17:0...	dbo			IRI_S2	IRI	2	3	4	5	7	1,000
CCL4	27/03/2024 17:0...	dbo			IRI_S3	IRI	3	2.7	3.2	4	5	1,000
CCL5	27/03/2024 17:0...	dbo			IRI_S4	IRI	4	3	4	5	7	1,000
CCL6	27/03/2024 17:0...	dbo			RUT_S0	RUT	0	3	5	6	9	1,000
CCL7	27/03/2024 17:0...	dbo			RUT_S1	RUT	1	3	5	6	9	1,000
CCL8	27/03/2024 17:0...	dbo			RUT_S2	RUT	2	4	6	9	15	1,000
CCL9	27/03/2024 17:0...	dbo			RUT_S3	RUT	3	4	6	9	15	1,000

Subnetwork Configuration in dTIMS

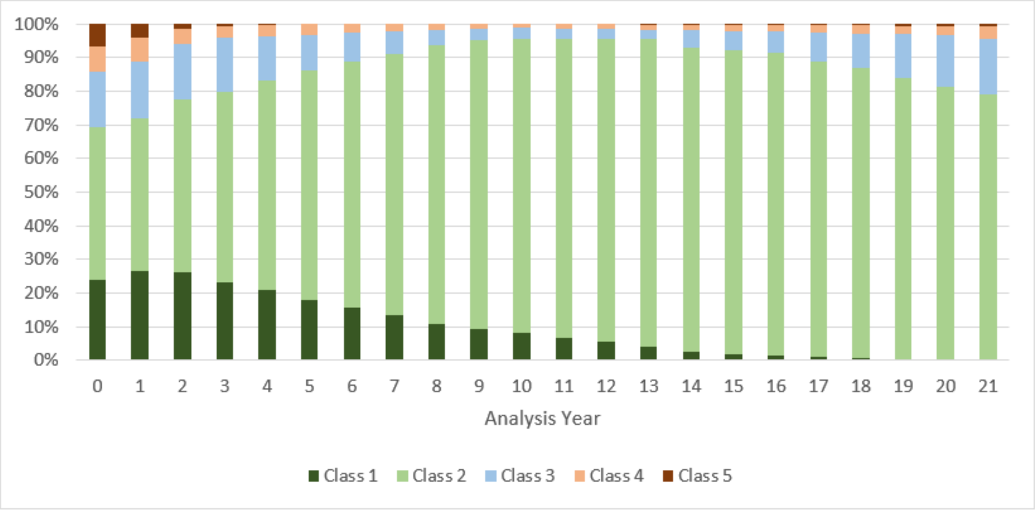
- Using a combination of Lookup Tables, CrossTab Transformations and Analysis Filters TII's pavement asset management processes could be captured and replicated in dTIMS

- The additional analysis tools available in dTIMS (Cross Asset Optimisation, SAM etc) enabled more nuanced approaches to maintenance strategy selection and optimisation than was previously available

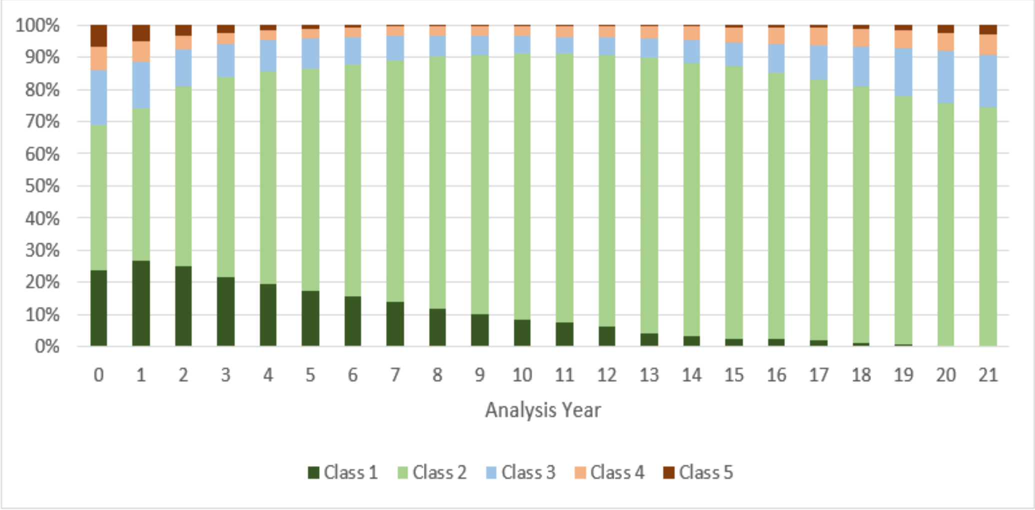


Additional Constraints - Labour

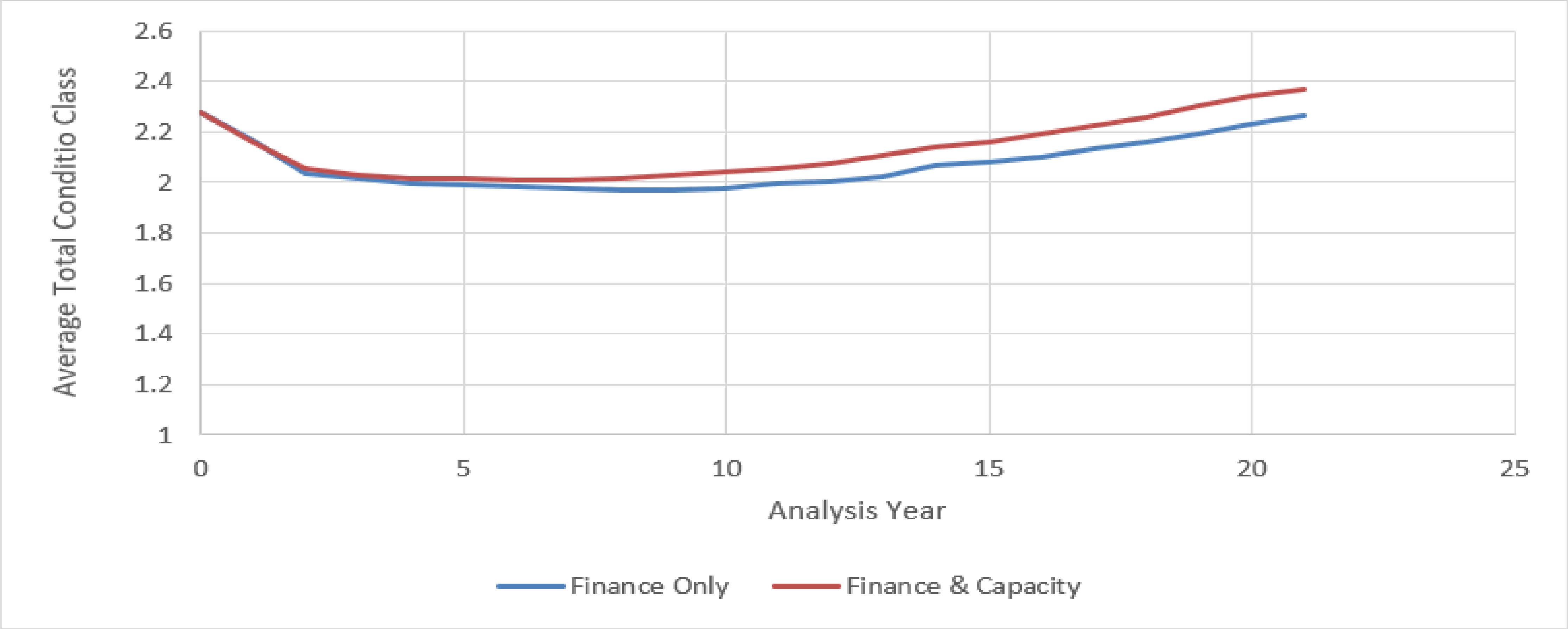
- Funding over the last 6-7 years has been at a level sufficient to cover pavement maintenance & rehabilitation needs
- Network is divided between 32 separate local authorities
- Over the last 2 – 3 years it's becoming apparent that in some LAs, funding is not the limiting factor on programme delivery.
- Availability of labour is more critical to delivering schemes than availability of funding
- An additional constraint was implemented in dTIMS which restricted the amount of work that could be assigned to given local authority based on their capacity to deliver schemes.



Financial Constraint Fair & Better in Year 21 = 96%



Financial & Manpower Constraints Fair & Better in Year 21 = 91%



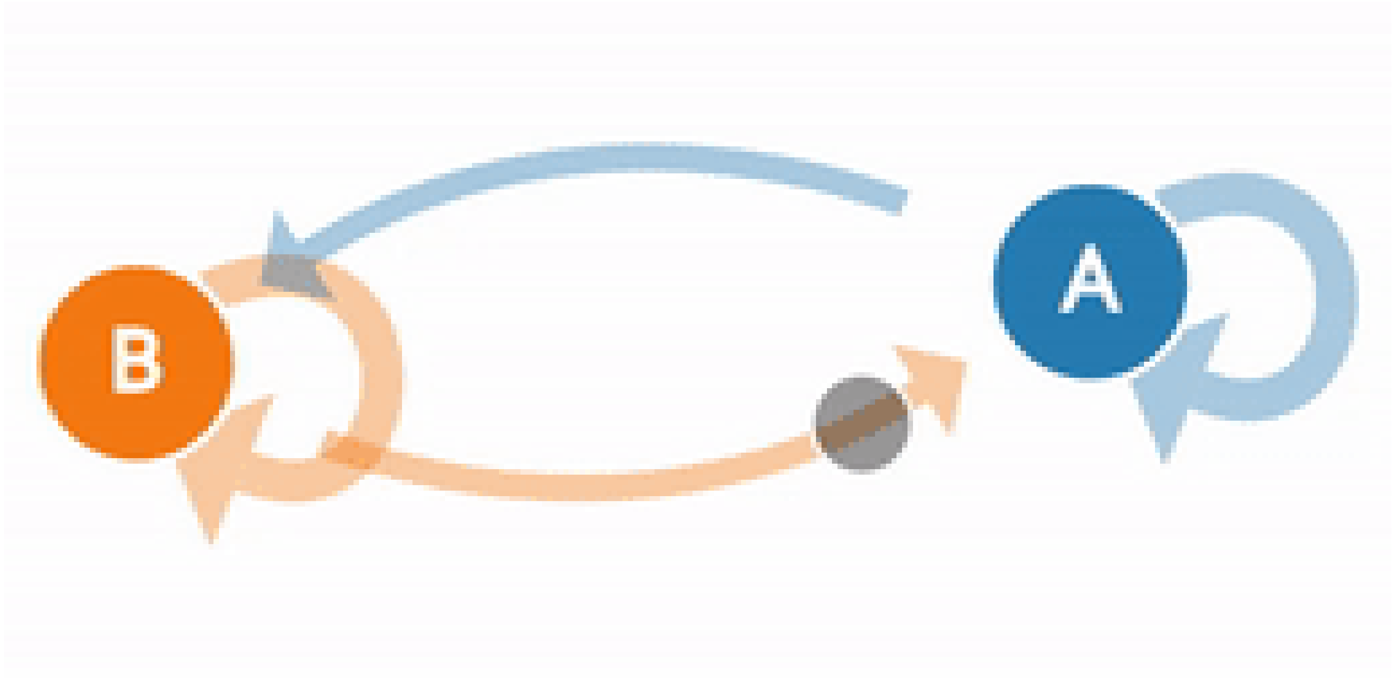
Updates to Deterioration Modelling – Probabilistic Modelling

- dTIMS in TII was initially configured using entirely deterministic modelling.
- In 2023 TII investigate moving from deterministic modelling to probabalisitc modelling to better capture the deterioration of the network.
- Development work was carried out in 2022/2023
- Probabalistic modelling was fully implemented in dTIMS in 2023 for pavement condition deterioration using Markov chains with Transition Probability Matrices (TPMS)

Deterministic modeling assumes that the behavior of a system is completely predictable and follows specific rules or equations. It assumes that if you know the initial conditions and the rules governing the system, you can precisely determine its future state.

Probabilistic models takes into account that outcomes are not always certain and can vary based on probabilities. Instead of providing precise predictions, probabilistic models provide likelihoods or probabilities of different outcomes.

Probabilistic Modelling - TPMS



		Future State	
		A	B
Initial State	A	P_{AA}	P_{AB}
	B	P_{BA}	P_{BB}

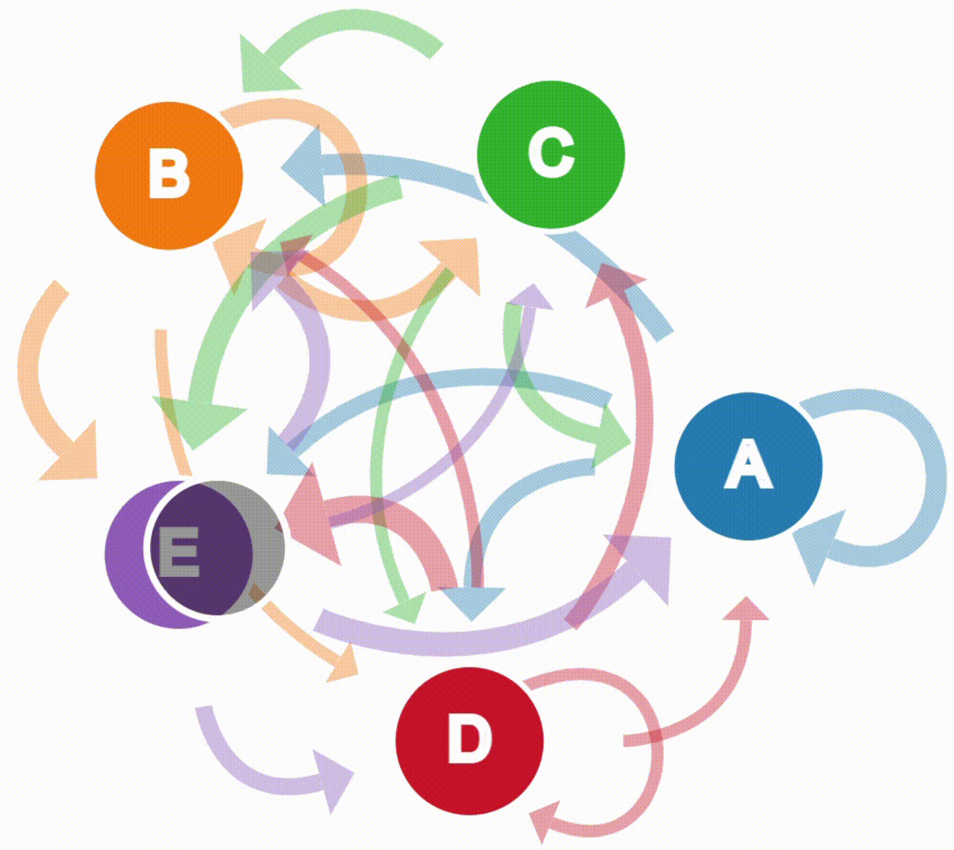
Distribution of elements after 1 time step:

$$A_1 = A_0 * P_{AA} + B_0 * P_{BA}$$

$$B_1 = B_0 * P_{BB} + A_0 * P_{AB}$$

Probabilistic Modelling - TPMS

TII use 5 Pavement Condition States => 5 x 5 Matrix



Initial \ Future	1	2	3	4	5
1	98.173	1.773	0.038	0.011	0.005
2	0	97.53	2.268	0.169	0.033
3	0	0	96.845	2.791	0.364
4	0	0	0	96.004	3.996
5	0	0	0	0	100

Probabilistic Modelling – TPM Development

- Data was compiled on the Irish National Road network at 100 metre intervals (Sample Units) from 2010 and 2021
- Sample Units are grouped into families, primarily by Sub-network with some subdivisions for traffic volumes. The condition class for each Sample Unit was tracked across the 11 year time period
- The proportional changes in condition class was calculated from which TPMs were derived for a single time step. These were aggregated into an overall TPM.
- This exercise was carried out for each of the three pavement condition parameters (IRI, Rut, LPV) for each time step

Direction 1

	1	2	3	4	5
1	95.7%	3.6%	0.5%	0.1%	0.1%
2	0.0%	89.6%	8.6%	1.2%	0.7%
3	0.0%	0.0%	87.5%	9.0%	3.5%
4	0.0%	0.0%	0.0%	83.7%	16.3%
5	0.0%	0.0%	0.0%	0.0%	100.0%
	2010-2012				

1	2	3	4	5
95.6%	3.8%	0.4%	0.1%	0.1%
0.0%	90.6%	8.2%	0.8%	0.4%
0.0%	0.0%	86.2%	9.4%	4.4%
0.0%	0.0%	0.0%	80.6%	19.4%
0.0%	0.0%	0.0%	0.0%	100.0%
2012-2014				

1	2	3	4	5
96.8%	2.8%	0.3%	0.1%	0.0%
0.0%	91.3%	7.7%	0.8%	0.2%
0.0%	0.0%	89.1%	7.1%	3.8%
0.0%	0.0%	0.0%	83.1%	16.9%
0.0%	0.0%	0.0%	0.0%	100.0%
2014-2016				

1	2	3	4	5
95.7%	3.7%	0.4%	0.1%	0.1%
0.0%	89.0%	9.2%	1.1%	0.7%
0.0%	0.0%	86.4%	9.3%	4.3%
0.0%	0.0%	0.0%	75.9%	24.1%
0.0%	0.0%	0.0%	0.0%	100.0%
2016-2018				

Direction 2

	1	2	3	4	5
1	96.0%	3.4%	0.4%	0.1%	0.1%
2	0.0%	90.7%	7.7%	1.5%	0.1%
3	0.0%	0.0%	85.7%	10.1%	4.2%
4	0.0%	0.0%	0.0%	87.5%	12.5%
5	0.0%	0.0%	0.0%	0.0%	100.0%
	2011-2013				

1	2	3	4	5
96.3%	3.2%	0.4%	0.1%	0.1%
0.0%	92.5%	5.8%	1.5%	0.2%
0.0%	0.0%	87.1%	10.7%	2.3%
0.0%	0.0%	0.0%	85.4%	14.6%
0.0%	0.0%	0.0%	0.0%	100.0%
2013-2015				

1	2	3	4	5
96.5%	2.7%	0.5%	0.1%	0.1%
0.0%	89.2%	8.2%	1.7%	0.9%
0.0%	0.0%	85.1%	11.9%	3.0%
0.0%	0.0%	0.0%	81.3%	18.8%
0.0%	0.0%	0.0%	0.0%	100.0%
2015-2017				

1	2	3	4	5
95.9%	3.6%	0.4%	0.1%	0.0%
0.0%	91.6%	6.3%	0.7%	1.3%
0.0%	0.0%	84.3%	11.7%	4.0%
0.0%	0.0%	0.0%	80.9%	19.1%
0.0%	0.0%	0.0%	0.0%	100.0%
2017-2019				

Probabilistic Modelling – TPM Development

Over 240 TPMs created during the development phase. These were improved on iteratively throughout the testing and debug phase.

Probabilistic Modelling – TPM Validation

Scenario I – Single Direction (3600 Sample Units):

- Average all TPMS from 2010 to 2016
- Take 2017 Condition Distribution as the Initial State Vector
- Predict 2019 Condition Distribution using the Average TPM

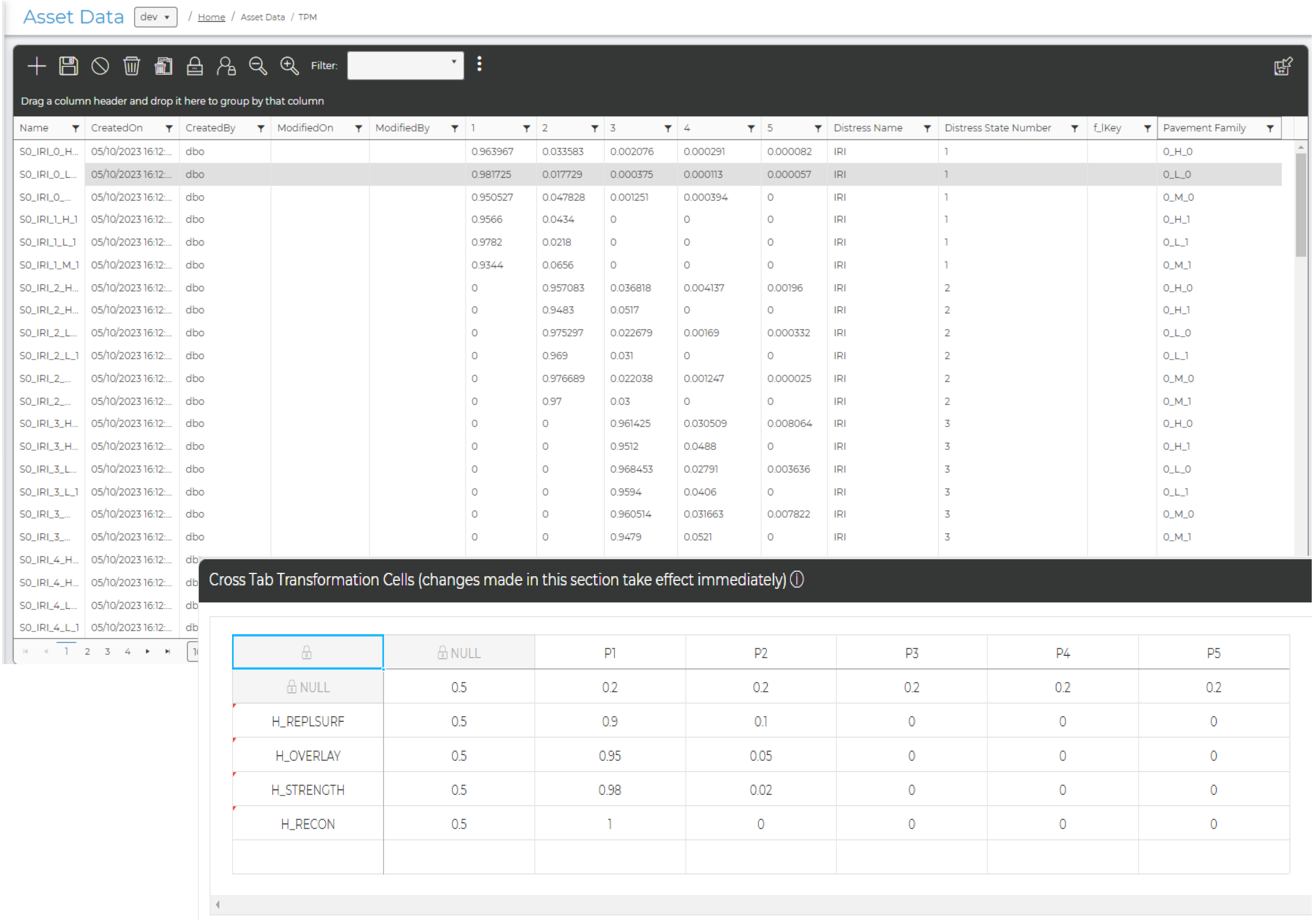
Scenario II – Both Directions (7200 Sample Units):

- Average all TPMs from 2010 to 2016
- Combine condition data from 2016 and 2017 to give an overall Initial State Vector
- Predict the condition distribution for the combined 2018 and 2019 data using the Average TPM

	Vector		
	Initial	***Predicted***	***Measured***
Scenario I	77.2%	71.4%	71.4%
	18.9%	23.0%	22.9%
	2.9%	4.2%	4.3%
	0.7%	1.0%	0.9%
	0.3%	0.4%	0.5%
Scenario II	75.9%	70.2%	70.6%
	19.7%	23.7%	23.3%
	3.2%	4.5%	4.6%
	0.8%	1.1%	1.1%
	0.3%	0.5%	0.5%

Probabilistic Modelling – Implementation in dTIMS

- 240 TPMs were reduced to approx. 30 in the final implementation
- All TPMs were stored in a single look-up table in dTIMS
- For each analysis section a Year 1 Condition Distribution was calculated (Initial State Vector)
- For each time step a new condition distribution was calculated using the Markov Function in dTIMS.
- Based on the predicted condition distributions, representative values for IRI, RUT and LPV were calculated.
- Treatments were triggered based on these values.
- Treatment resets comprised resetting the condition distribution to a new improved distribution. Reset distribution varied depending on the Subnet and the level of treatment.



Name	CreatedOn	CreatedBy	ModifiedOn	ModifiedBy	1	2	3	4	5	Distress Name	Distress State Number	f_IKey	Pavement Family
S0_IRI_0_H...	05/10/2023 16:12:...	dbo			0.963967	0.033583	0.002076	0.000291	0.000082	IRI	1		0_H_0
S0_IRI_0_L...	05/10/2023 16:12:...	dbo			0.981725	0.017729	0.000375	0.000113	0.000057	IRI	1		0_L_0
S0_IRI_0_...	05/10/2023 16:12:...	dbo			0.950527	0.047828	0.001251	0.000394	0	IRI	1		0_M_0
S0_IRI_1_H_1	05/10/2023 16:12:...	dbo			0.9566	0.0434	0	0	0	IRI	1		0_H_1
S0_IRI_1_L_1	05/10/2023 16:12:...	dbo			0.9782	0.0218	0	0	0	IRI	1		0_L_1
S0_IRI_1_M_1	05/10/2023 16:12:...	dbo			0.9344	0.0656	0	0	0	IRI	1		0_M_1
S0_IRI_2_H...	05/10/2023 16:12:...	dbo			0	0.957083	0.036818	0.004137	0.00196	IRI	2		0_H_0
S0_IRI_2_H...	05/10/2023 16:12:...	dbo			0	0.9483	0.0517	0	0	IRI	2		0_H_1
S0_IRI_2_L...	05/10/2023 16:12:...	dbo			0	0.975297	0.022679	0.00169	0.000332	IRI	2		0_L_0
S0_IRI_2_L_1	05/10/2023 16:12:...	dbo			0	0.969	0.031	0	0	IRI	2		0_L_1
S0_IRI_2_...	05/10/2023 16:12:...	dbo			0	0.976689	0.022038	0.001247	0.000025	IRI	2		0_M_0
S0_IRI_2_...	05/10/2023 16:12:...	dbo			0	0.97	0.03	0	0	IRI	2		0_M_1
S0_IRI_3_H...	05/10/2023 16:12:...	dbo			0	0	0.961425	0.030509	0.008064	IRI	3		0_H_0
S0_IRI_3_H...	05/10/2023 16:12:...	dbo			0	0	0.9512	0.0488	0	IRI	3		0_H_1
S0_IRI_3_L...	05/10/2023 16:12:...	dbo			0	0	0.968453	0.02791	0.003636	IRI	3		0_L_0
S0_IRI_3_L_1	05/10/2023 16:12:...	dbo			0	0	0.9594	0.0406	0	IRI	3		0_L_1
S0_IRI_3_...	05/10/2023 16:12:...	dbo			0	0	0.960514	0.031663	0.007822	IRI	3		0_M_0
S0_IRI_3_...	05/10/2023 16:12:...	dbo			0	0	0.9479	0.0521	0	IRI	3		0_M_1
S0_IRI_4_H...	05/10/2023 16:12:...	db											
S0_IRI_4_H...	05/10/2023 16:12:...	db											
S0_IRI_4_L...	05/10/2023 16:12:...	db											
S0_IRI_4_L_1	05/10/2023 16:12:...	db											

1 2 3 4

	NULL	P1	P2	P3	P4	P5
NULL	0.5	0.2	0.2	0.2	0.2	0.2
H_REPLSURF	0.5	0.9	0.1	0	0	0
H_OVERLAY	0.5	0.95	0.05	0	0	0
H_STRENGTH	0.5	0.98	0.02	0	0	0
H_RECON	0.5	1	0	0	0	0

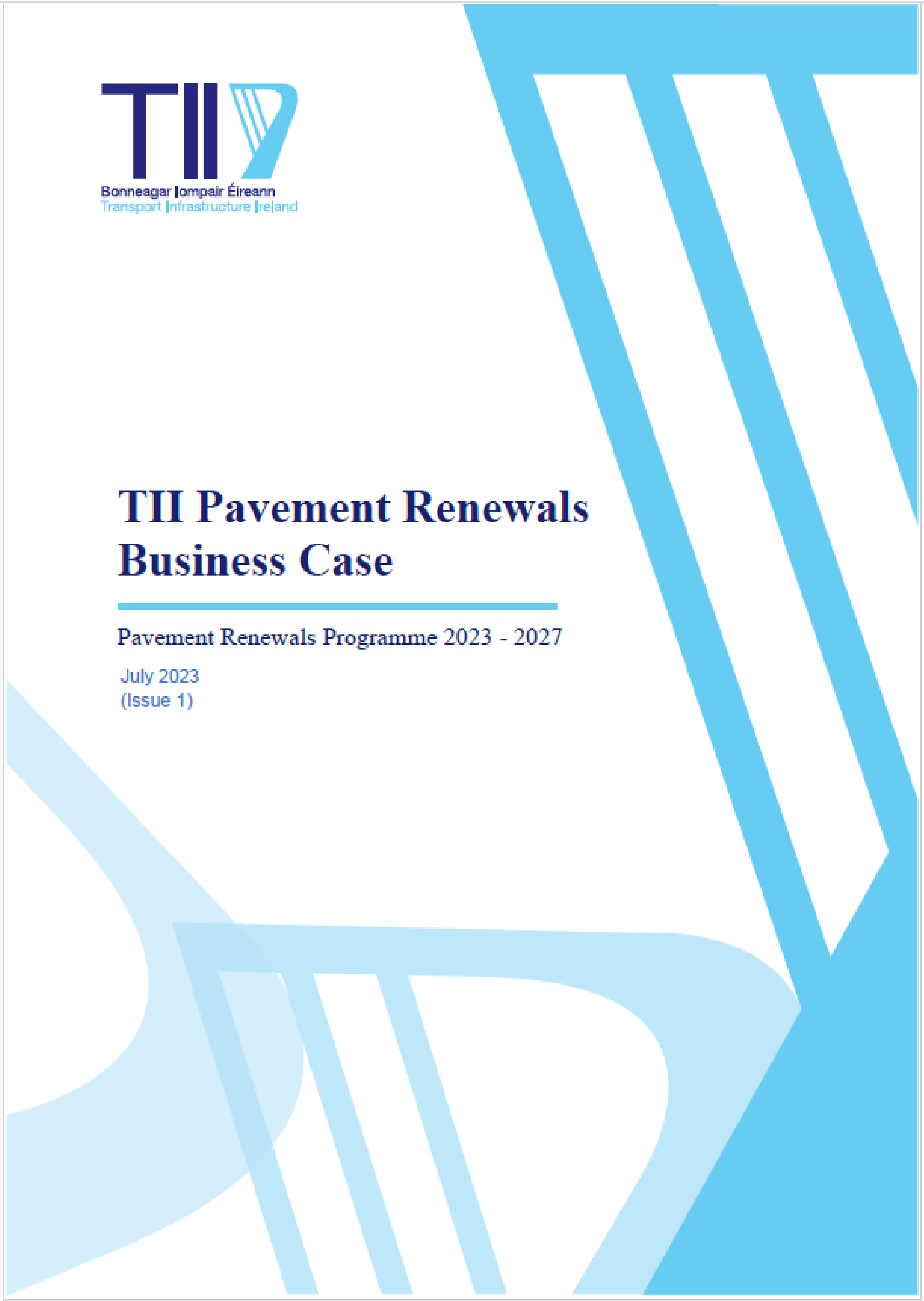
How dTIMS impacts our Pavement Asset Management


Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Transport Infrastructure Ireland

Business Case

Delivery of Pavement Renewals Programme on the National Road Network


Bonneagar Iompair Éireann
Transport Infrastructure Ireland

TII Pavement Renewals Business Case

Pavement Renewals Programme 2023 - 2027

July 2023
(Issue 1)

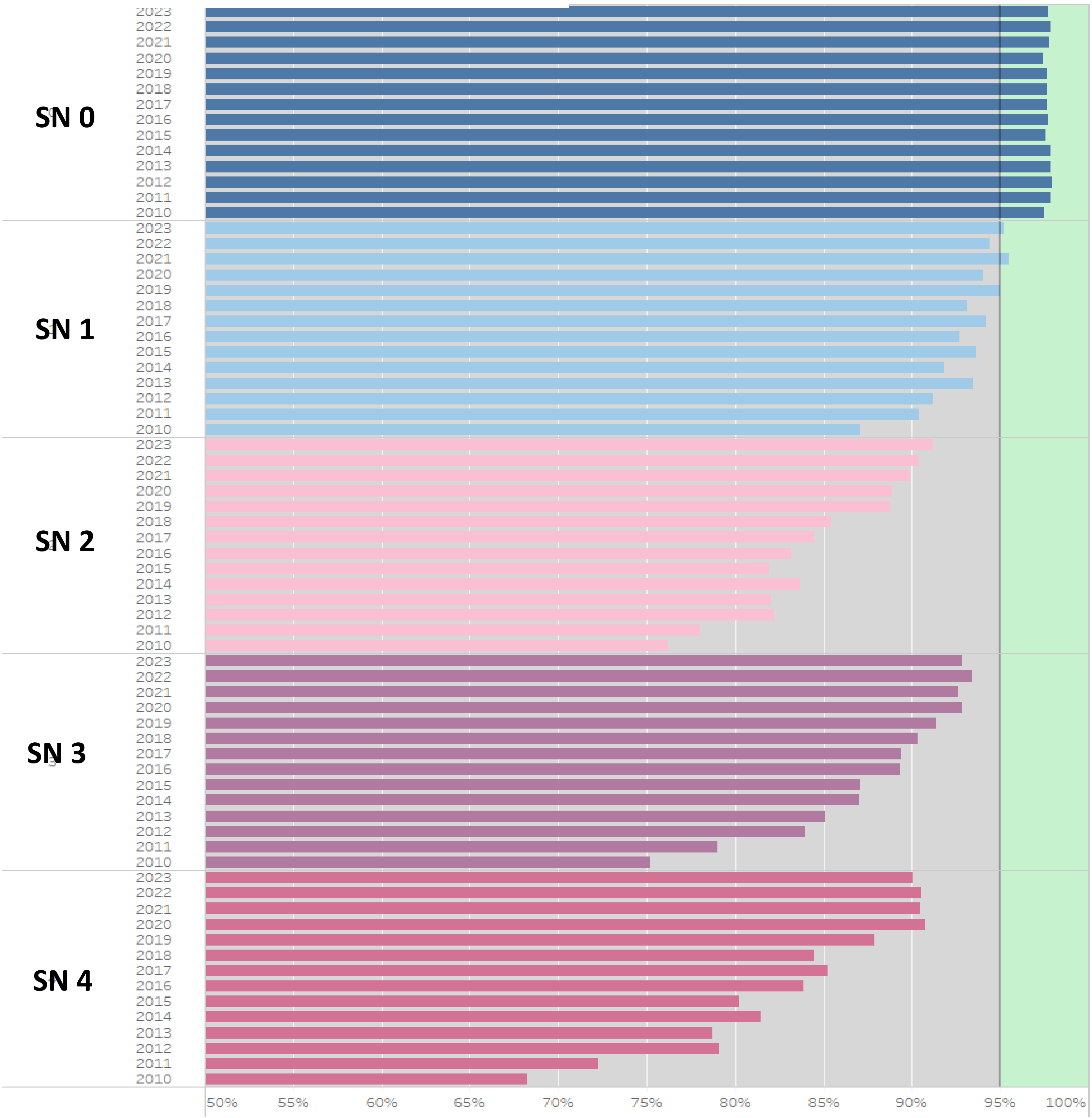
Pavement Renewals Business Case 2016 – 2021
Optimal Annual Budget = €140M

Pavement Renewals Business Case 2023 – 2027
Optimal Annual Budget = €110M

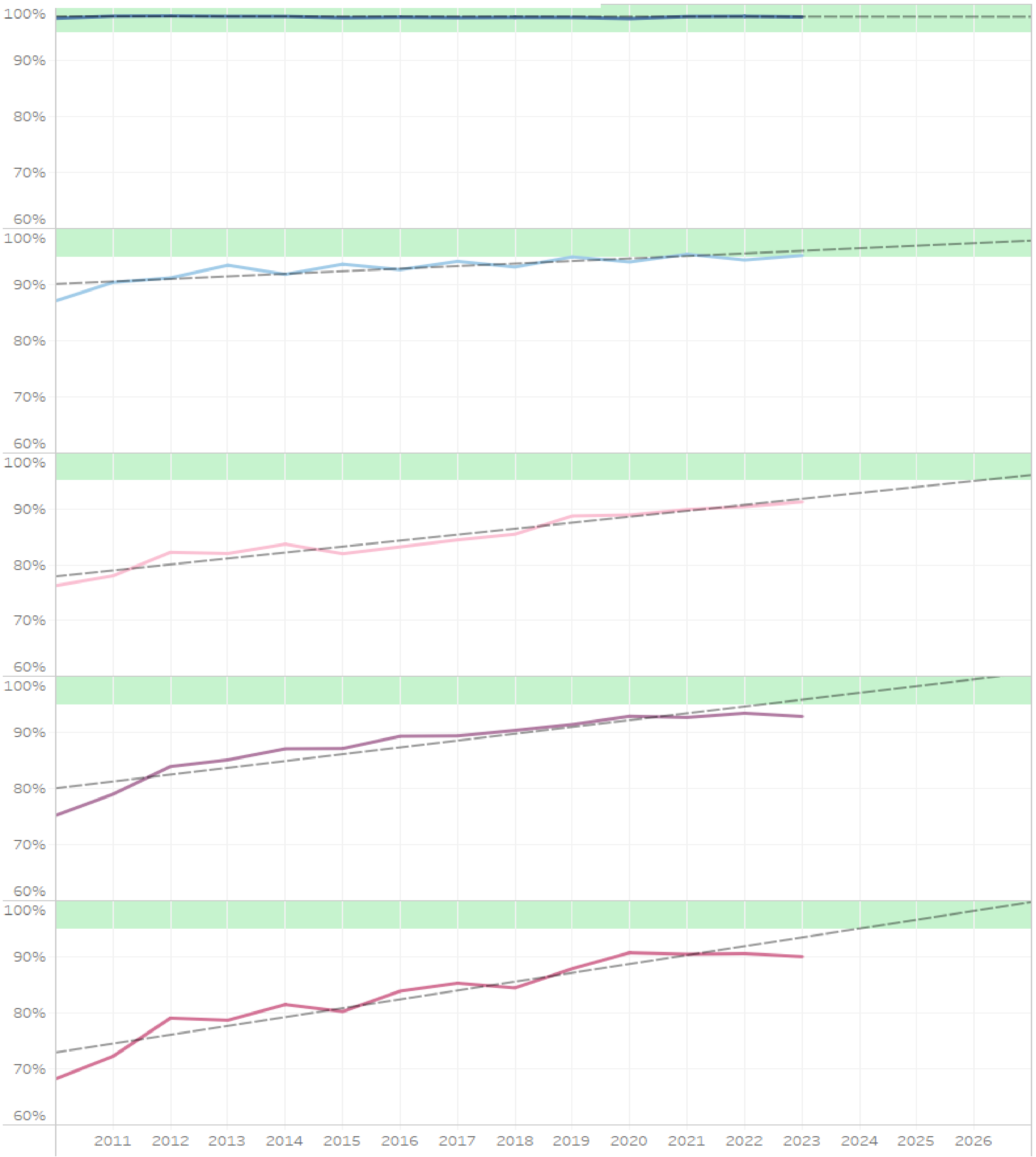
How dTIMS impacts our Pavement Asset Management

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Network Condition - % Fair or Better



Longterm Trends



Years to Target

0
0
4
2
4

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Thank You – Questions?

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TII Reporting Dashboard March 2022

Year: All | Subnet: All | Local Authority: All | Route: All | Network: All

Network Length

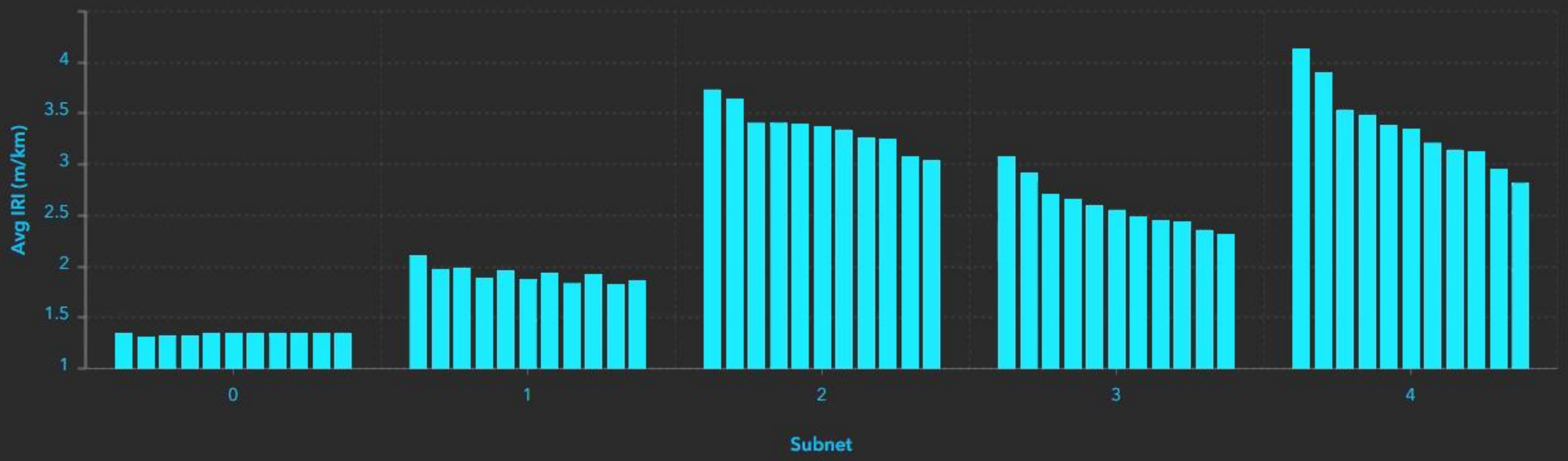
5,317km

Subnet

Summary Statistics

Subnet	Avg IRI (m/km)	Avg Left Rut(mm)	Avg LPV 3M	Avg MPD (mm)
0	1.3	2.5	0.5	1.6
1	1.9	2.8	1	1.8
2	3.4	4.9	2.9	1.3
3	2.6	5.3	1.6	1.4
4	3.4	7.9	2.8	1.4

Historical Trends - IRI



IRI | Rut | LPV 3m