

2024

Prof Annie Bekker



Engineering Research Chair

Department of Mechanical and Mechatronic Engineering



Photo: Stefan Els

Outline

1.



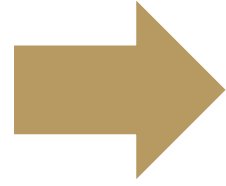
2.

Railways of
the future

3.

Gibela engineering
research chair

4. How we use
digital twins



ALSTOM + **UBUMBANO**



To build a new passenger rail fleet

600 new Gibela X'trapolis Mega trainsets for



Manufacturing processes using CUTTING EDGE TECHNOLOGY...



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7-axis welding robots

FIRST
OF THEIR KIND
in the global rail industry

R350 MILLION
in specialized equipment

10 000 PARTS
250-linked industrial activities

LEAN
manufacturing process



AT FULL PRODUCTION...



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A photograph of a modern, white and blue high-speed train under construction in a large industrial factory. The train is positioned on a yellow overhead crane system. The background shows the complex structure of the factory with various levels and railings.

1.5 TRAINS per week

62 TRAINS per year

AT FULL PRODUCTION...



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62 TRAINS per year

THE FASTEST PRODUCTION RATE IN THE WORLD

Development of local suppliers



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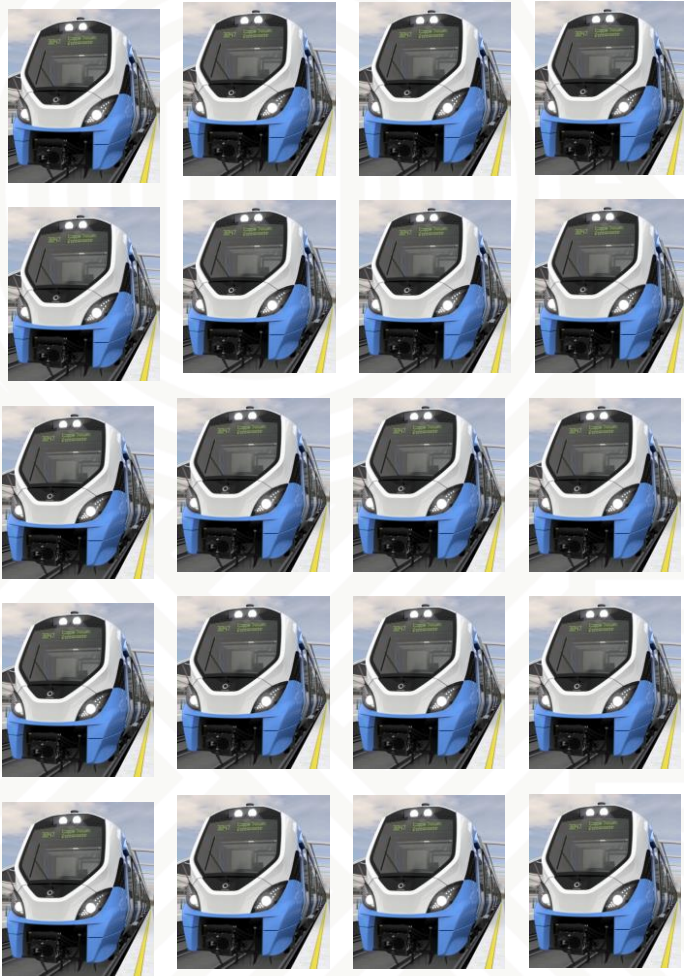
81.4 MILLION
spent on 42 entities

REVITALIZATION OF RAIL, ECONOMIC GROWTH, ALLEVIATION OF POVERTY

Start of manufacturing...



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... the first **20**
trainsets built in Brazil

T
O
D
A
Y



... trainset **224**
in Dunnottar plant



X'Trapolis Mega



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saam vorentoe



131m LONG
weighing **220 tons**

1200 PASSENGERS
in **6 cars**

SPEED OF 120 km/h
Made of **South African stainless steel**

Technical support and spares supply



MAINTENANCE
and performance commitments

19 YEARS
across 5 depots

2016-2035

Outline



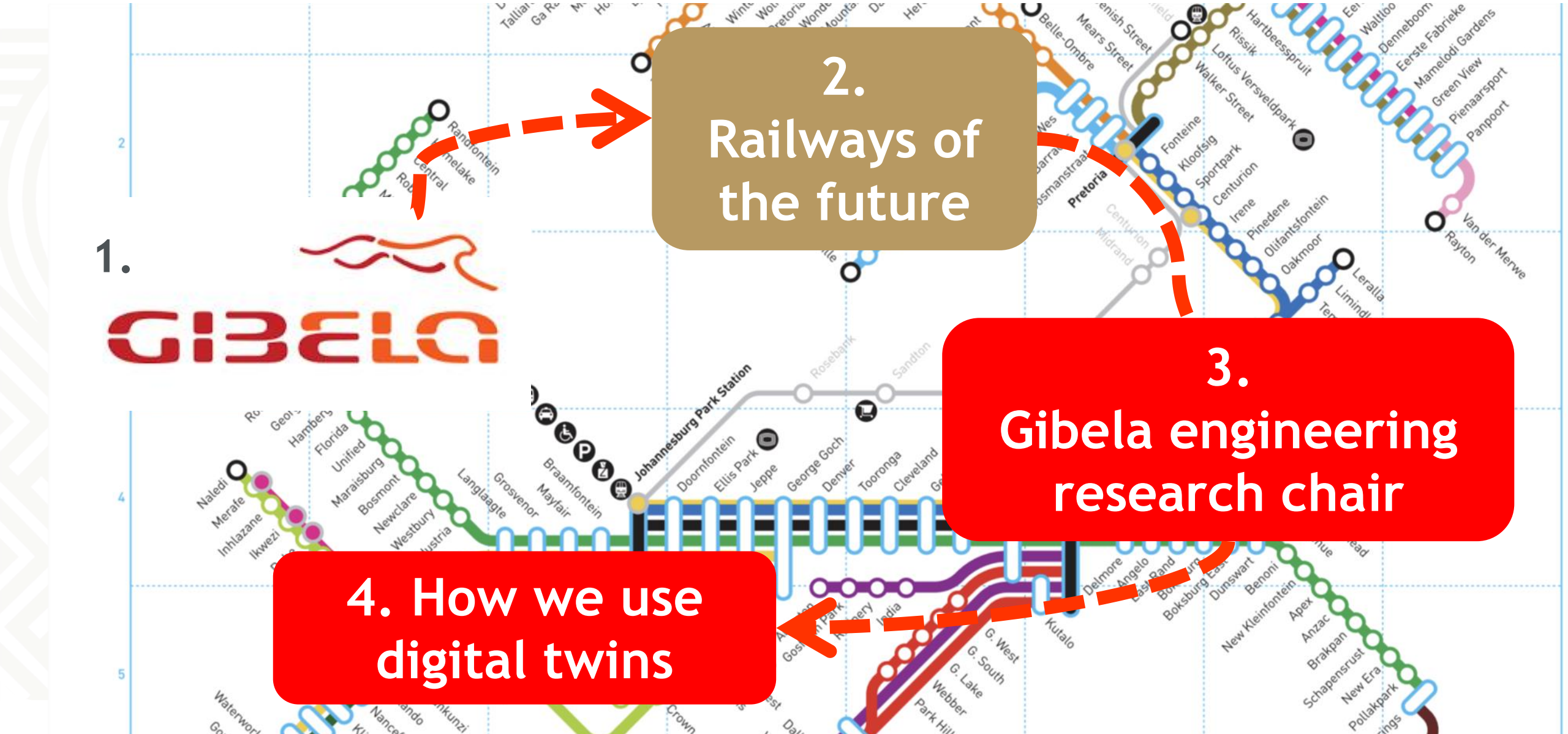
1.



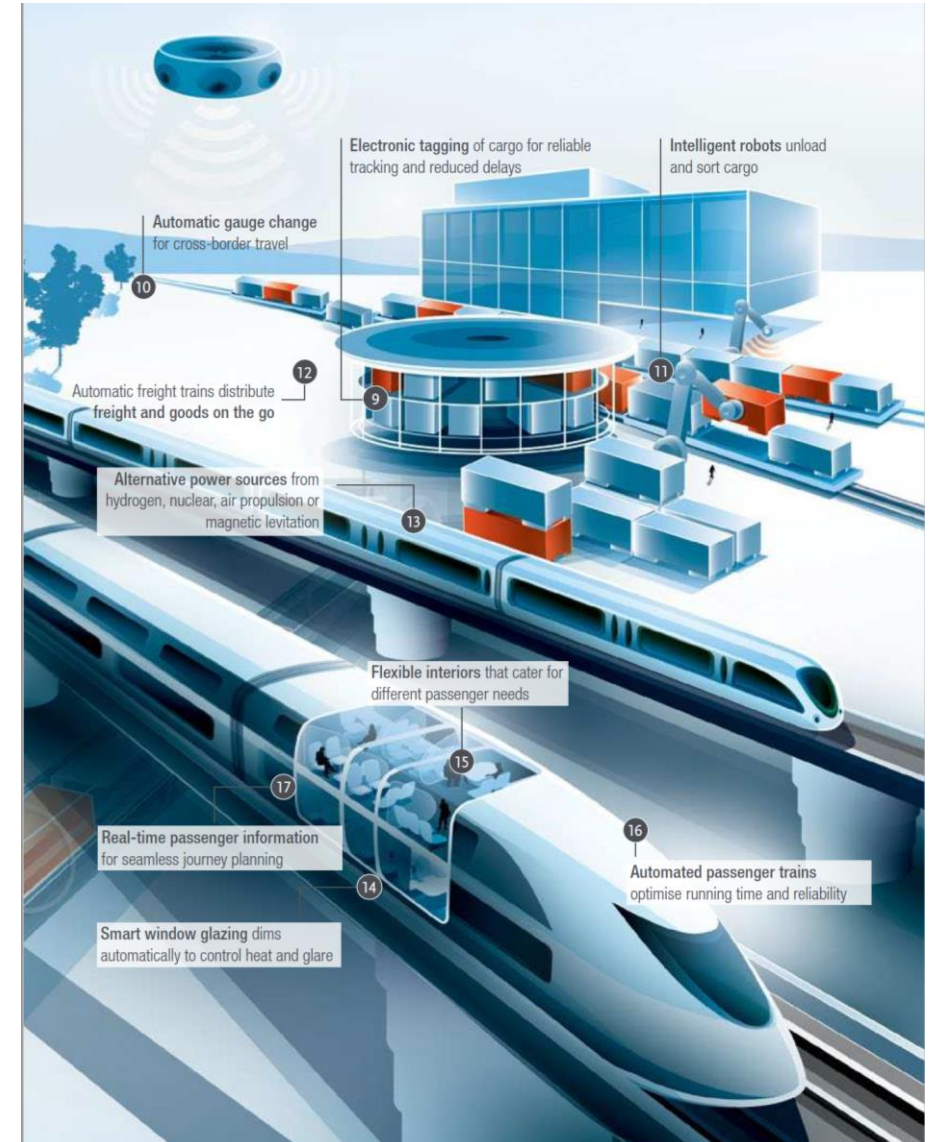
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2. Railways of the future



Railways of the future - 2030



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1

WHAT

TODAY

THE FUTURE

Rolling stock



Railways of the future - 2030



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2

WHAT

TODAY

THE FUTURE

OPERATIONS



CONNECTED - SERVICITIZATION



Boost revenue and profitability



Product innovation



Better insights over operations through data generation



Better product usage and customer outcomes



Increased customer satisfaction and loyalty



Higher competitive advantage

Railways of the future - 2030



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3

WHAT

Track and rolling stock inspection



TODAY



THE FUTURE

PREDICTIVE &
CONDITION-BASED
MAINTENANCE



Railways of the future - 2030



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4

WHAT

TODAY

THE FUTURE

Operations and
Safety



Automatic
elimination of
exposure and risk

Railways of the future - 2030

Passengers will expect certainty in terms of time, so reliable and accurate real-time information will be key.



Integrated transport apps allow trips to be chosen according to optimal pricing and convenience. In the future it will also be possible to book and pay for journeys across all modes, providing a seamless journey-planning tool.

Current trends

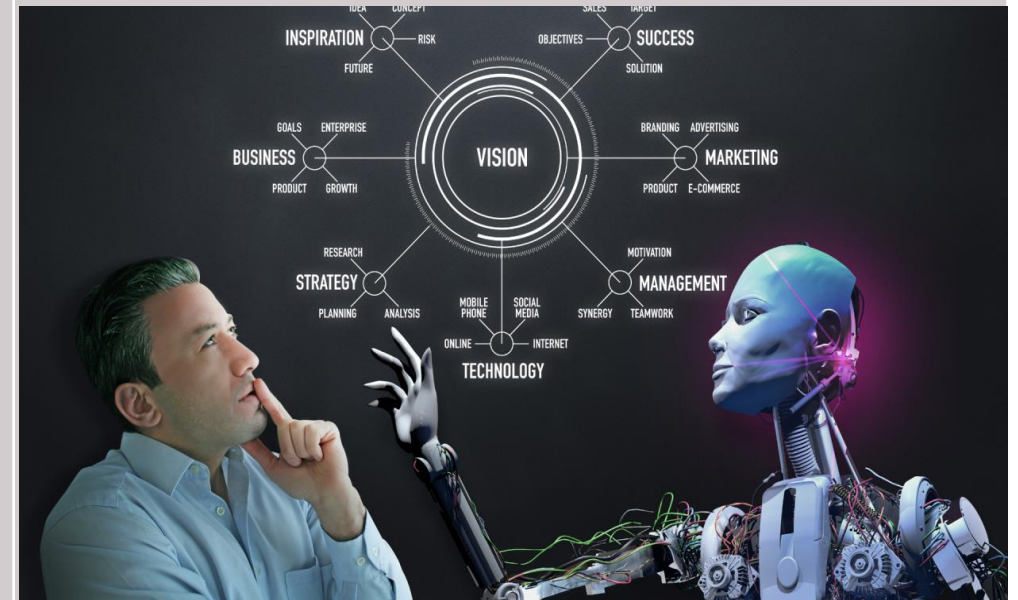
5

WHAT

TODAY

THE FUTURE

Customer experience



Railways of the future - 2030

Current trends

6

WHAT

TODAY

THE FUTURE

Energy &
environment

Rail operations
are functional,
not necessarily
measured



Outline

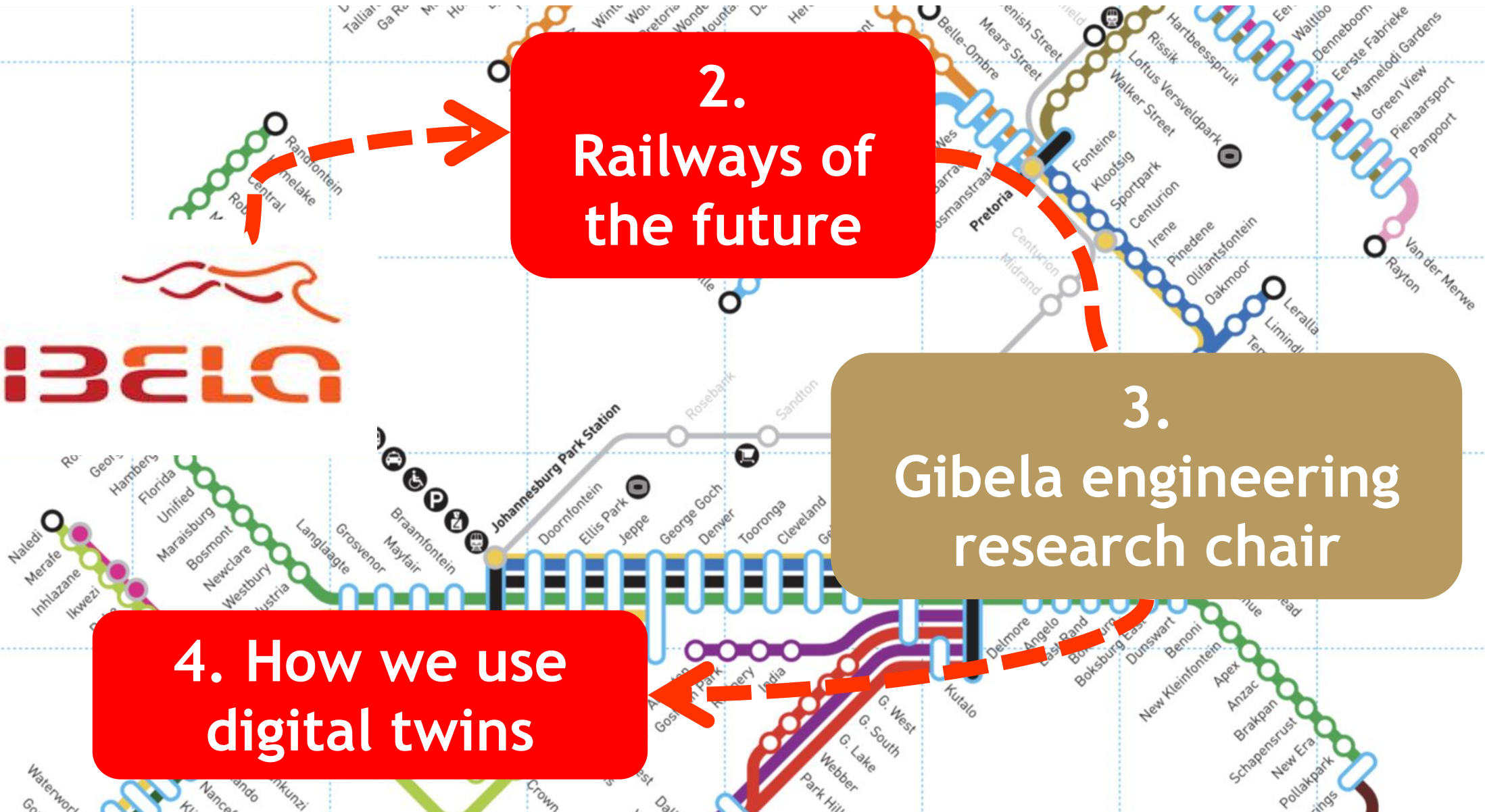
1.



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Railways of
the future

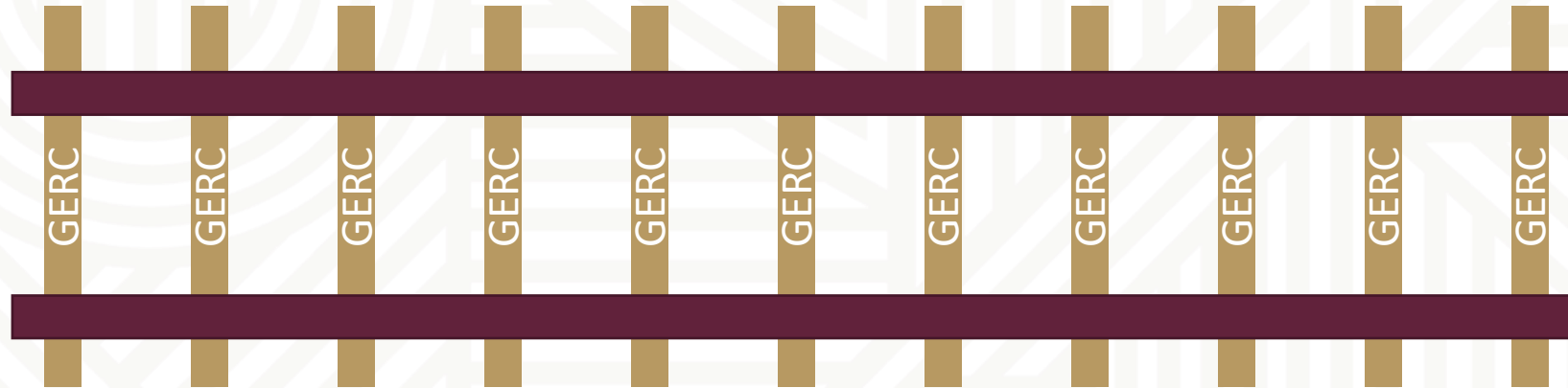
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Gibela engineering
research chair

4. How we use
digital twins



Gibela Engineering Research Chair (GERC)

@Stellenbosch University



Stellenbosch

UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

Cross-pollination between academic and industrial environments



Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

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1. Social responsibility



Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

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2. Short courses for industry



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Share Stellenbosch expertise with Gibela and understand more about industry



3. Student “skill up” workshops



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Outline

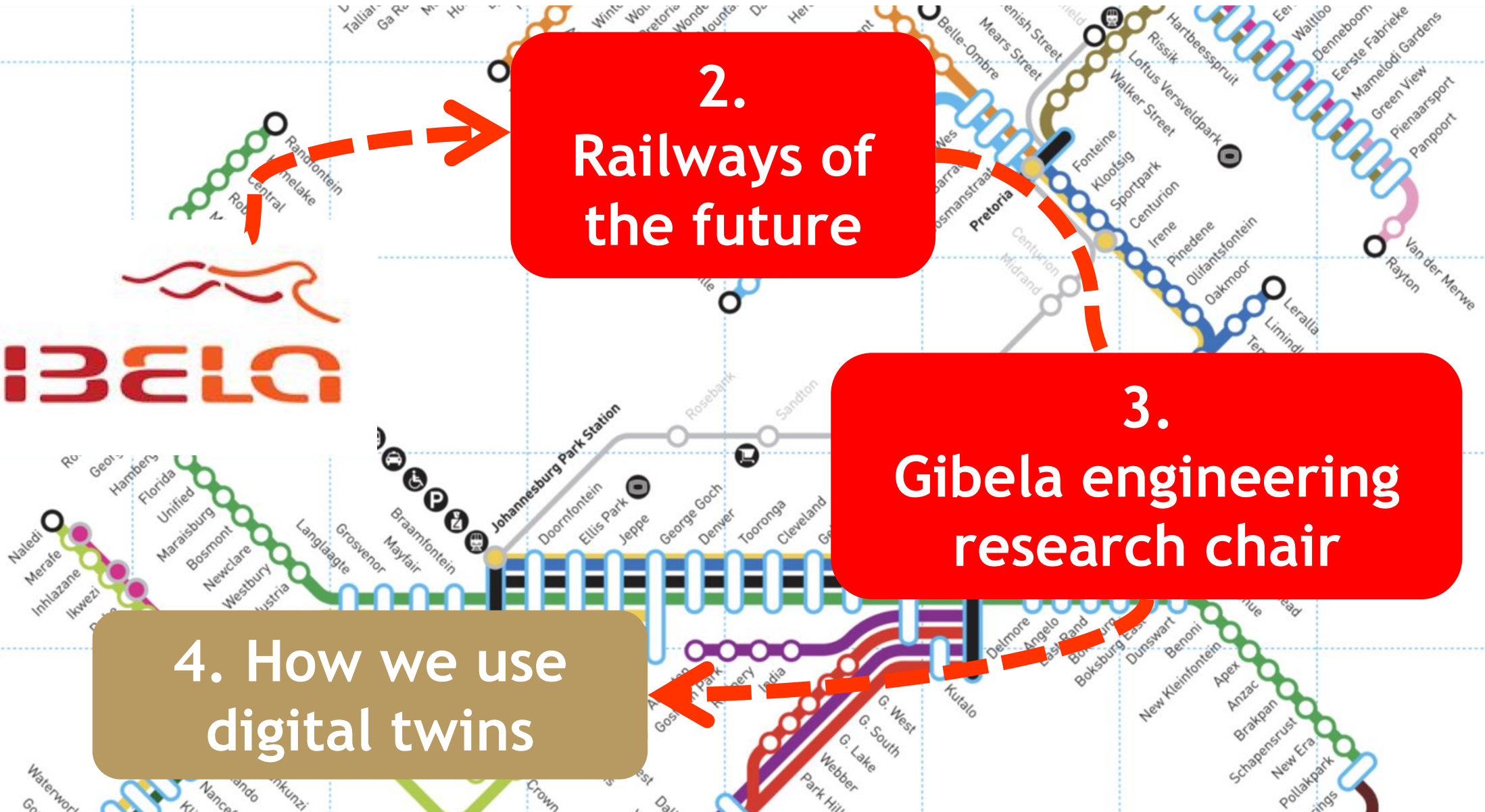
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digital twins



TECHNICAL VISION



Stellenbosch

UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT



WHAT? Create a niche in monitoring applications and asset management technologies

WHO? for the Gibela X'Trapolis Mega trainsets by

HOW? combining sensors, data, models and analytics in digital services

WHY? to deliver operational and decision support

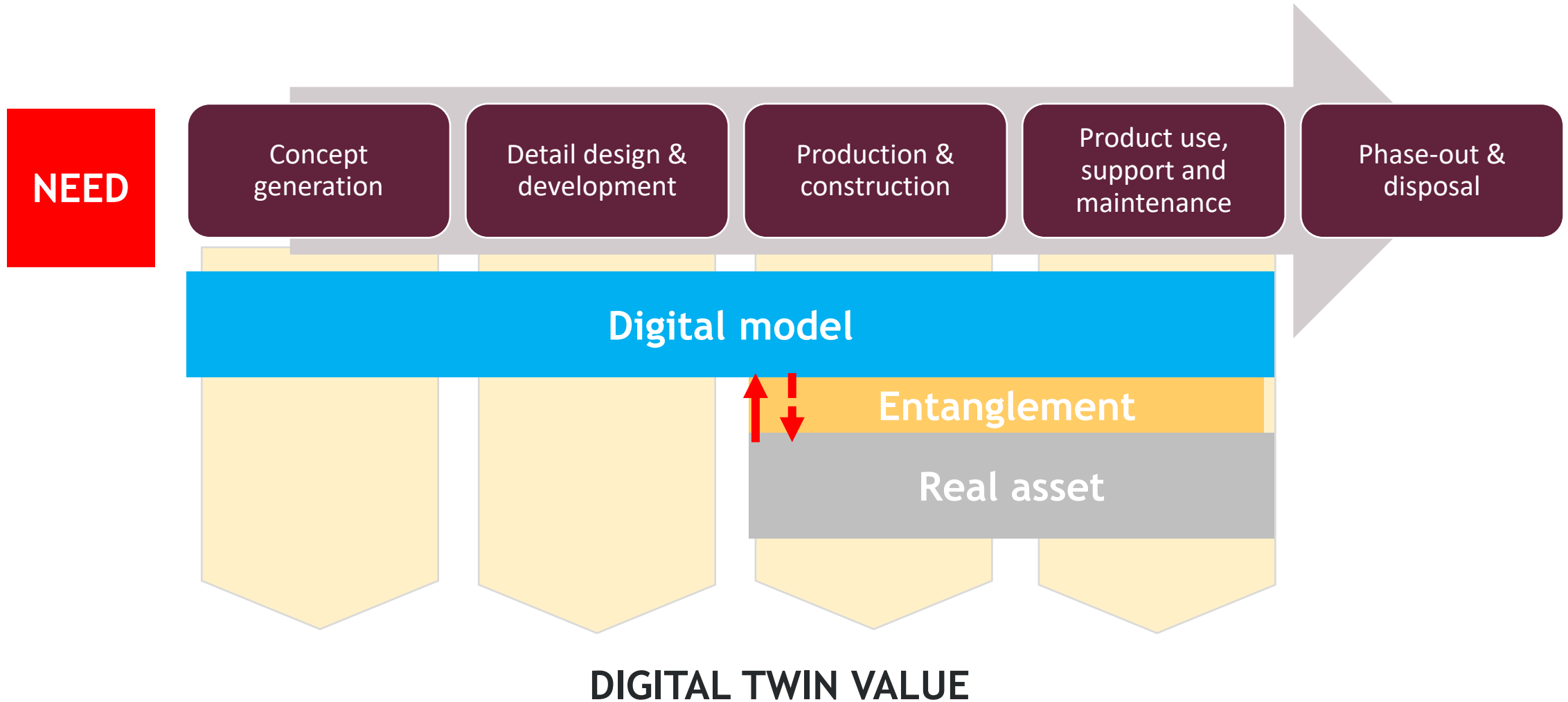
Digital twin



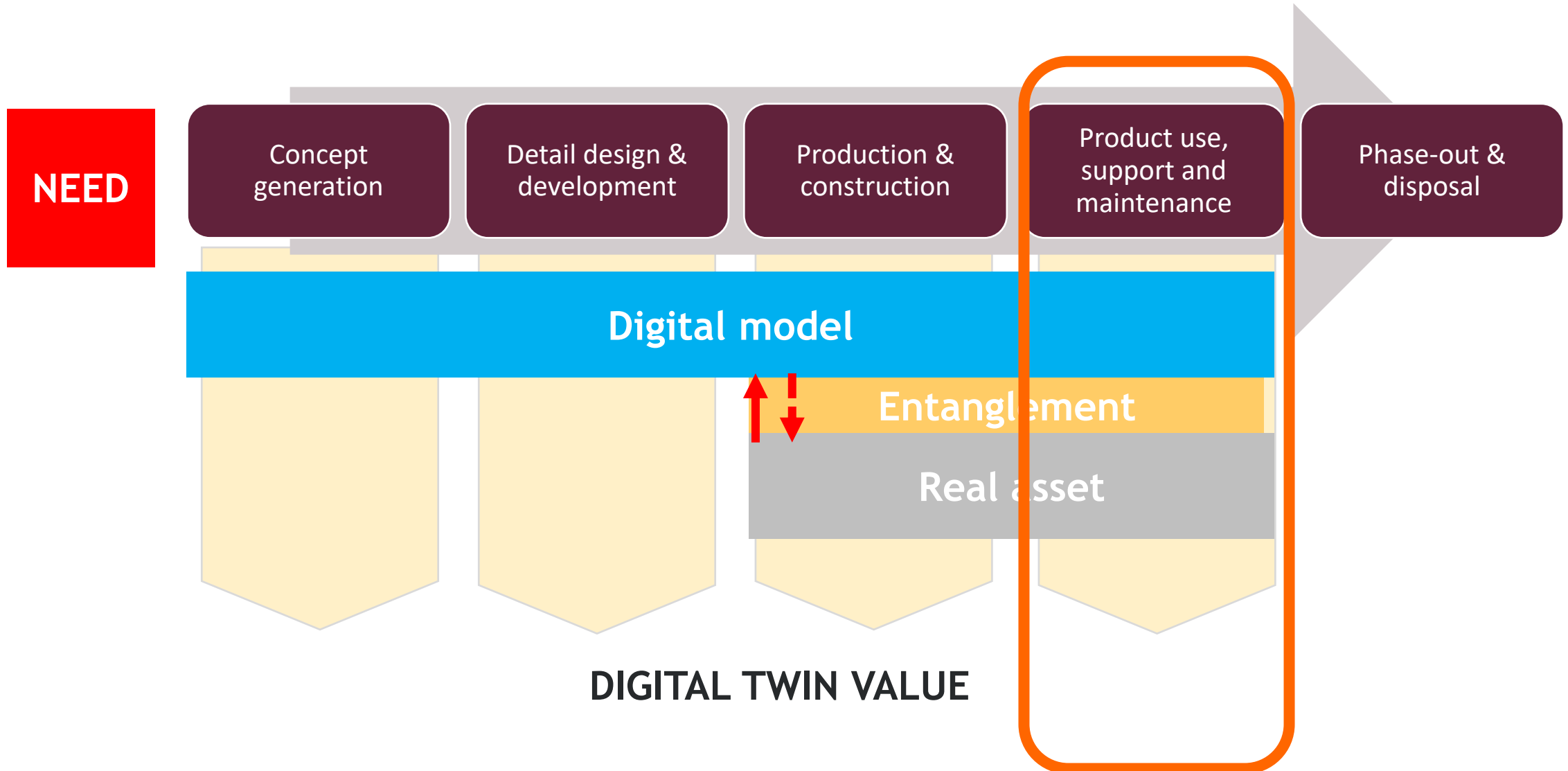
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Digital twins operate through the full life-cycle



Digital twins operate through the full life-cycle



Real asset - X'trapolis Mega



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D
A
T
A



PHYSICAL STATE

- Current configuration (new parts)
- Current cost
- Speed, weight

CONTROL INPUTS

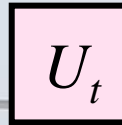
- Traintracer CFM logs

OBSERVATIONAL DATA

- Alstom modern train concept equipped with sensors (proprietary but available)
- Conditions of the environment

+ New sensor installations

PHYSICAL



Control inputs



Physical state



Observational data

Digital representation

DIGITAL



DIGITAL STATE

- Current configuration
- Current cost
- Speed, weight
-

QUANTITIES OF INTEREST

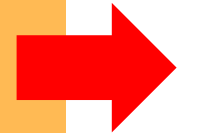
- Industry models and dashboards
- Models of the environment

+ NEW MODELS

- Physics-based
- Data-driven
- Hybrid

D_t Digital state

Q_t Quantities of interest



D
A
T
A

Digital model / shadow / twin

DIGITAL

PHYSICAL



D_t Digital state

U_t Control inputs

S_t Physical state

Q_t Quantities of interest

O_t Observational data

R_t

Reward

Decision support for operations and maintenance

Digital twin value



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EXAMPLES



Virtual sensor

Provide insight into asset behaviour on locations without sensor observations.



Fingerprint

Understand asset operations by matching against a catalogue of behavioural patterns.

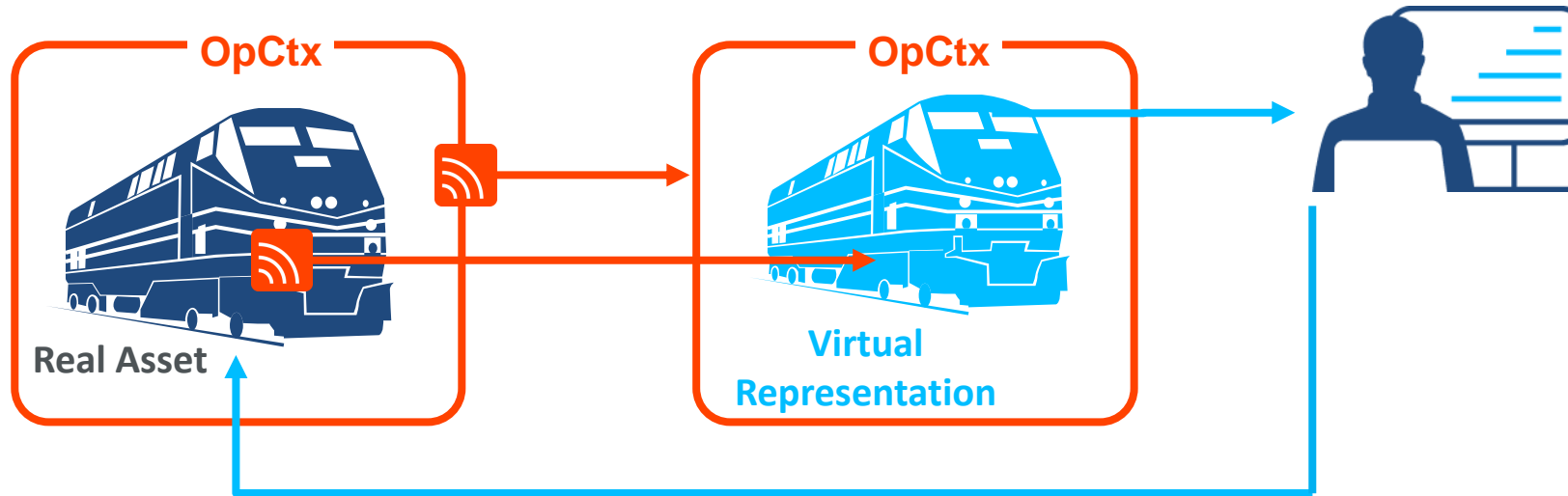


Mirror

Recreate complete immersive operators experience to manage remote assets

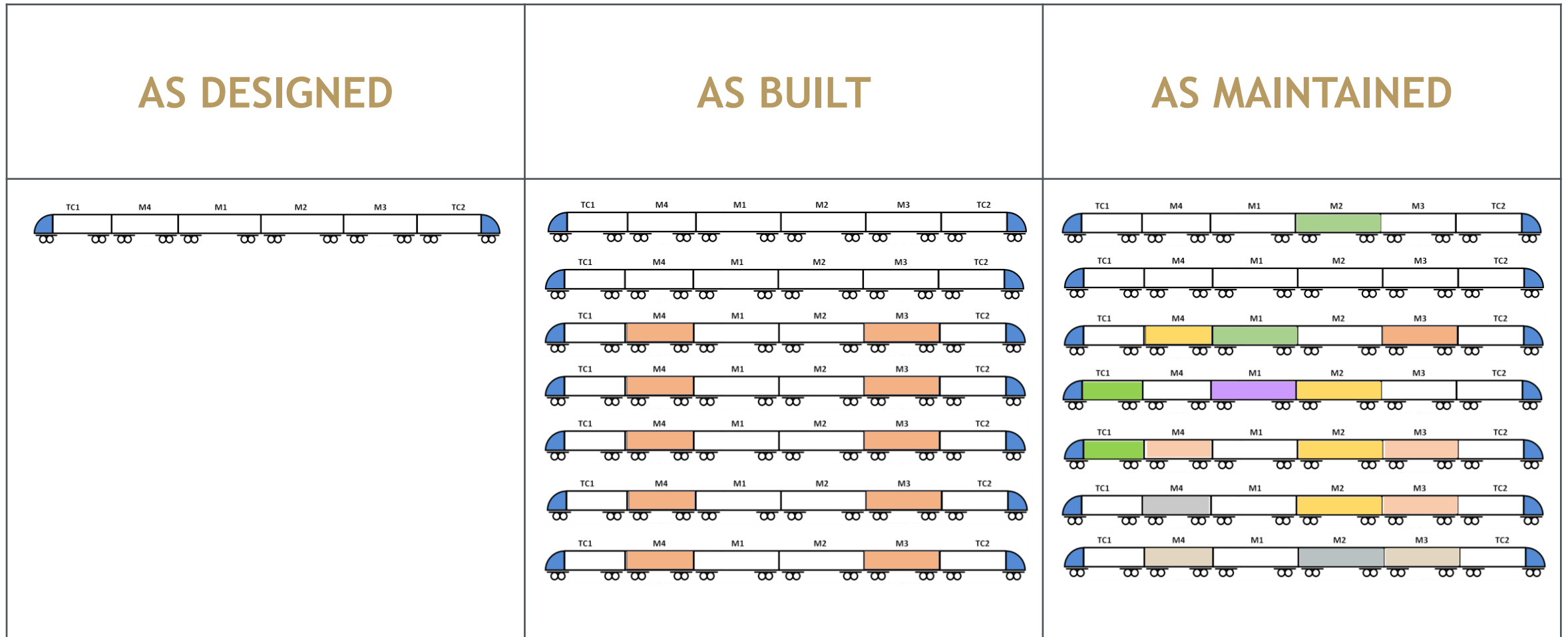


MIRROR



Example: Lifecycle costing of a rail fleet

Reflection of “as is” state of a rail fleet - and calculation & projection of costs

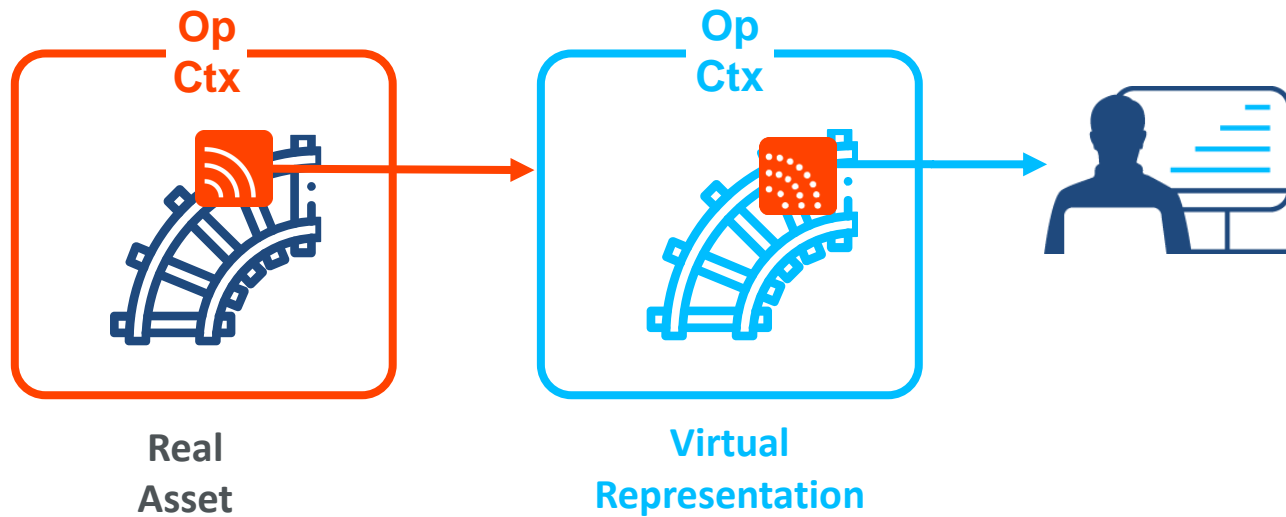




Virtual sensor



A “measurement” without a sensor at that location



Virtual sensor for wheel force

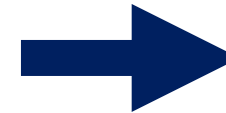
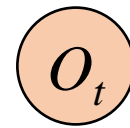


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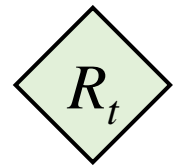
REAL TRAIN ON INSTRUMENTED RAIL SECTION



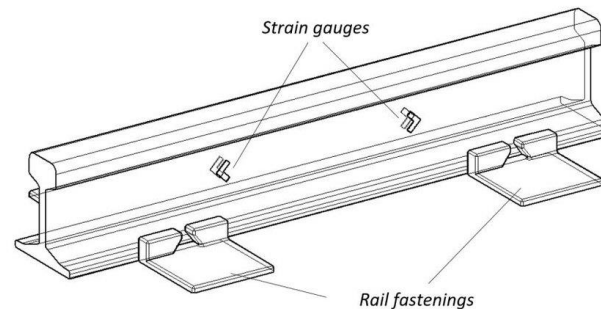
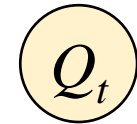
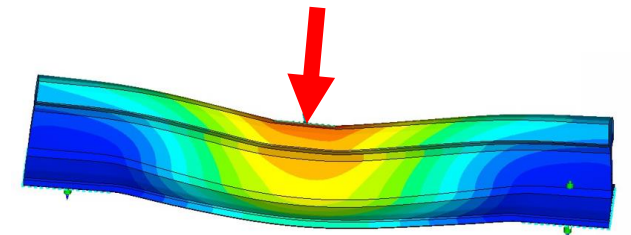
MEASUREMENTS



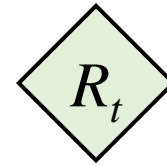
MODEL



FORCE



Mapping of wheel forces

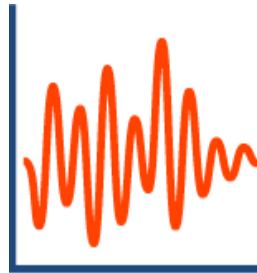


WHEEL FORCE PROJECTION

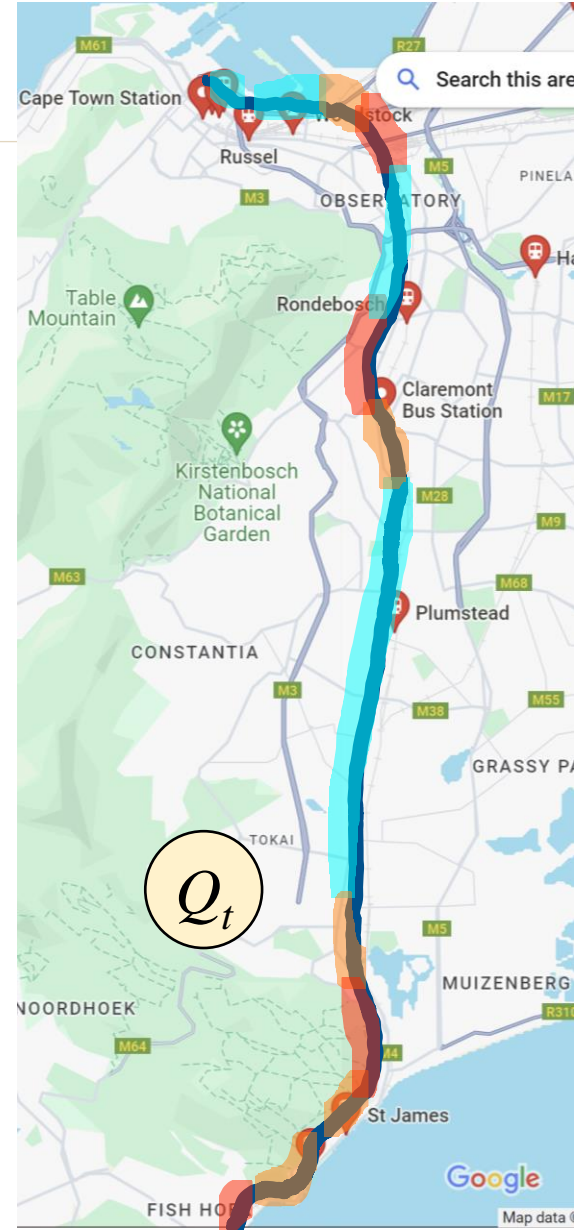
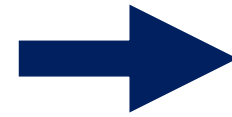
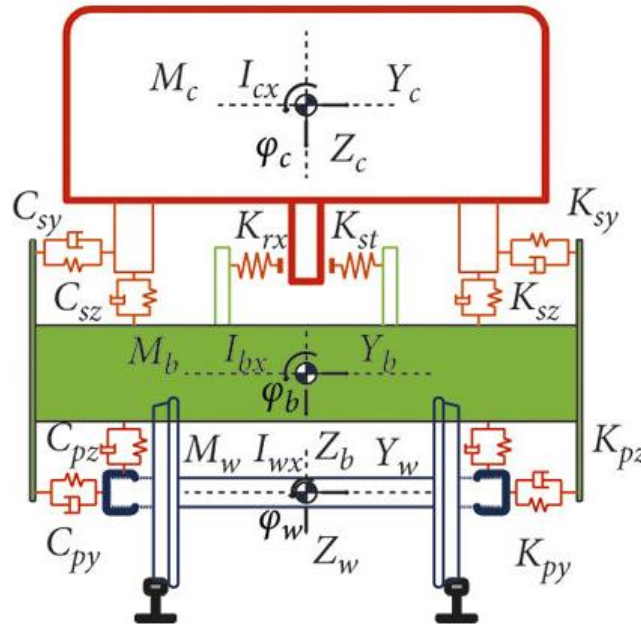
PHYSICAL
ASSET



O_t
MEASUREMENTS

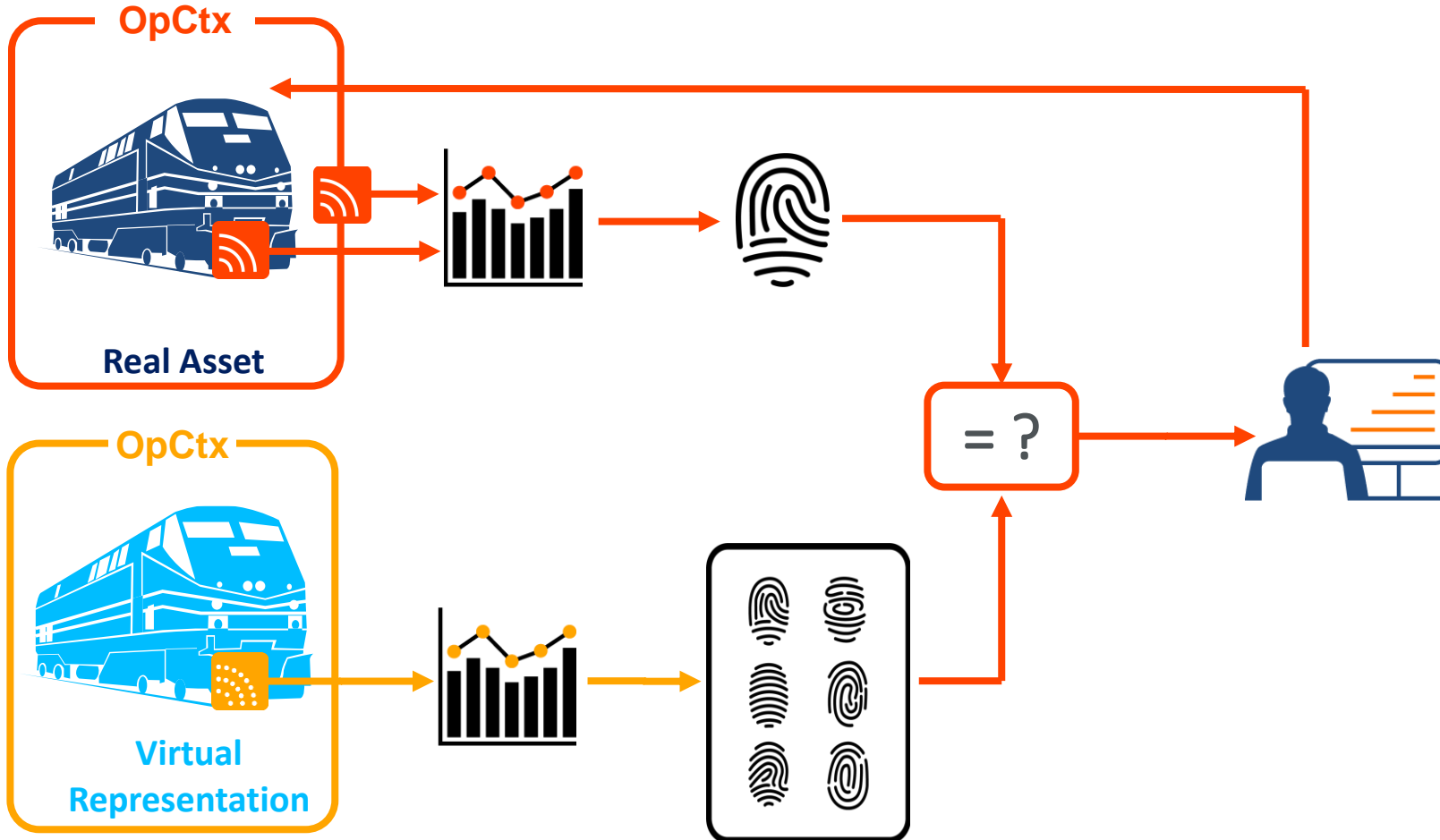


PHYSICS-BASED
DYNAMIC TRAIN
MODEL





Fingerprint



Low speed flat spot / damage detection on wheels

PHYSICAL
ASSET



MEASUREMENTS



DIAGNOSTICS



USER



1 **DETECTION**
Wheel flat
damage? Y/N

2 **LOCALIZATION**
Which bogie /
wheel?

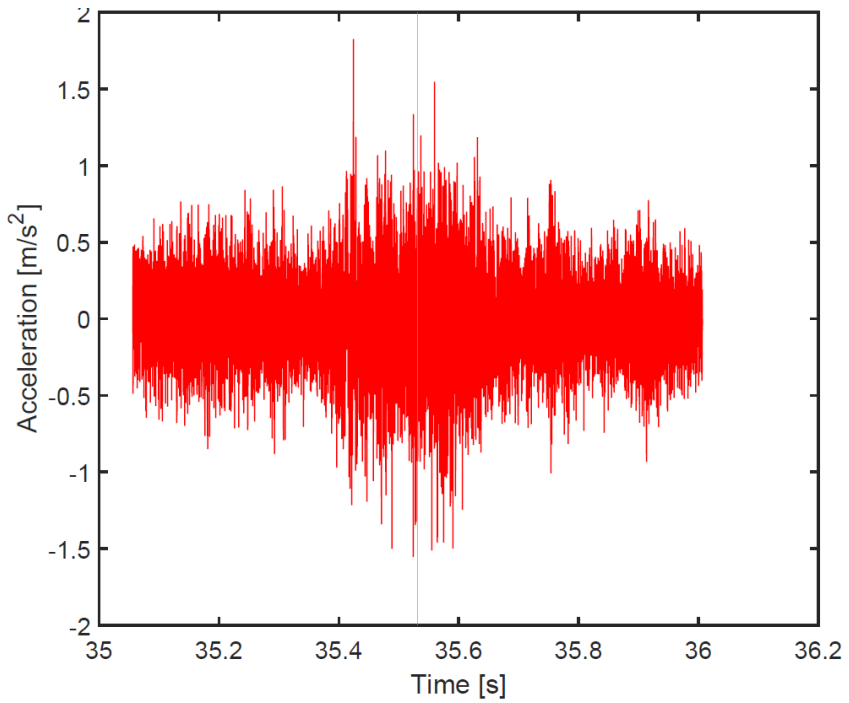
3 **CHARACTERIZATION**
Size
Type of defect?

Vertical accelerometer measurements

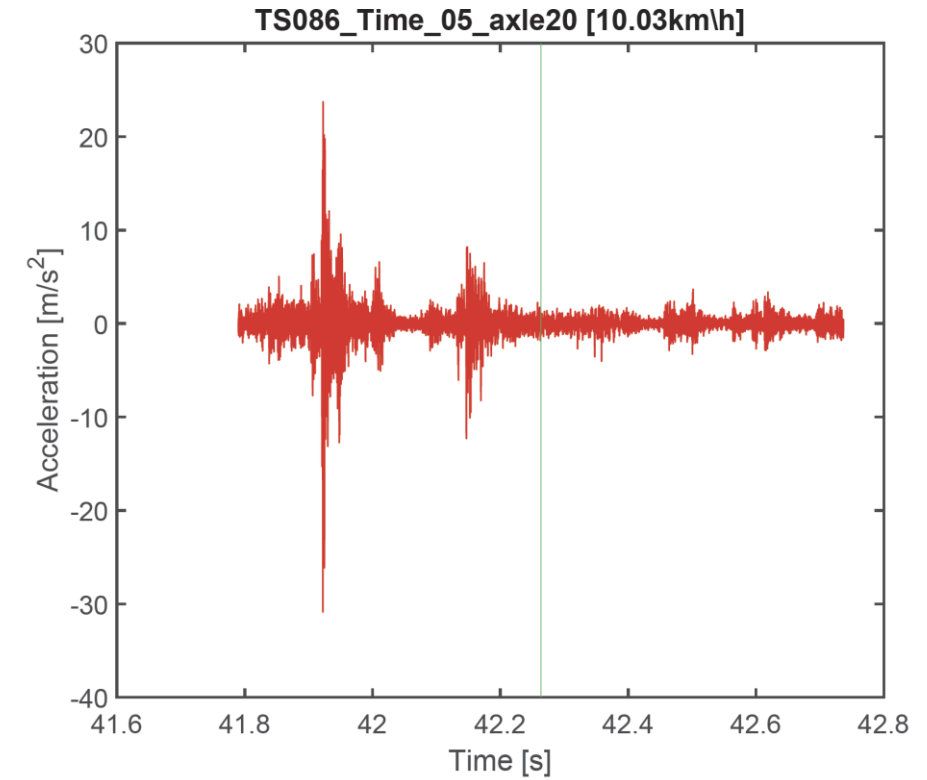




Normal wheel

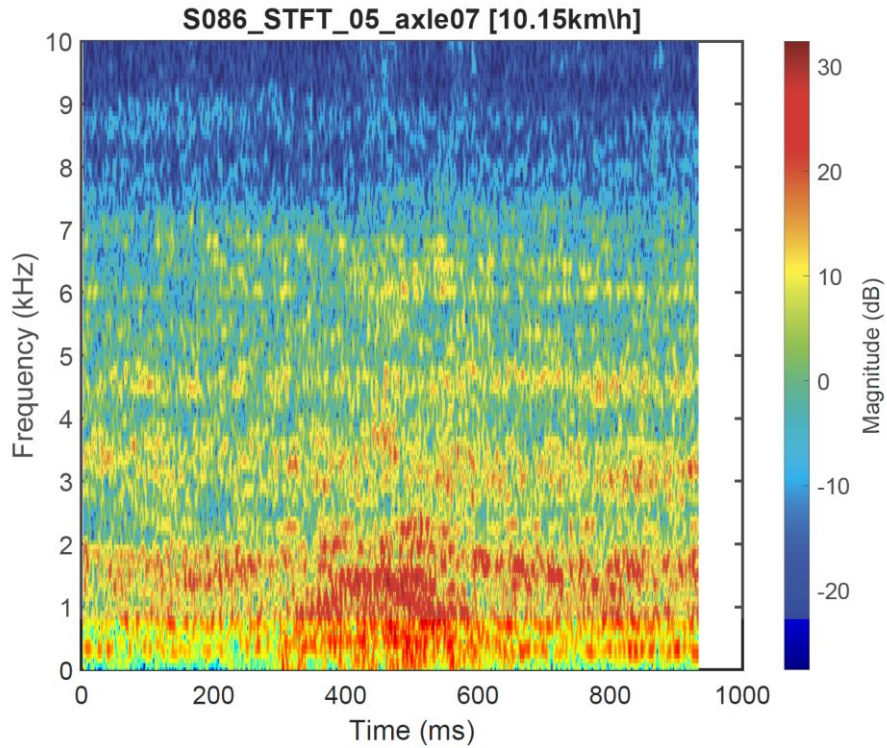


- Damaged wheel – 10 km/h

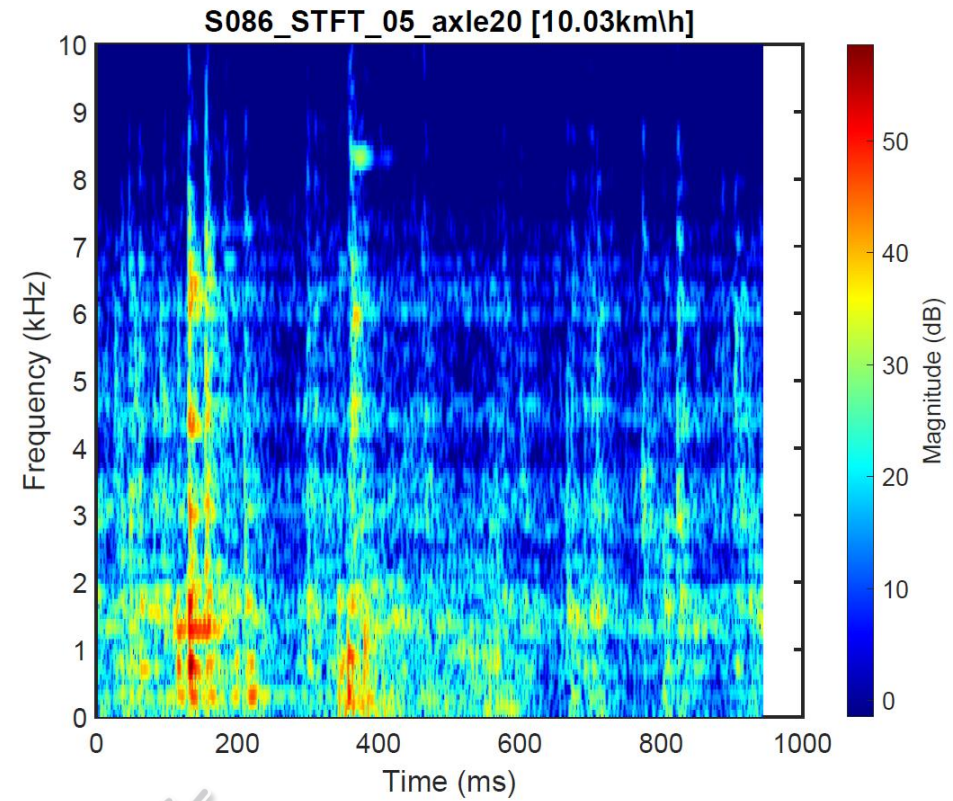




Normal wheel



Damaged wheel - 10 km/h



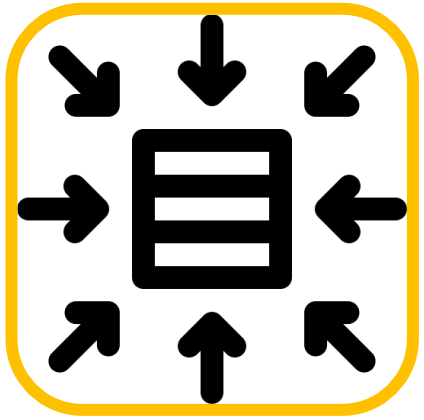


Fingerprint

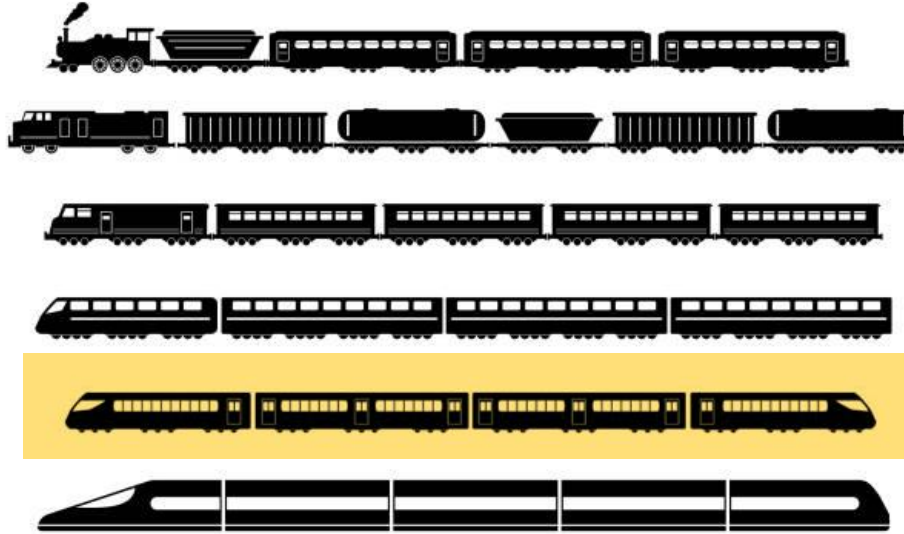


Advantages

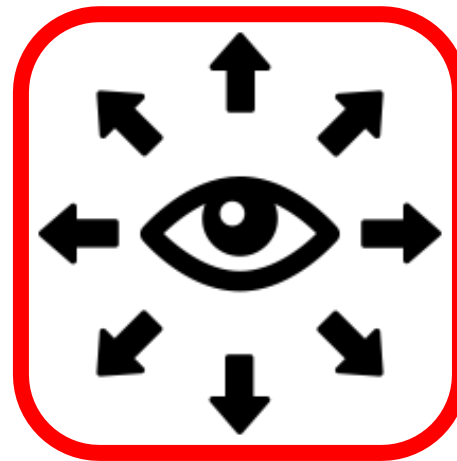
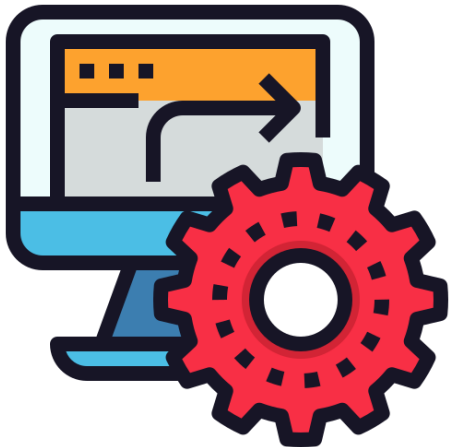
INFORMATION
AGGREGATOR



GRANULAR MONITORING



AUTOMATION

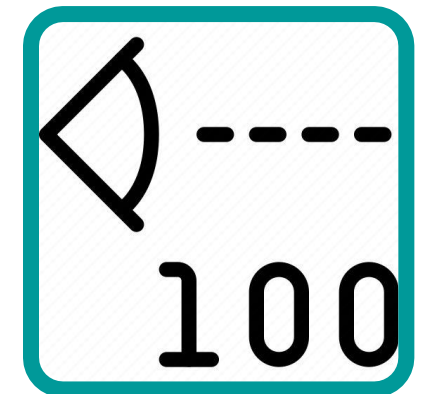


VIGILANCE



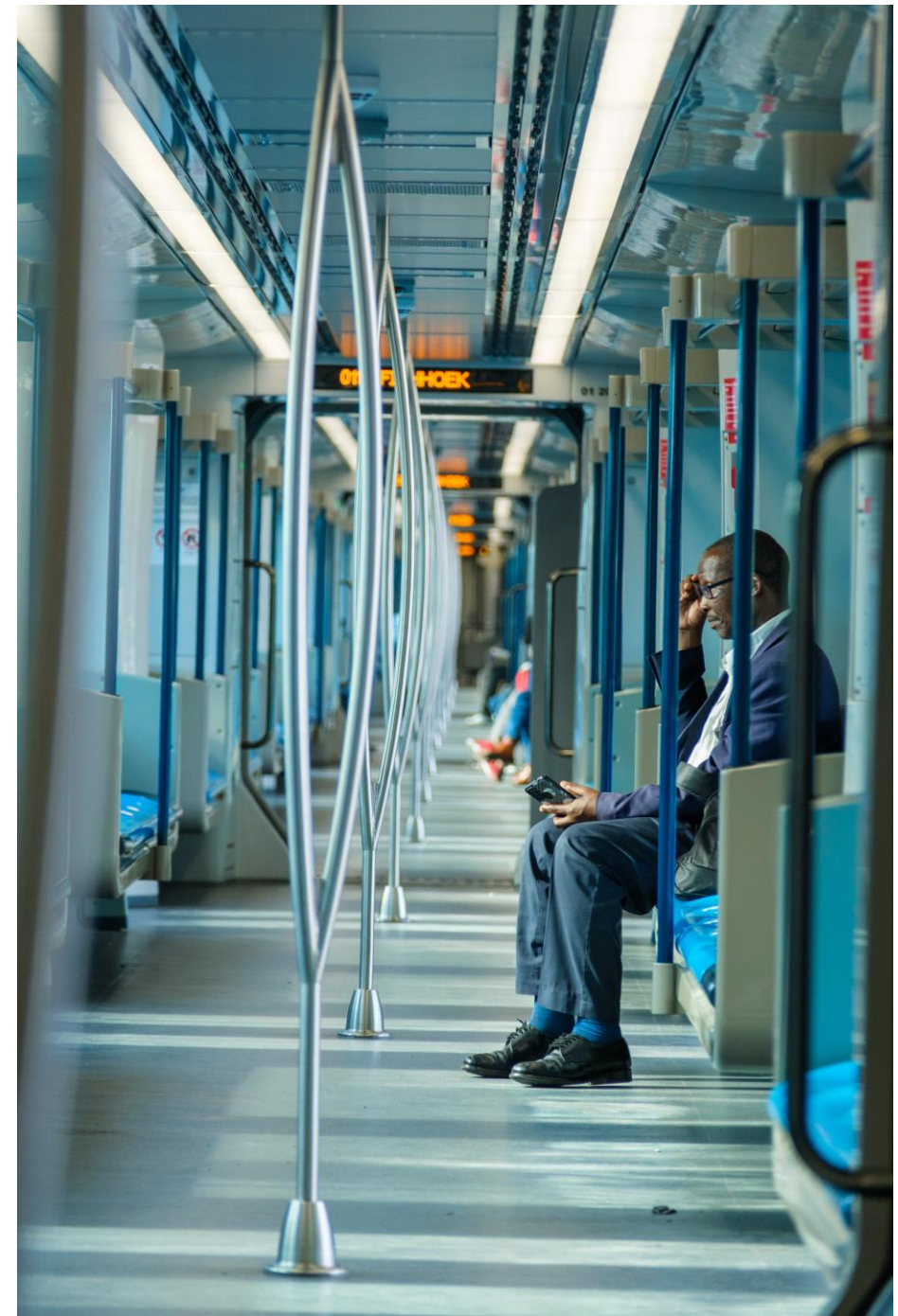
SOFTWARED EXERTISE

VISIBILITY



“A developed country is not a place where the poor have cars. It’s where the rich use public transportation”

– Gustavo Petro, Mayor of Bogotá



Thank you



Annie Bekker

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Skills transfer and experiences

Gibela is responsible for incorporating Economic Development into project execution, with the goal of developing local suppliers capable of delivering to production, service and quality standards

Supplier and Enterprise Development Performance

R81.4m total supplier and enterprise development spend across 42 independent entities

R73m
Financial support

- » Providing suppliers access to funding, favourable credit terms and free issuing of material
- » 24 suppliers assisted

R1.7m
Incubation support

- » Gibela's business support provides suppliers with mentorship, entrepreneurial learning sessions, access to specialists and a team of business guides
- » 5 Black-owned companies received support

R6.7m
Technical and Industrial Support

- » Providing suppliers with training/access to technical expertise to improve their on time delivery capability and to the required standard
- » 22 beneficiaries currently under training with mentors in place

The desired effect of supplier and enterprise development

-  Improved businesses performance (capability and skills)
-  Enhanced routes of supply and supplier diversity
-  Job creation (through an increase in production)
-  Transfer of skills across various areas of the value chain
-  Increased market opportunities and access
-  Development of an export market
-  Exposure to international best practice and standards

Ultimately...

- » Contributing to the revitalisation of the railway industry
- » Alleviation of poverty and contribution to the economic growth of South Africa