Road Maintenance Forum (RMF)
Smart Mobility Cluster
PDC Offerings

Wednesday, 17 July 2024

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

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Pavement Infrastructure Asset Management Process

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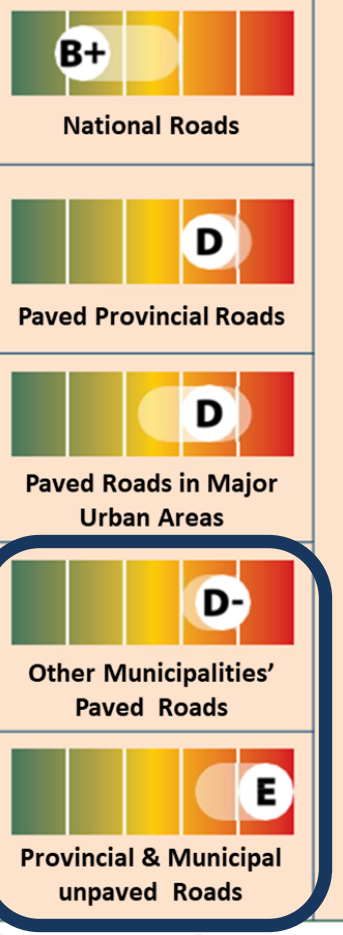
Road Sector Condition: 2022 SAICE Infrastructure Report Card

Roads (Extract from SAICE Infrastructure Report Card)



South Africa's road network is approximately 750 000 km long, making it the tenth longest in the world. About 160 000 km of the network are paved. SANRAL manages 21 403 km of this paved network (13% of these are toll roads), with the balance shared between provinces and municipalities.

The proportion of the national road system in poor or very poor condition is below 7% thanks to SANRAL's strong maintenance and expansion regimen, which is excellent by global standards. By contrast, the secondary and tertiary road network is experiencing accelerated rates of deterioration, compromising both road safety and the efficiency of moving freight.

Most provincial and local road authorities do not regularly undertake or publish assessments of the condition of their road networks, and repairs are therefore typically reactive, e.g. fixing potholes rather than conducting regular preventative maintenance. Moreover, maintenance and improvements are generally underfunded, and the future negative consequences of this trend on the longevity of roadways are rarely assessed.

Except for the Western Cape, the condition of most paved provincial roads is substandard. There is a risk of further deterioration due to increased vehicle overloading, poor maintenance and the steady reduction of skilled personnel in roads departments. In major urban areas the condition of paved roads has also continued to deteriorate. While obtaining reliable road condition data for smaller municipalities was not possible, their roads generally suffer from significant and increasing maintenance neglect.

Provincial and municipal authorities share the country's gravel roads approximately equally. Gravel roads constitute nearly 80% of the country's road network, but few of them are in a satisfactory condition due to lack of capacity and insufficient funding.

Most South Africans (73% of the population) depend heavily on public and non-motorised transport. Around 20% of workers walk all the way to their place of employment. All public transport users also require pedestrian infrastructure for their first/last kilometre, as well as stops, stations and ranks. Statistics on infrastructure conditions for these modes are mostly unavailable, often due to a complete lack of services. This not only creates inefficiencies in public transport services, but also contributes to an extremely high road fatality rate (12 577 persons in 2021), of which over 40% are pedestrians.

[2022, SAICE]

Research Capacity

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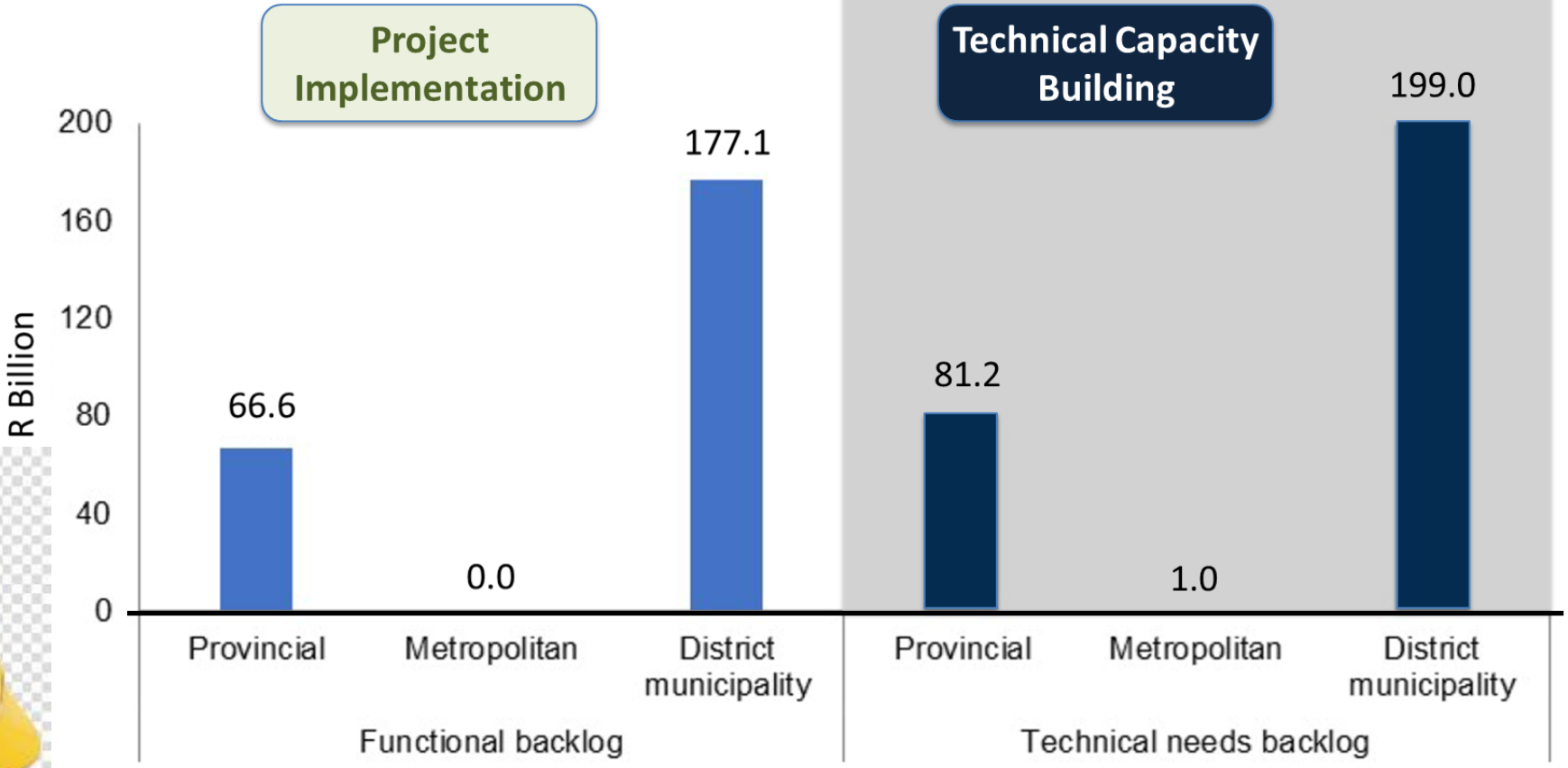
Municipalities: 2017 Maintenance Backlog (D.Ross & M Townsend)



Maintenance Backlog for Gravel Roads, 2017 (D. Ross and M. Townsend)

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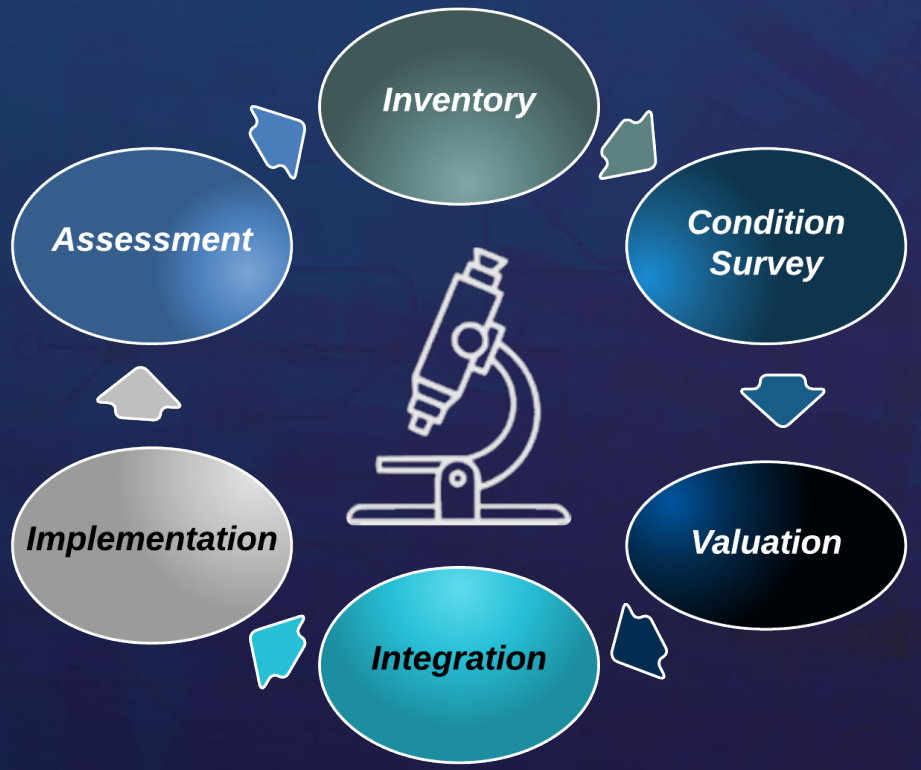

Implementation

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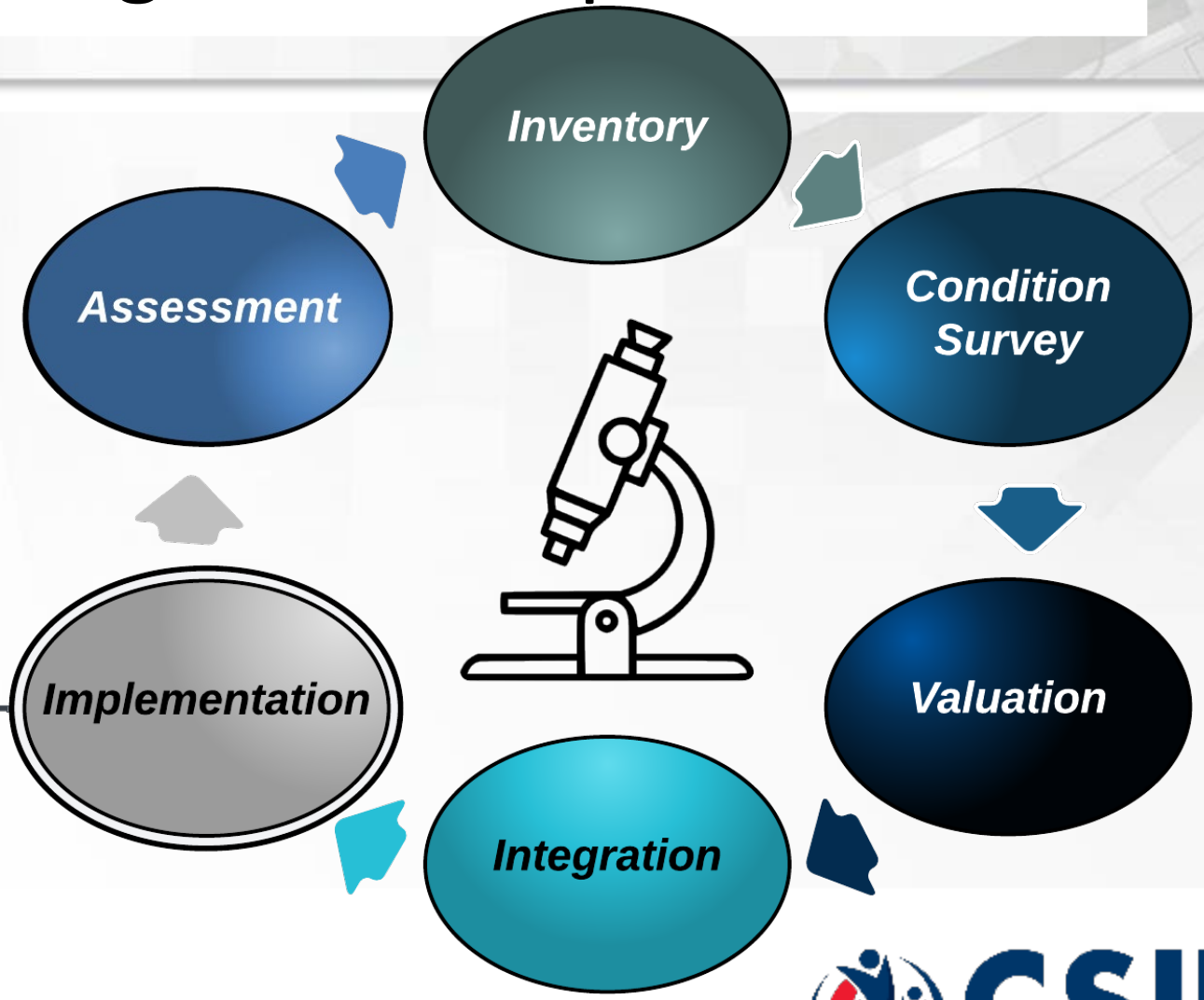
Pavement Asset Management: Implementation

Innovative, Resilient Road Material Catalogue

- Recycled Plastic Asphalt
- Nano Modified Emulsions
- Geosynthetic Material
- Glassphalt
- Robust Cation
- Etc.



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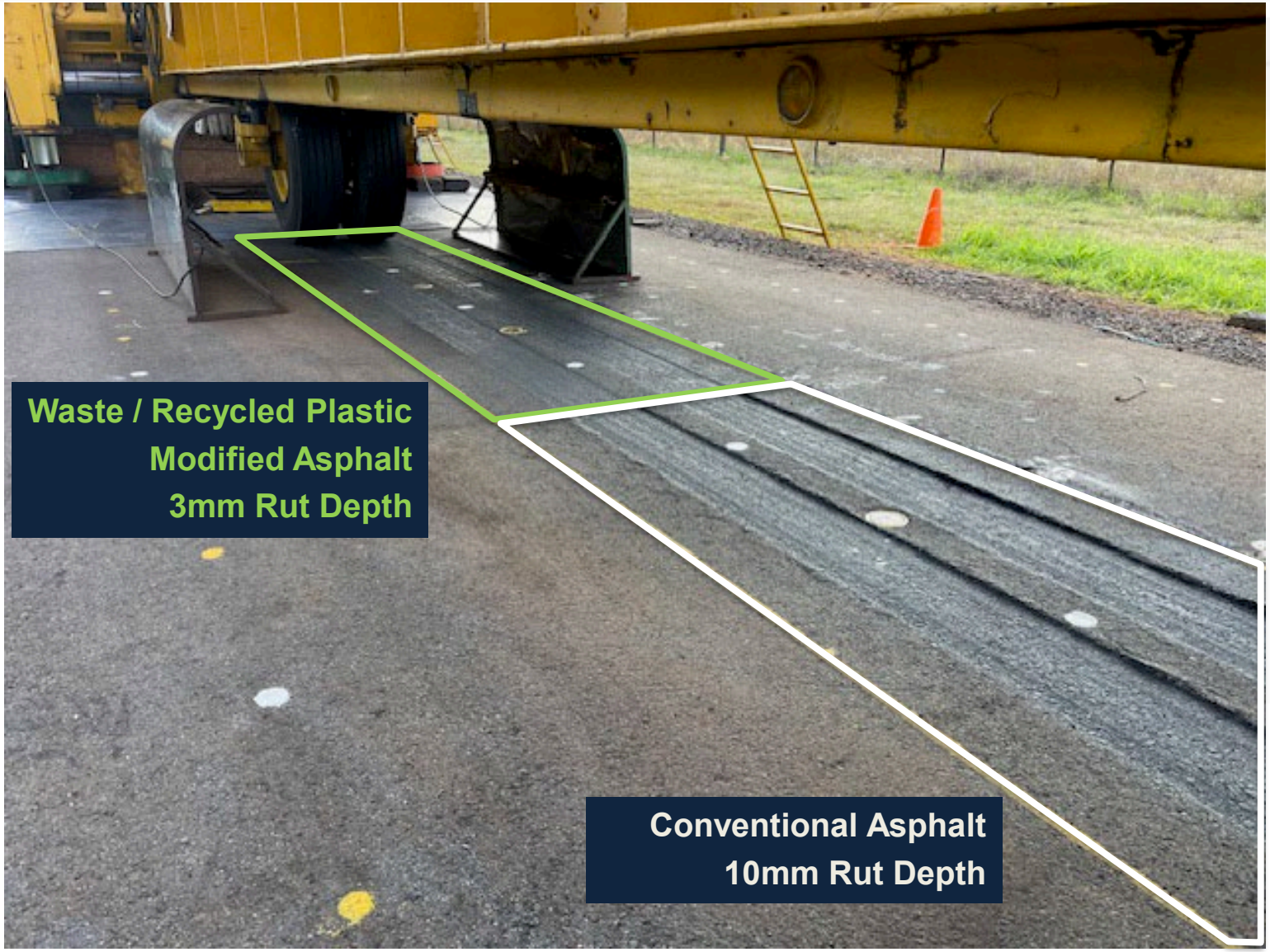
Waste / Recycled Plastic Modified Asphalt vs Conventional Asphalt



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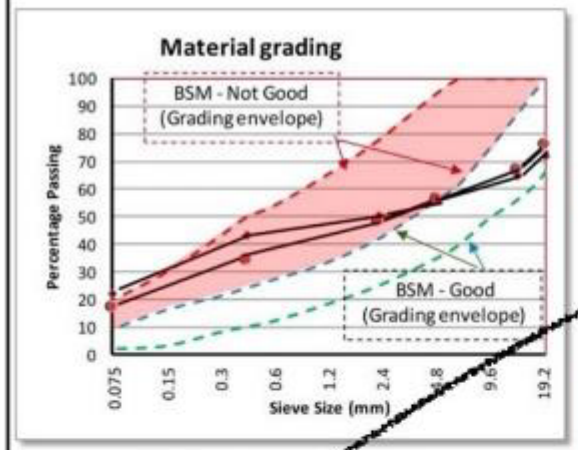
Base and Sub-base material for Accelerated Pavement Testing (APT) (MMLS3) of thin (chip seal) surfacings

Material grading



Material Test results

Fraction	%
Coarse Sand (CS)	29 - 33
Fine Sand (FS)	28 - 35
Coarse Fine Sand (CFS)	10 - 11
Medium Fine Sand (MFS)	11 - 17
Fine Fine Sand (FFS)	6 - 8
Silt and Clay (S & C)	35 - 39
OMC (%)	11.4
MDD (kg/cub m)	2030
VM	1.85
Atterberg Limits	
Liquid Limit (LL)	28 - 30
Plasticity Index (PI)	8 - 14
PI (0.075)	
Linear Shrinkage (LS)	4 - 7
CBR (mod AASHTO)	
95%	10 - 17
93%	9 - 14
Classification	
H.R.B.	A-2-6
COLTO	G8
TRH14	G8

G8

Mineral Percentages present in Material Sample

Minerology	Total sample %		0.075 mm Fraction %	
Mineral Groups	Individual	Combined	Individual	Combined
Quartz	43.20	43.20	23.0	23.0
Plagioclase	14.8		6.6	
Augite	2.4		1.3	
Enstratite	0.0		0.5	
Actinolite	3.8		1.4	
Microcline	6.5		4.2	
		27.5		14.0
Mica: Muscovite	12.2	12.2	36.2	36.2
Clay: Kaolinite	6.1		15.0	
Clay: Smectite	7.5		3.0	
Calcite	0.5	14.1	6.5	24.5
Talc	3.1	3.1	2.3	2.3

Mineral Groups:
(Weathering = chemical decomposition)

- **Primary** (Not subject to Weathering)
- **Primary** (Subject to Weathering)
- **Mica**
- **Secondary minerals**

(Nano-scale crystals/molecules)

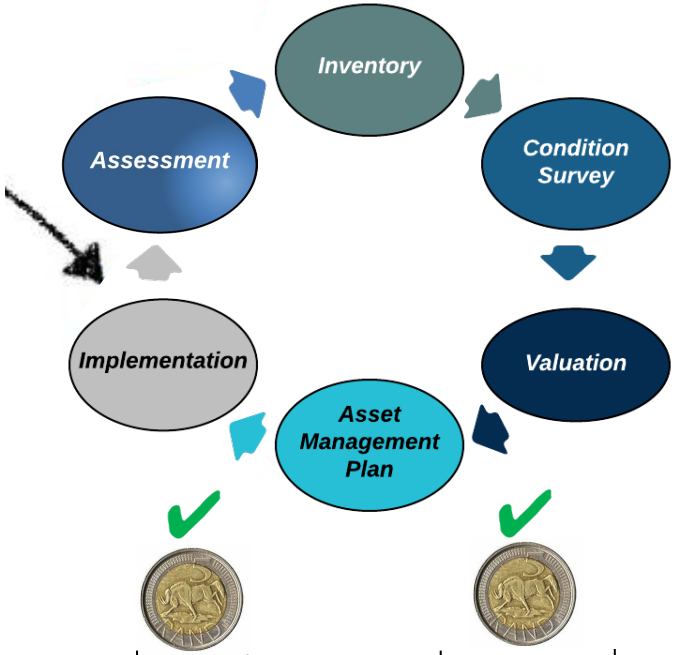
Results: Stabilisation

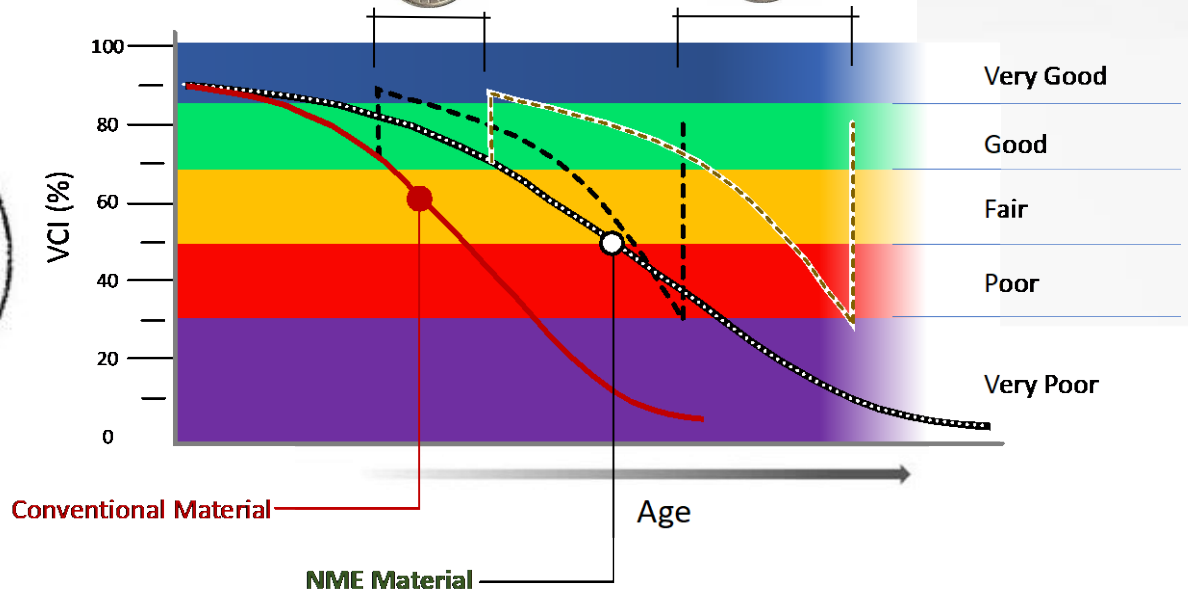
	New-age Modified Emulsion (NME)				Conventional Emulsion stabilisation	Unit
	0.7	1.0	1.2	1.5	1.5% S60 Emulsion + 1.0 % Cement	%
Tests:						
UCS(dry)	3395	4807	4859	2620	3277	kPa
UCS(wet)	1745	1830	1671	1865	656	kPa
UCSw/d %	51	38	34	71	20	%
ITS(dry)	254	420	268	232	167	kPa
ITS(wet)	61	321	221	184	61	kPa
ITSw/d %	24	76	82	79	37	%

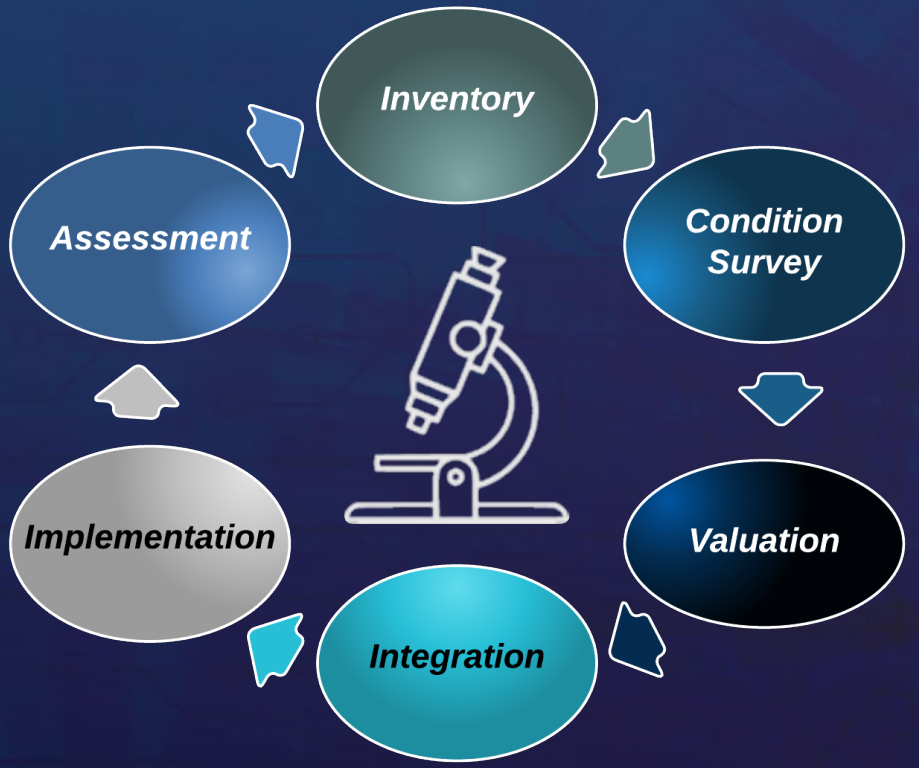
NME

Use of NME generating COST R10M/km against R2M/km and TIME saving on Upgrade Projects

Asset Management System







Assessment

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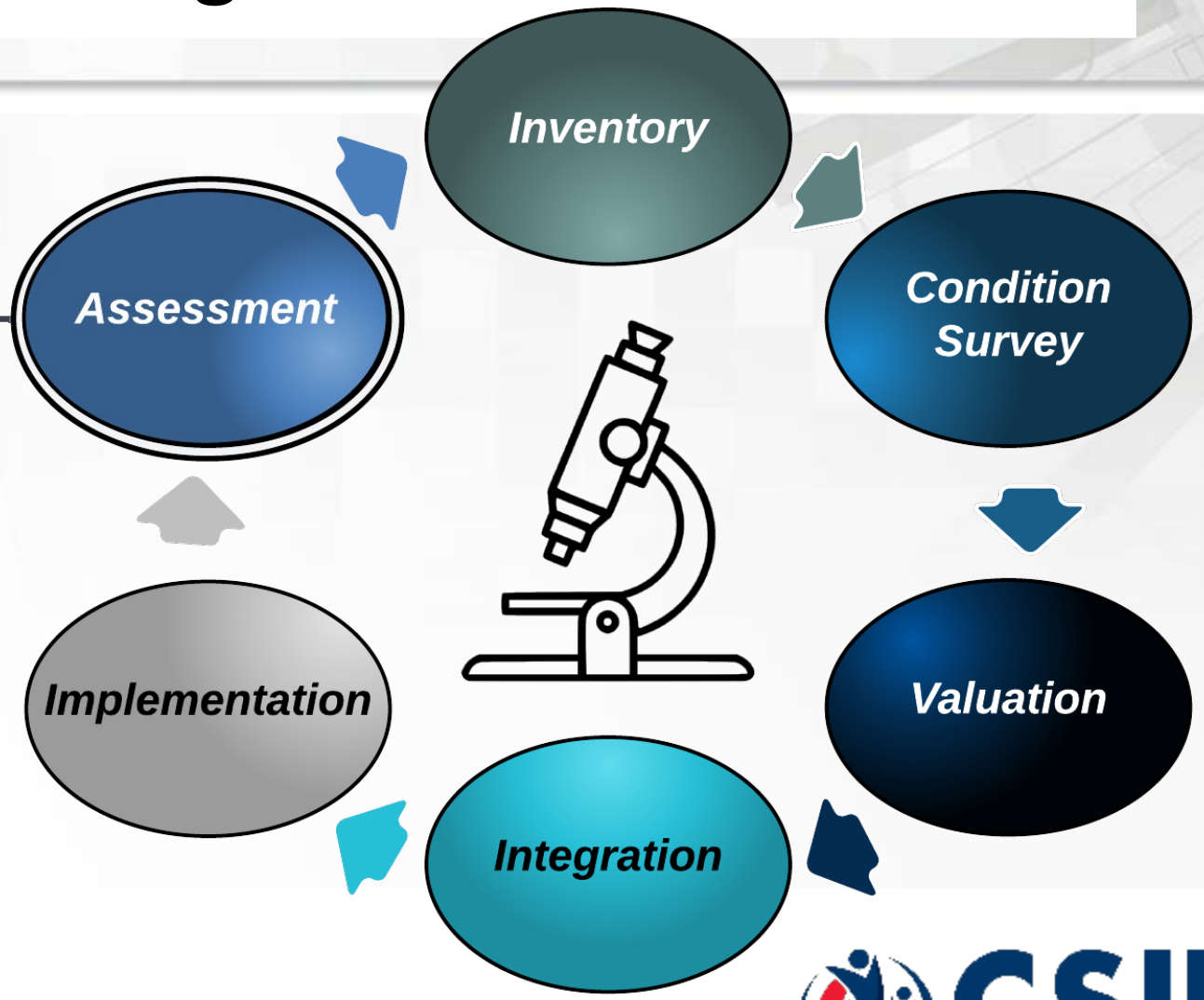
Pavement Asset Management: Assessment

Efficient Pavement Structure Performance Assessment

- Artificial Intelligence
- Machine Learning
- Image Analysers
- Traffic Stream Simulator
- MDD Improvement
- FWD Remaining Life
- Design & Assessment Software Development
- Etc.



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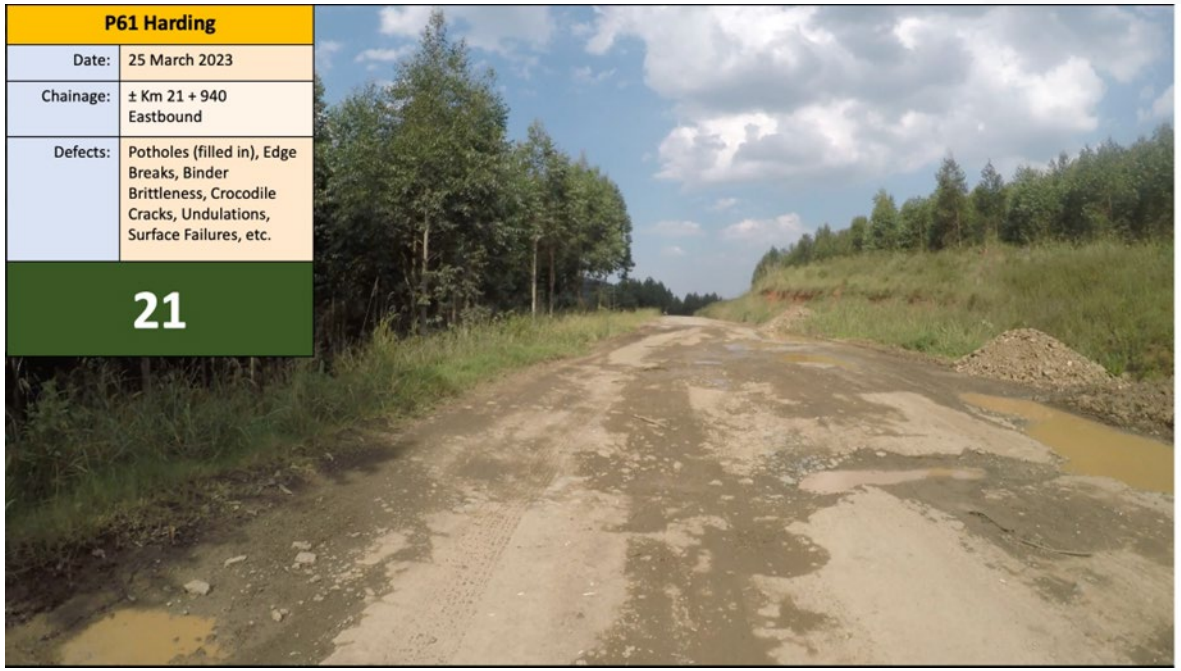
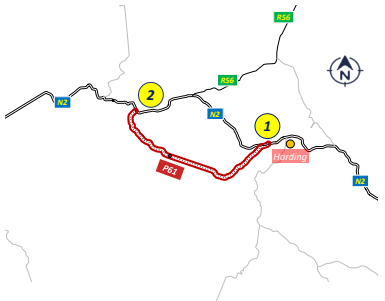
Visual Condition Assessment: TRH22 / Deduct Instrument Measurements: IRI, RUT, MPD





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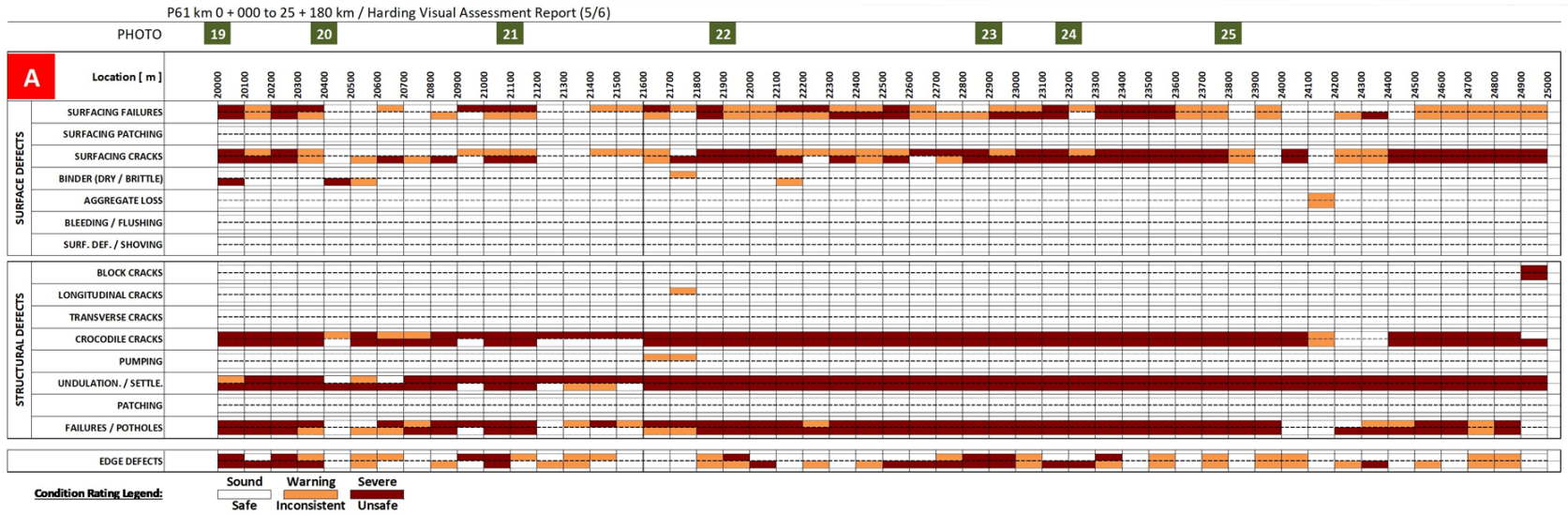
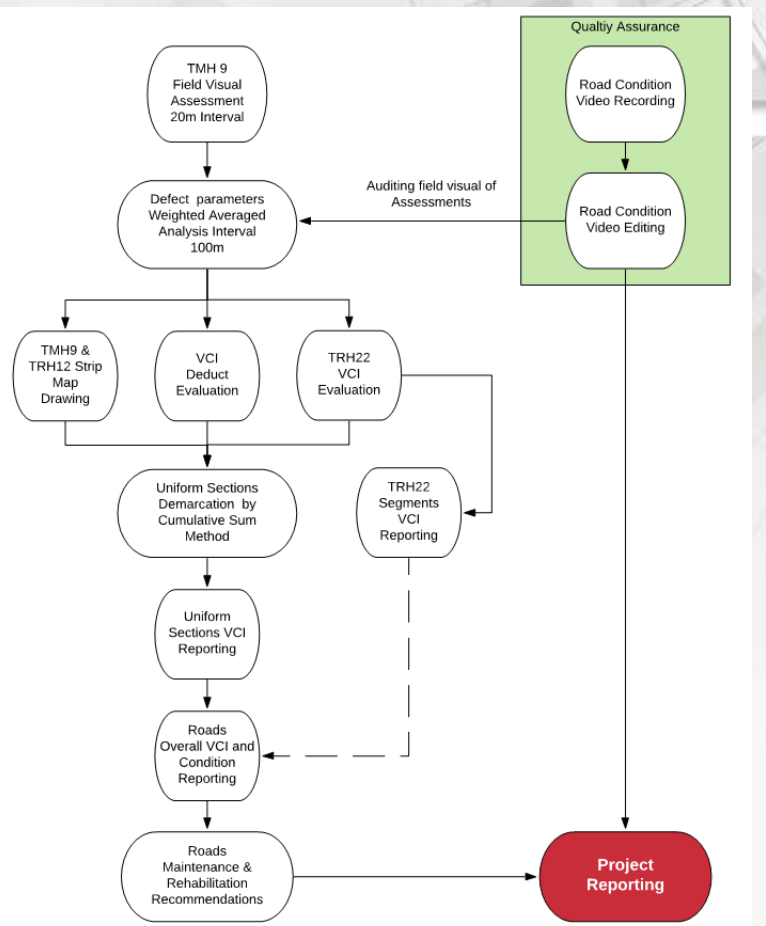
Project Level – Network Level Conditions





Condition	Recommended Intervention
Very Poor	Reconstruction
Poor	Major Rehabilitation
Fair	Minor Rehabilitation
Good	Preventative Maintenance
Very Good	Routine Maintenance

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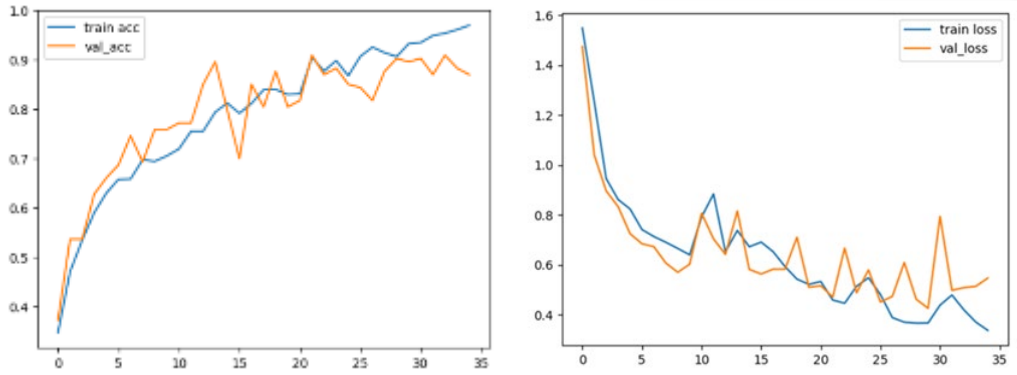
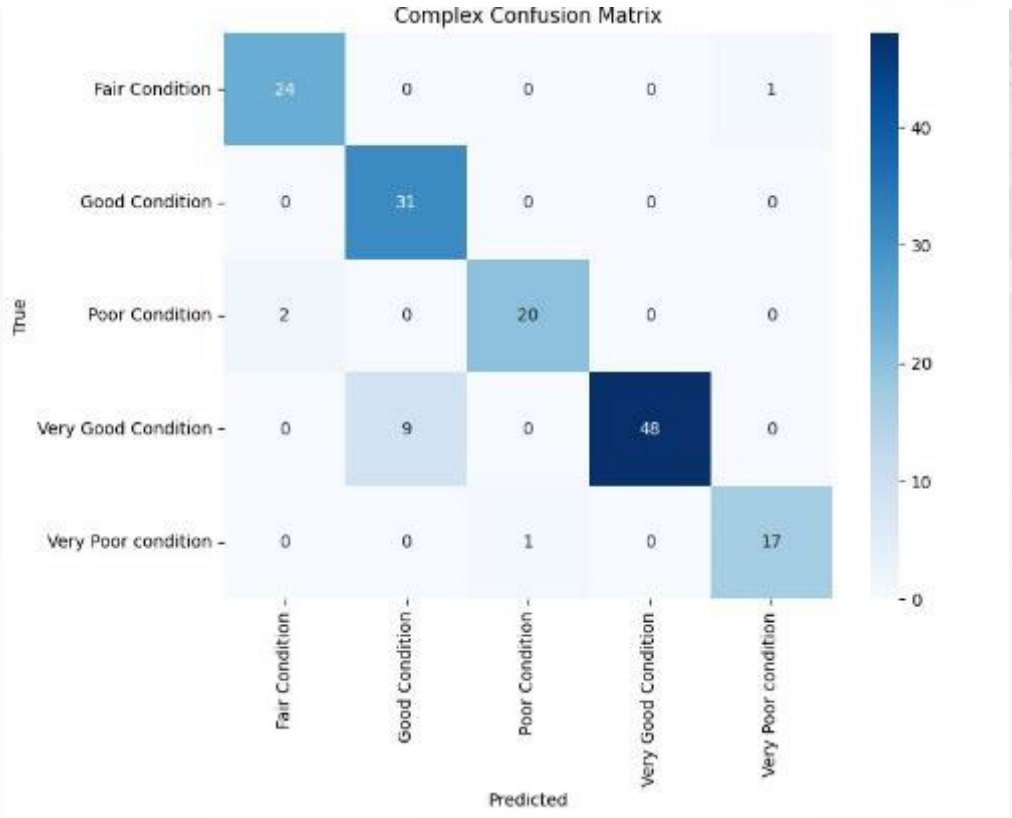
VCI of the future, Image Analysers – AI & Machine Learning



Transfer Learning Model Accuracy and Losses



Model Confusion Matrix

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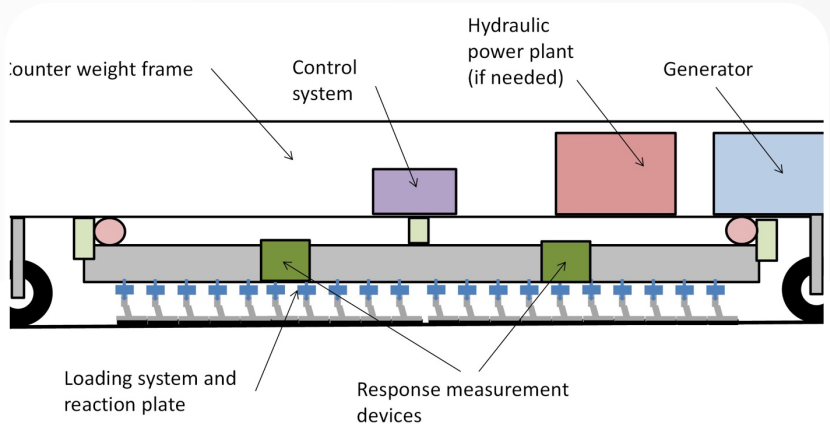
Accelerated Pavement Testing

CSIR developed the Heavy Vehicle Simulator, a mobile laboratory that can apply 20 years of traffic to a road section in as little as three months, whilst monitoring road performance with sophisticated set of instruments. Nineteen HVSs have been sold and are operating in countries such as the USA, India, Indonesia, Saudi Arabia, Costa Rica, China, South Korea, Argentina, Sweden and Mexico.

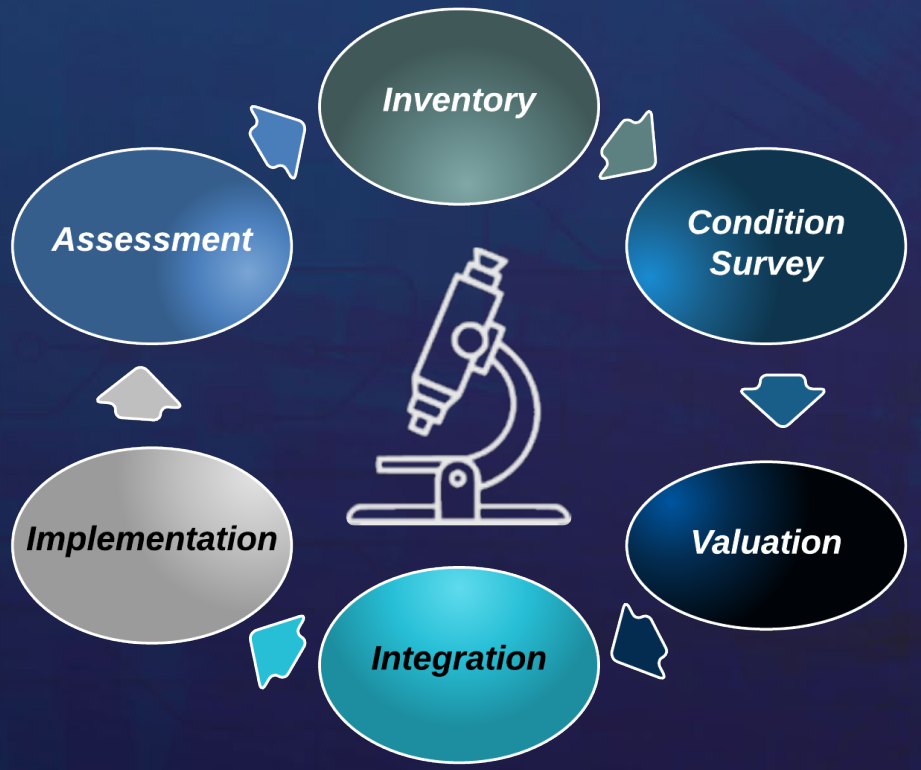
The newly developed Traffic Stream Simulator, consists of an array of actuators simulating a rolling wheel and has the following advantages: (a) High traffic speeds > 40km/h; (b) 10 times more production than the HVS; (c) can simulate: dynamic loading; real, mixed traffic stream; and both vertical and longitudinal forces. It is based on modular technology that fits underneath an existing Heavy Vehicle Simulator.

Relevance to ATNS - Applicable to maintaining integrity of road pavements and could be adaptable to determining residual life for strategic upgrades

Heavy Vehicle Simulator



Traffic Stream Simulator



Inventory

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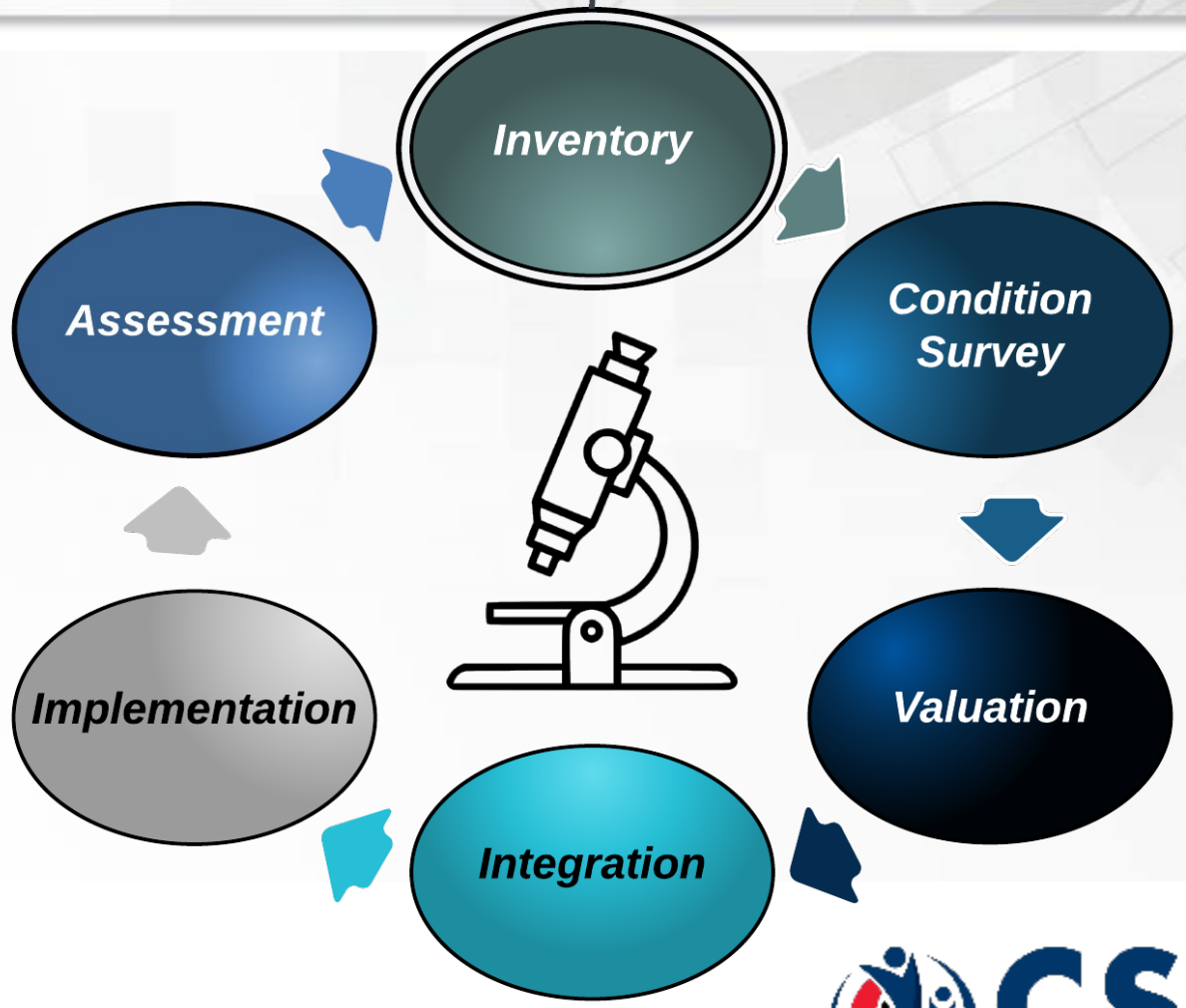
Pavement Asset Management: Inventory

Dynamic Inventory

- Big Data Project
- Internet of Things
- National Pavement As Built Portal
- National Inventory Database
- Inventory, GIS based, Projects As Built Software Development
- Etc.



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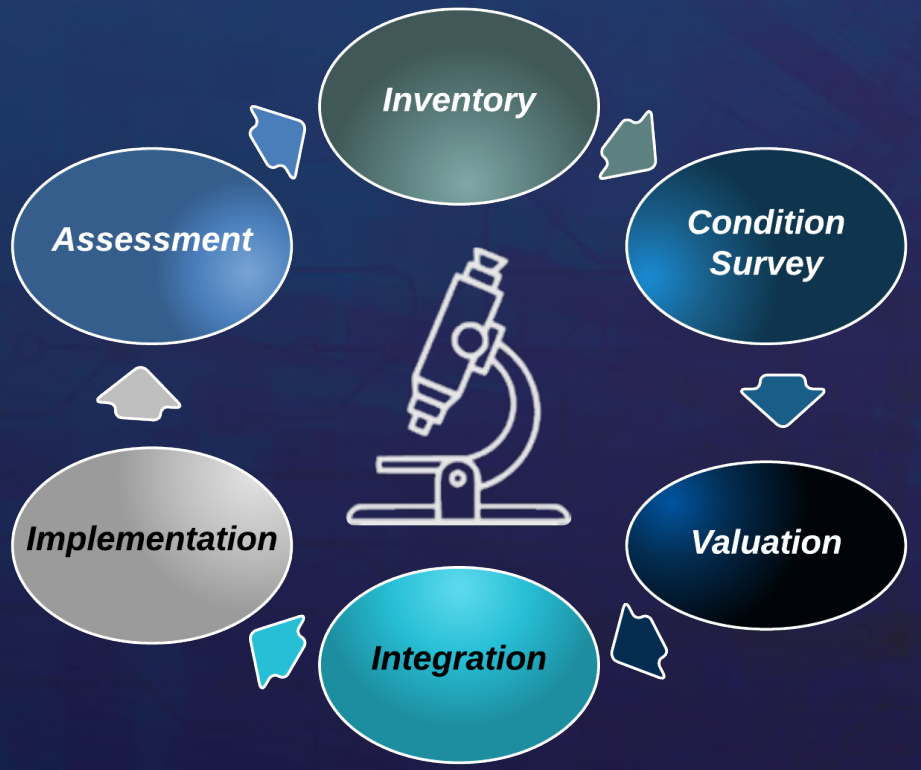

Condition Survey

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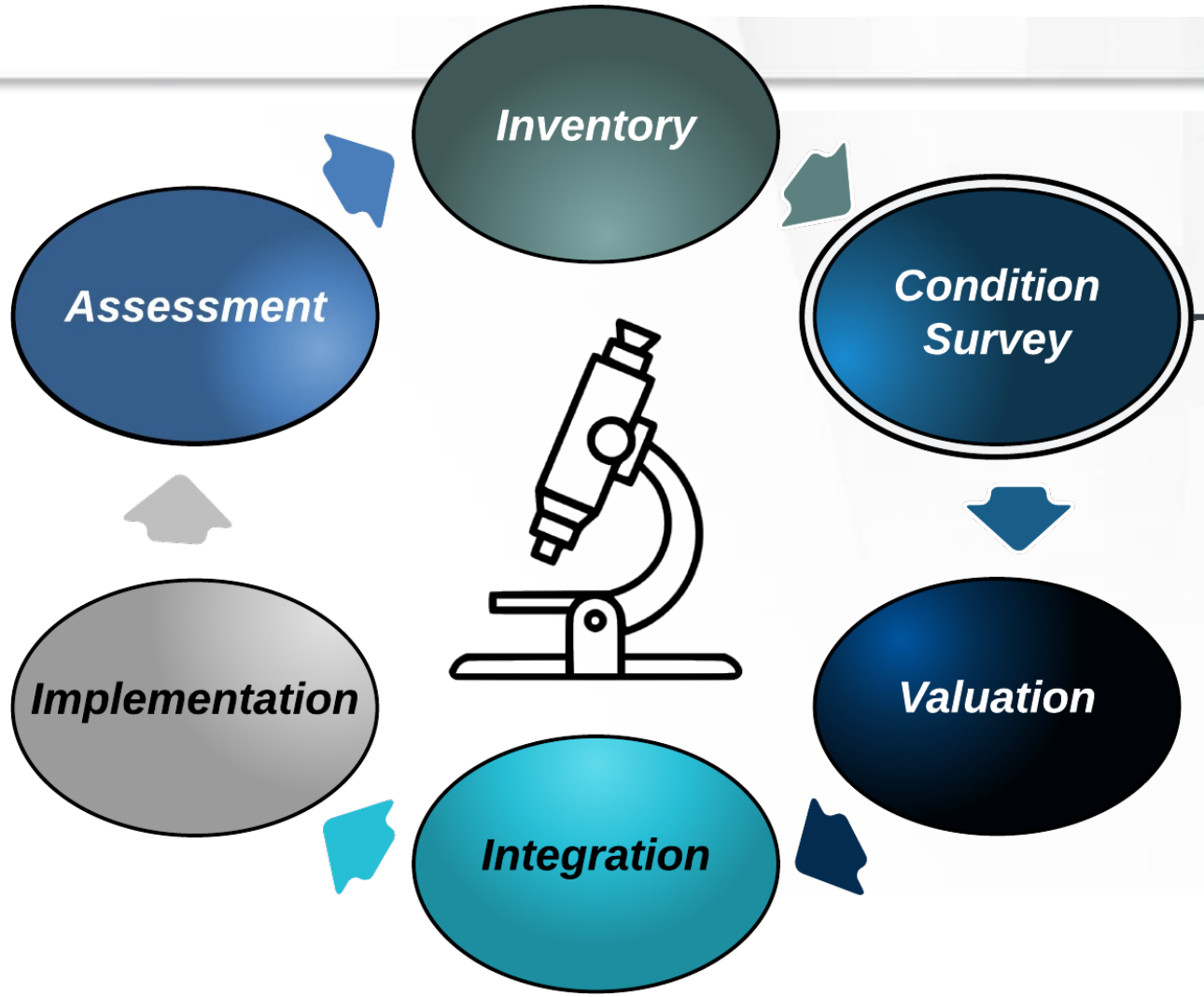
Pavement Asset Management: Condition Survey



Resilience Factors

- Climate Mitigation
- Climate Adaptation
- Net Zero Carbon Footprint
- Circular Economy
- Etc.

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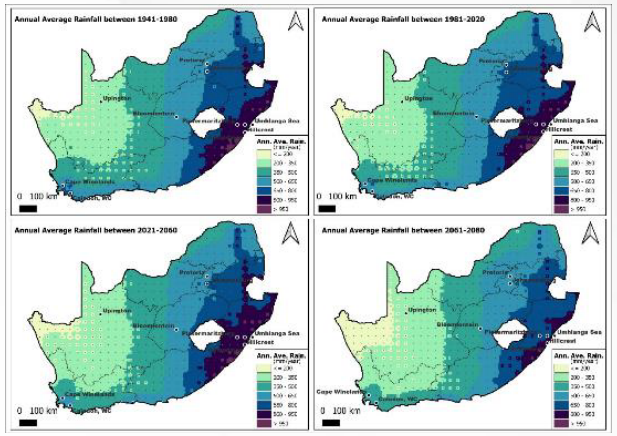
Climate Adaptation - Concrete pavements

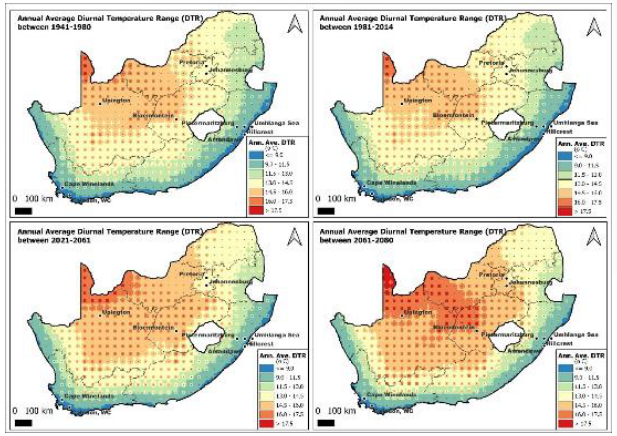
Climate model methodology for material selection and pavement design application :

- Literature review
- Micro-structural considerations
- Curling/warping behaviour related to temperature and moisture changes
- Concrete pavement design considerations for South Africa (cncPave)
- Discussion and specification recommendations
  - Early-age environmental considerations
  - Long-term environmental considerations
  - Cement and concrete mix characterization

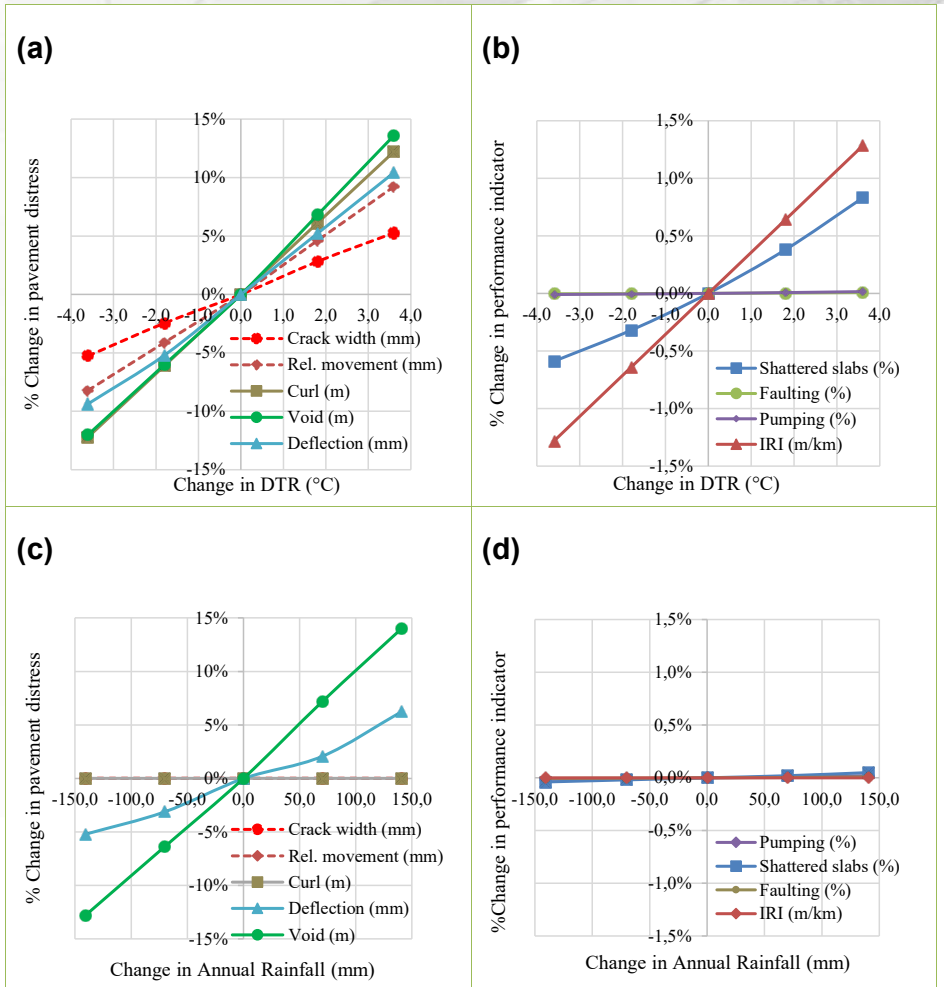
Relevance to ATNS: Long-term planning for climate risk mitigation



Progression in annual rainfall between 1941 and 2080 (Mokoena et al., in press)

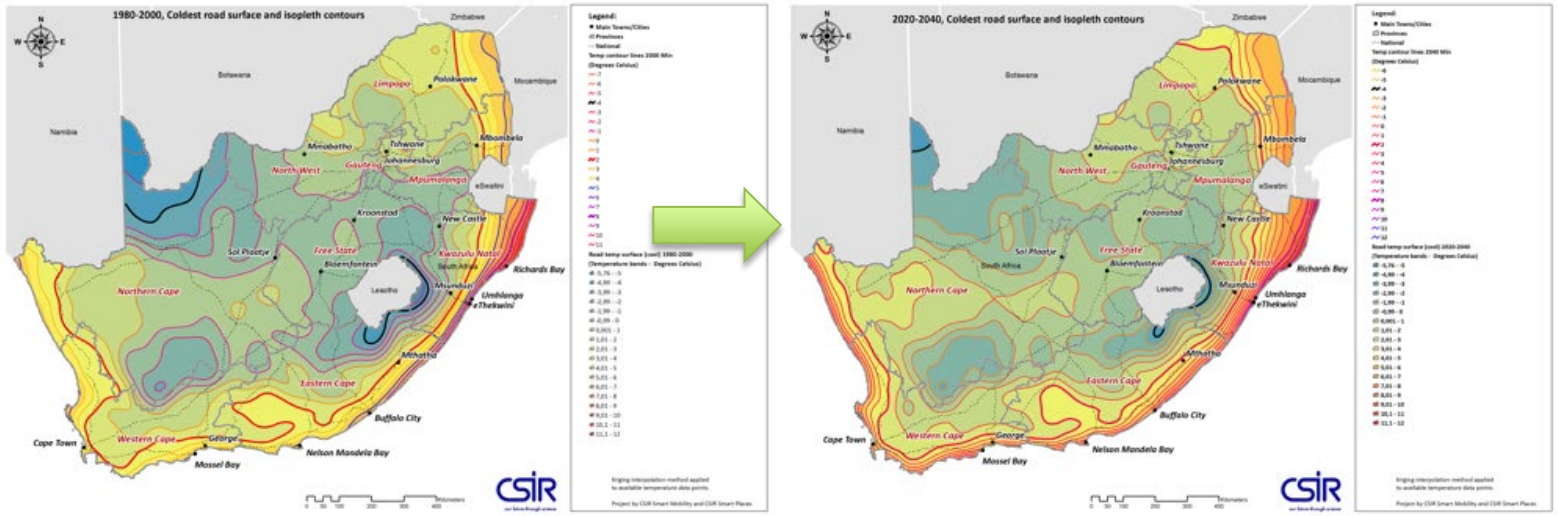


Progression in average DTR between 1941 and 2080 (Mokoena et al., in press)

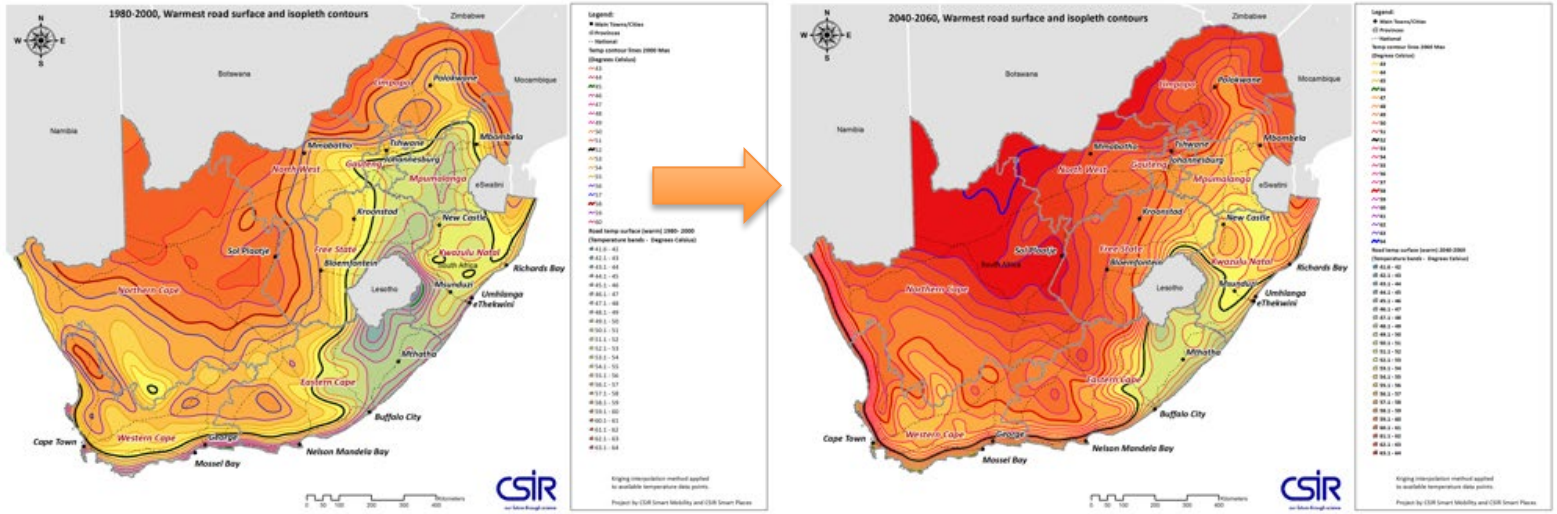


% Change in pavement distress and performance indicators for varying changes DTR and annual rainfall (Mokoena et al., in press)

Climate Adaptation - Temperature research: Asphalt pavements



Minimum pavement surface temperature progression between 1980 and 2060 (Mokoena et al., 2019)



7-day maximum pavement temperature progression between 1980 and 2060 (Mokoena et al., 2019)

ThermalPADS

Weather station data

- Measured temperatures
- Actual weather station readings
- Incomplete datasets
- Sparsely situated

Climate model data

- Projected temperatures
- Use of climate models
- Complete datasets
- High resolution

Need: Performance based material, design, maintenance specifications and criteria that incorporate climate variability

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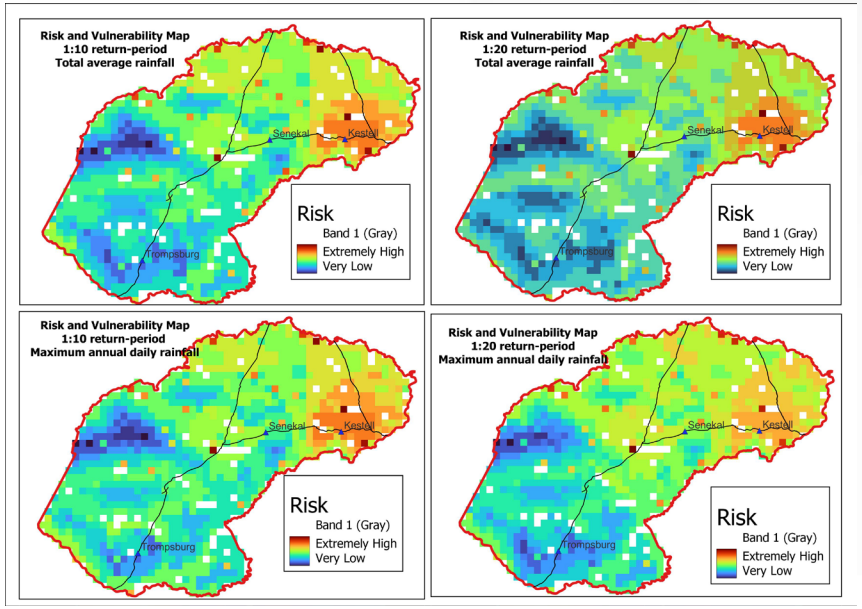
Risk and Vulnerability Assessment - Extreme rainfall Case Study (N5)

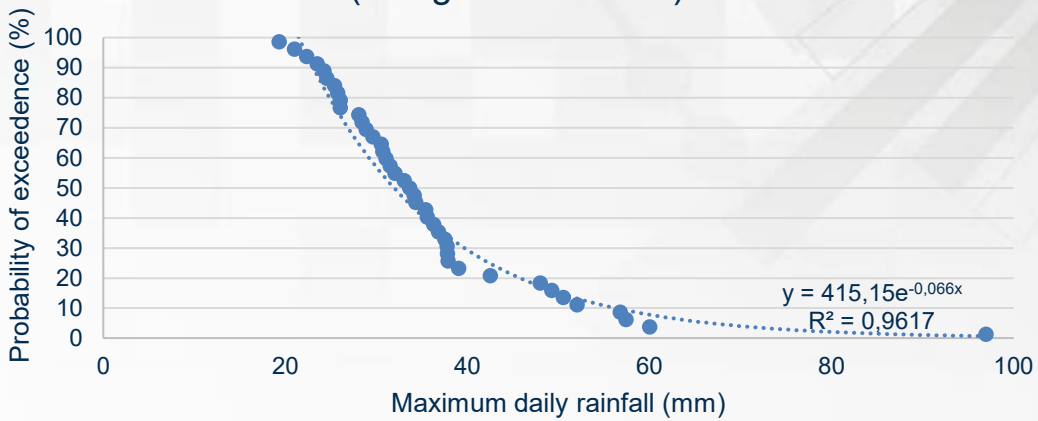
- Rainfall data analysis
- Assessment of change in return period
- Risk and Vulnerability assessment review and case study

Considerations

- Land cover
- Elevation
- Soil type
- Slope



Probability of exceedance for annual maximum rainfall between 1982-2022 in Senekal (Gringorten method)



- Bioretention as an adaptation option for stormwater control on South African roads

Circular Economy - Road construction using plastic waste

DESCRIPTION

- The development of innovative technologies using plastic waste material for road construction as a means of using alternative materials without compromising the performance of the road.

IMPACT AND BENEFITS

- Use of alternative local road construction materials
- Waste beneficiation
- Creating sustainable jobs

SA PRIORITIES SUPPORTED

- A drive for industrial growth (including localization of technologies)
- Infrastructure investment and delivery

Relevance to ATNS: Circular economy and use of alternative materials for construction of paved roads.

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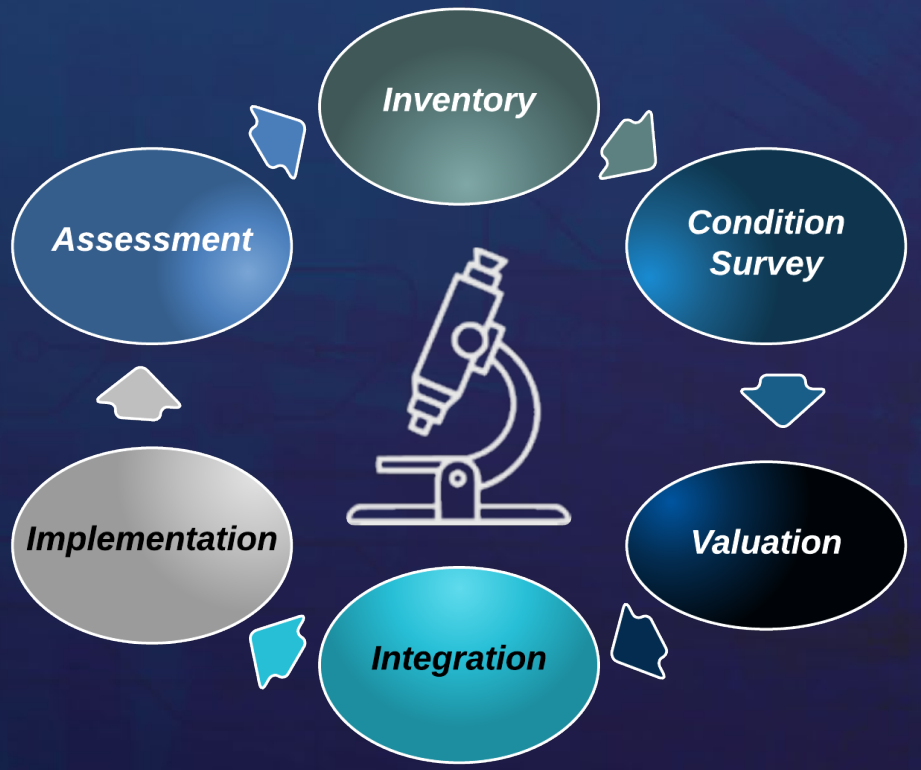

Valuation

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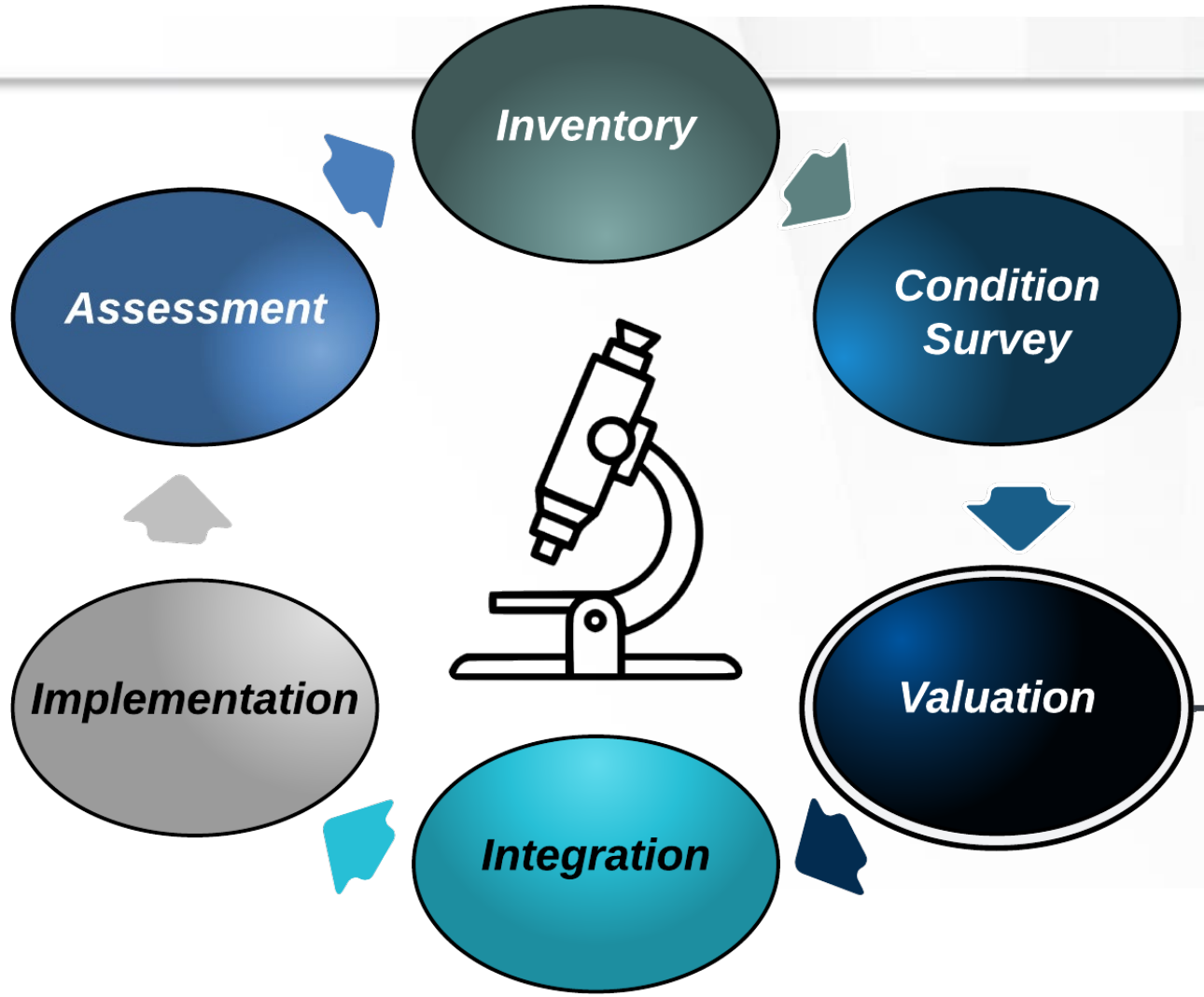
Pavement Asset Management: Valuation



Valuation:

- Research based Prioritisation Criteria
- Jurisdiction specific BOQ with material cost estimates
- Research based PWOC inputs and evaluations
- Logistic Costs

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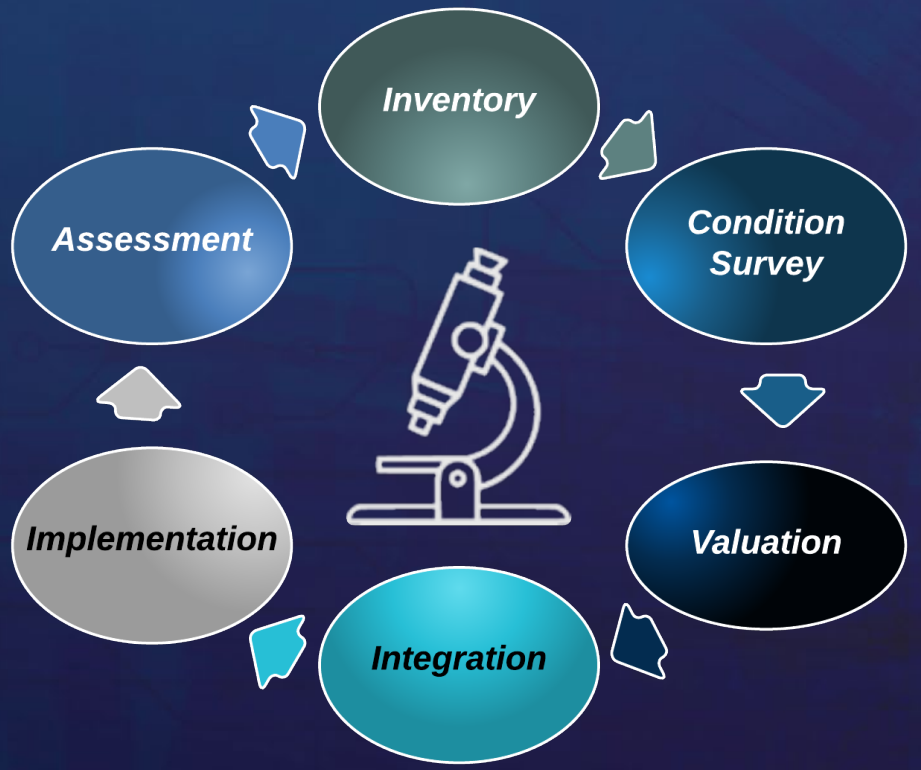

Integration

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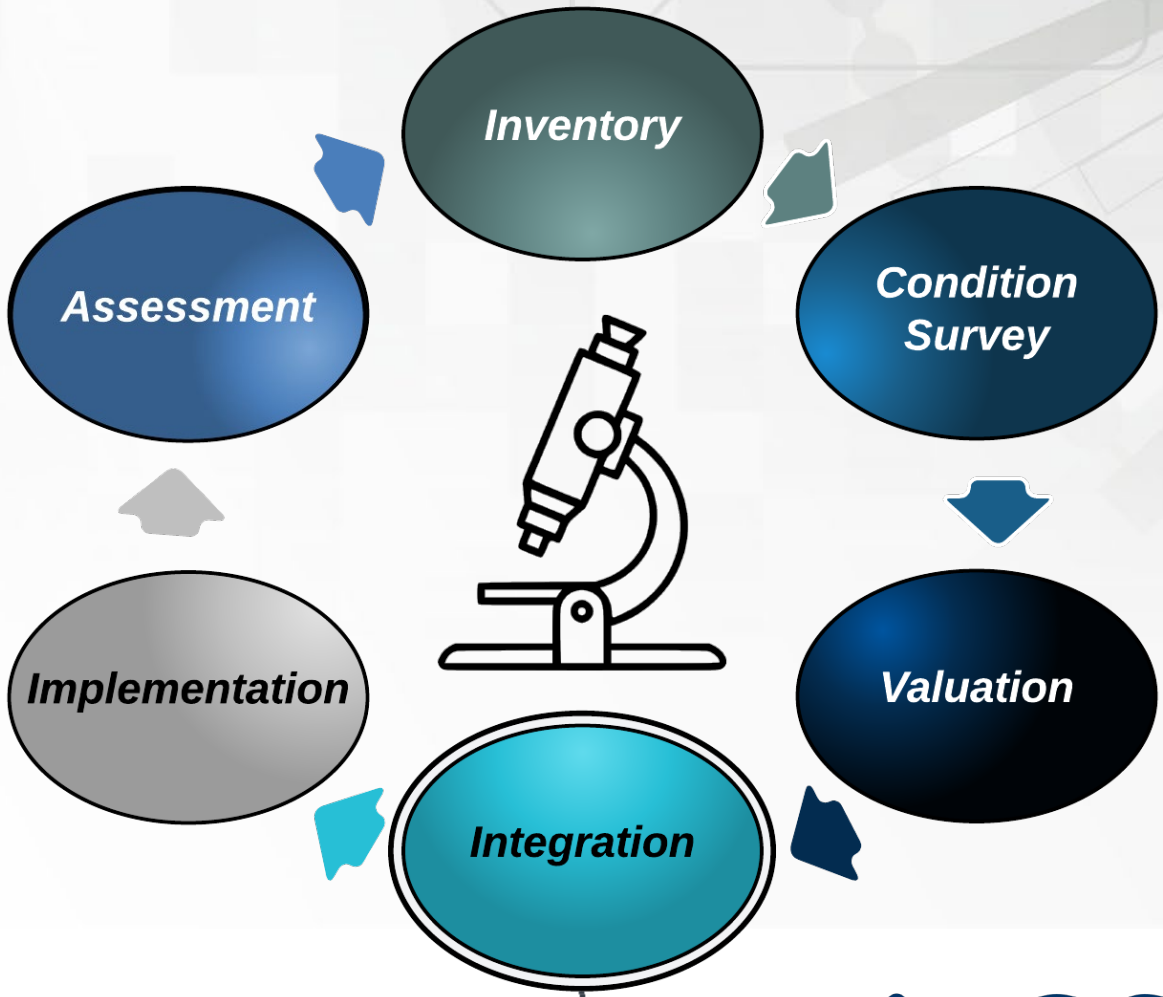
Pavement Asset Management: Integration

Technology Transfer Projects:

- New Road Construction
- Road Rehabilitation Projects
- Road Upgrade Projects
- Road Maintenance Projects
- Professional Registration Initiatives
- Technical Capacitation
- Etc.



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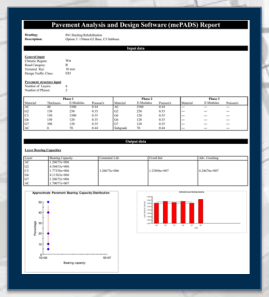
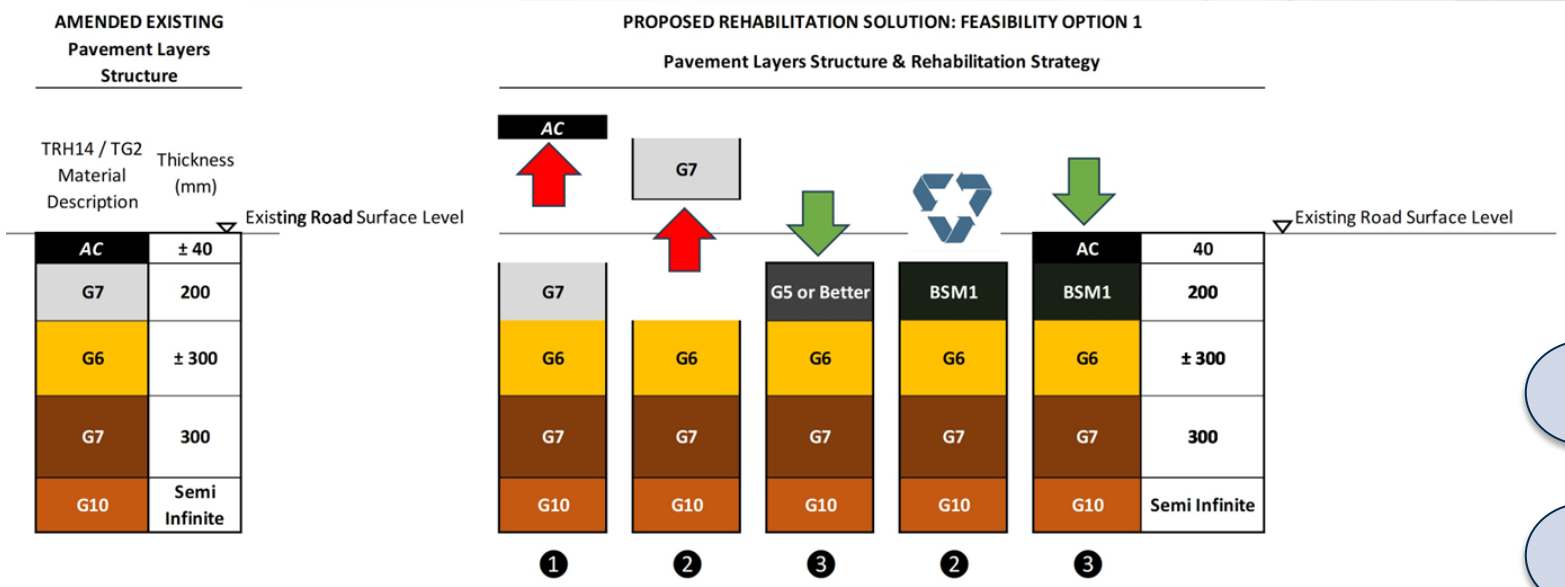
Integration through Technology Transfer Projects



- G1 INITIATION
- G2 CONCEPT
- G3 DESIGN DEVELOPMENT
- G4 DESIGN DOCUMENTATION
- G5 WORKS
- G6 HANDOVER
- G7 CLOSE OUT



Road Category	Construction Cost Range (R / km)	
Local Street	4 000 000,00	8 000 000,00
Farm to Market	8 000 000,00	20 000 000,00
National Road	20 000 000,00	140 000 000,00

Design and Construction Cost Definition Phase

4 Conditional Survey

5 Valuation

6 Asset Management Plan

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6

Real Life Technology Transfer Projects: Works Skill Incubation Opportunity

- G1 INITIATION
- G2 CONCEPT
- G3 DESIGN DEVELOPMENT
- G4 DESIGN DOCUMENTATION
- **G5 WORKS**
- G6 HANDOVER
- G7 CLOSE OUT

- Construction Supervision
- Quality Control (Client Reference Laboratory Establishment)
- Strategic Recruitment of Client Technical Personnel etc.

ECSA
Engineering Council of South Africa

SACPCMP
The South African Council for the Project and Construction Management Professions

Project Management Institute

sanas
South African National Accreditation System

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Thank You