UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

Engineering 4.0
Progress & Processes

Prof Wynand JvdM Steyn – HOD Civil Engineering

14 November 2019

Engineering 4.0

- Concept & History
- Design
- Construction
- Training
- Reference
- Concrete
- APT
- Active traffic
- Other laboratories

Concept & History

- Discussions between SANRAL & UP started in 2015
- MoU
  - Signed on 28 June 2016
  - UP, SANRAL, CSIR
- Final UP Council approval
  - 15 November 2017
- Site handover
  - 31 July 2018
- Construction started
  - 17 October 2018
- Contractual completion
  - 28 February 2020

Engineering 4.0 Vision

Sustainable, Optimized, Smart, Equitable transportation networks supporting social & economic development in disruptive & evolutionary society

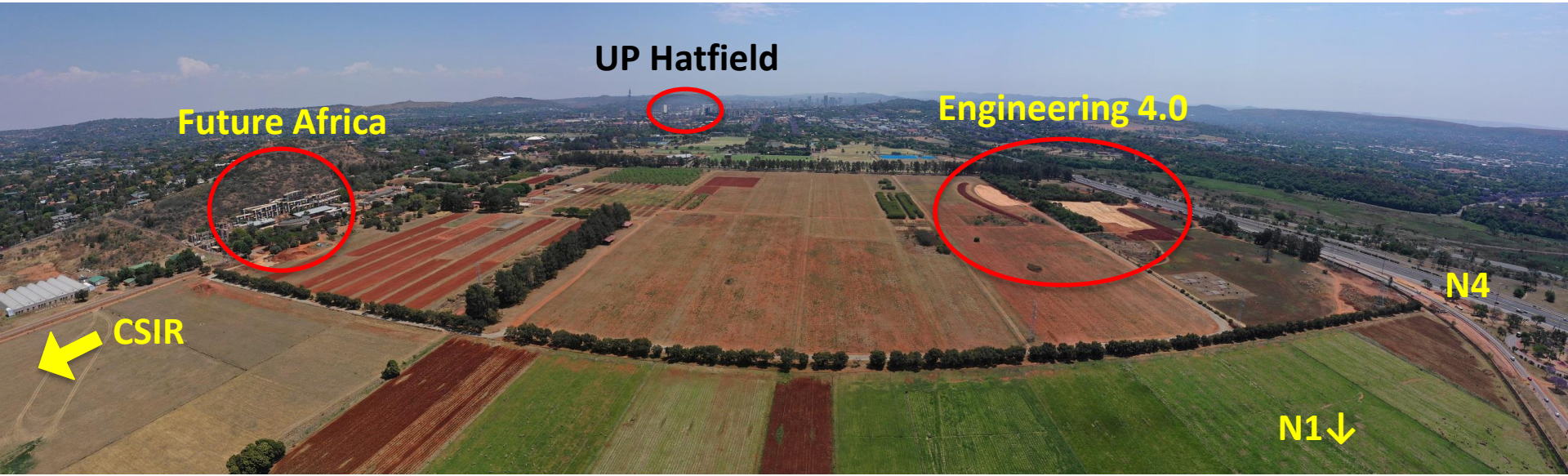
Engineering 4.0 Vision – Developing environment

- Autonomous & Electrical vehicles
  - Gravel & secondary road networks
  - Sustainable charging
  - Autonomous agricultural equipment
- Smart materials
  - Optimal use of marginal materials using nano-stabilizers
  - Responsive & intelligent materials
- IoT networks
  - Appropriate information for optimized systems
  - Data networks in rural areas
- Shared services
  - Equitable opportunities
- Smart Transportation within Smart Environments (cities, towns, dwellings & rural)
  - High-tech urban to informal settlements
  - Rural agricultural networks
- Novel design, construction, maintenance
  - Equitable employment
- Sustainability & optimized environment
  - Clean, safe, healthy living & working conditions

UP Engineering 4.0

- Multi-phase planning
- Phase 1
  - SANRAL National road materials reference laboratory
  - SANRAL Training & certification laboratory
  - Concrete research laboratory
  - Accelerated Pavement Testing (APT) track
  - Active vehicle test track
- Phases 2+
  - Remaining Civil Engineering facilities
  - Offices & lecture spaces
  - Various other engineering laboratories
  - Rail track

Innovation Africa @ UP campus



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Design

FIGURE 3
FACILITY PHASING

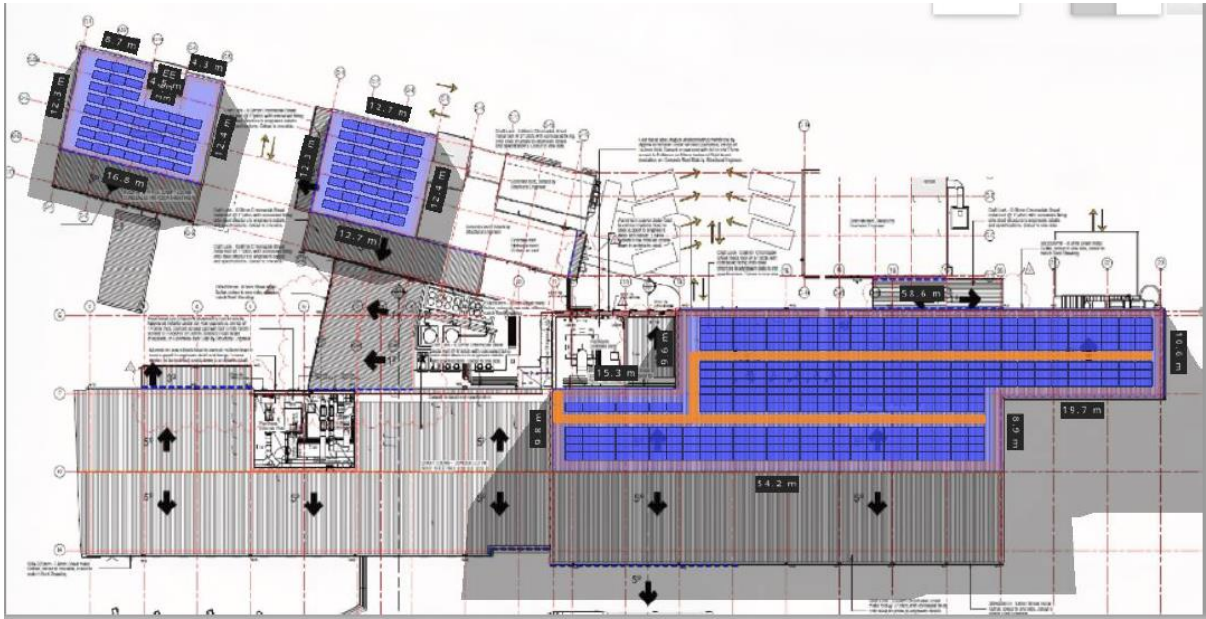
Design

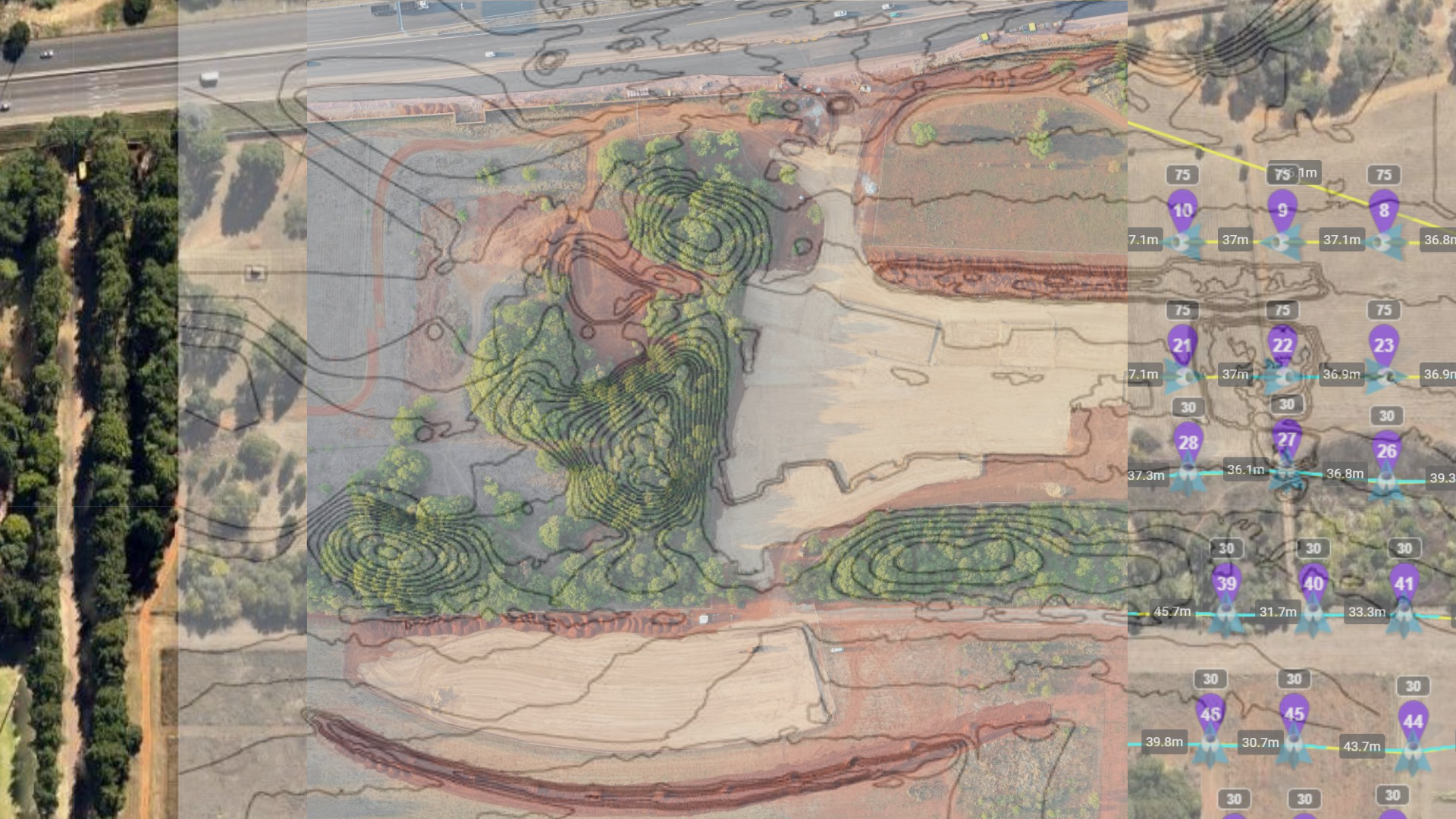
- Biophilic - human's innate attraction to nature & natural processes

6 500 m²

Green energy

- Roof PV
  - 431 panels x 350 W
  - 150 kW capacity
- EV charge station




75
10
9
8
7.1m
37m
37.1m
36.8m
75
21
22
23
7.1m
37m
36.9m
36.9m
30
28
27
26
37.3m
36.1m
36.8m
30
39
40
41
45.7m
31.7m
33.3m
30
46
45
44
39.8m
30.7m
43.7m

Construction

- Tilt-up construction process
- WBHO main contractor
- 18 months project
- Within time, budget & brief

ABNORMAL


BABCOCK


DYNAMIC


SANTANA

Engineering 4.0

Pavement Demand & Supply

- Demand
  - Traffic, Environment
- Supply
  - Materials, Structure

- Objective
  - Demand < Supply

Training laboratory

- Training of
  - laboratory technicians
  - students
- Certification of technicians

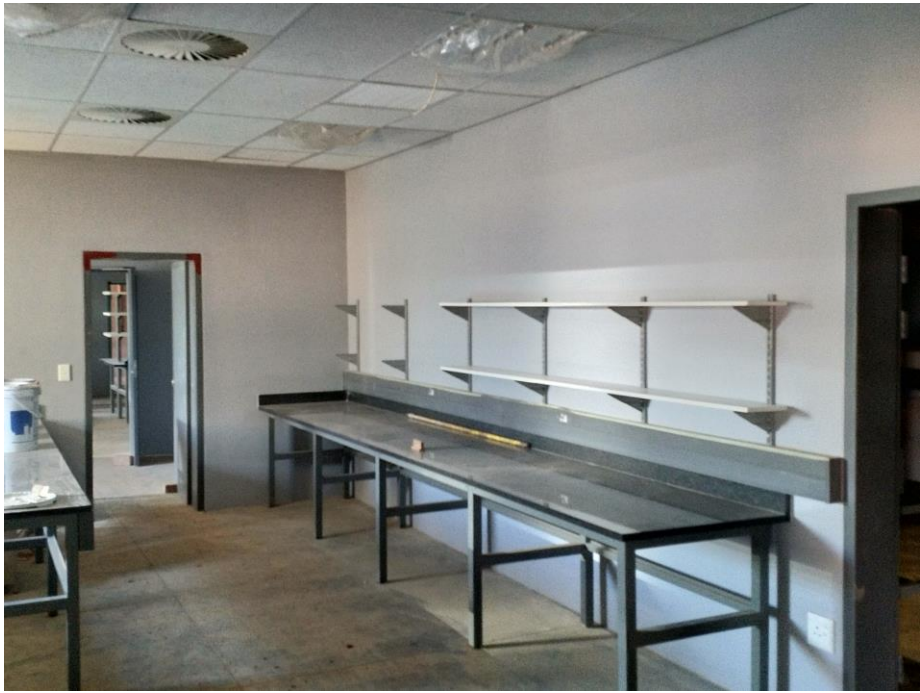
Laboratory testing VR

- Immersive off-site training
- Muscle memory development
- Certification in laboratory
- In co-operation with IT

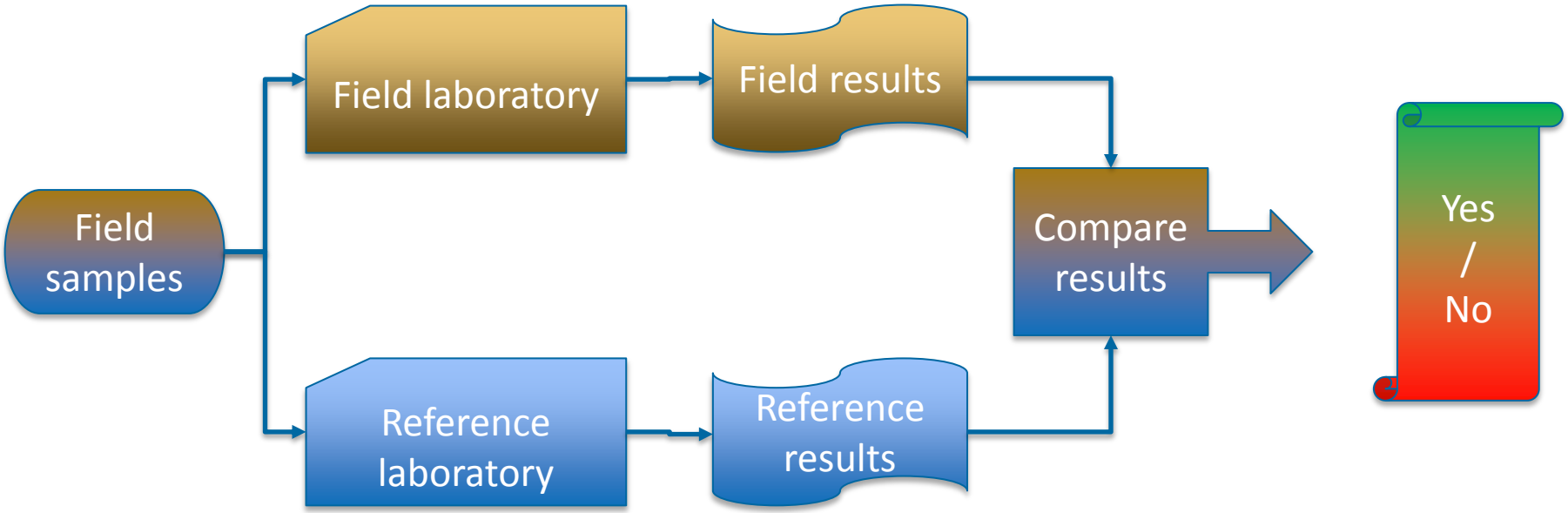
Reference laboratory

- Duplicate testing of site materials
  - Evaluate
    - site results
    - equipment & technician quality
- Develop materials properties database
- Ongoing improvement in fundamental materials understanding

- Calibrated, standard tests & equipment

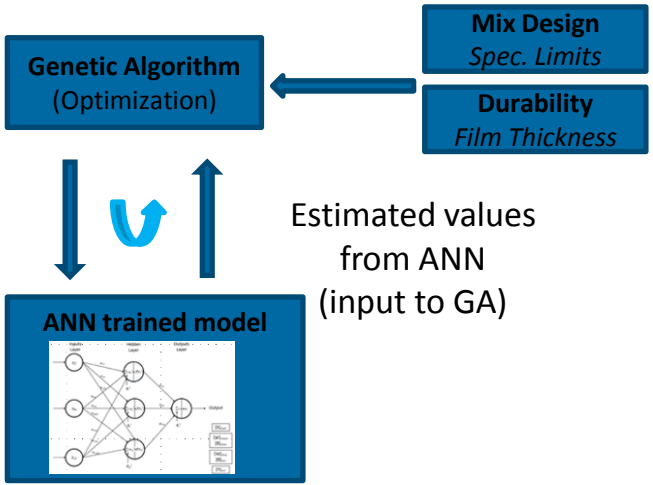


Duplicate testing

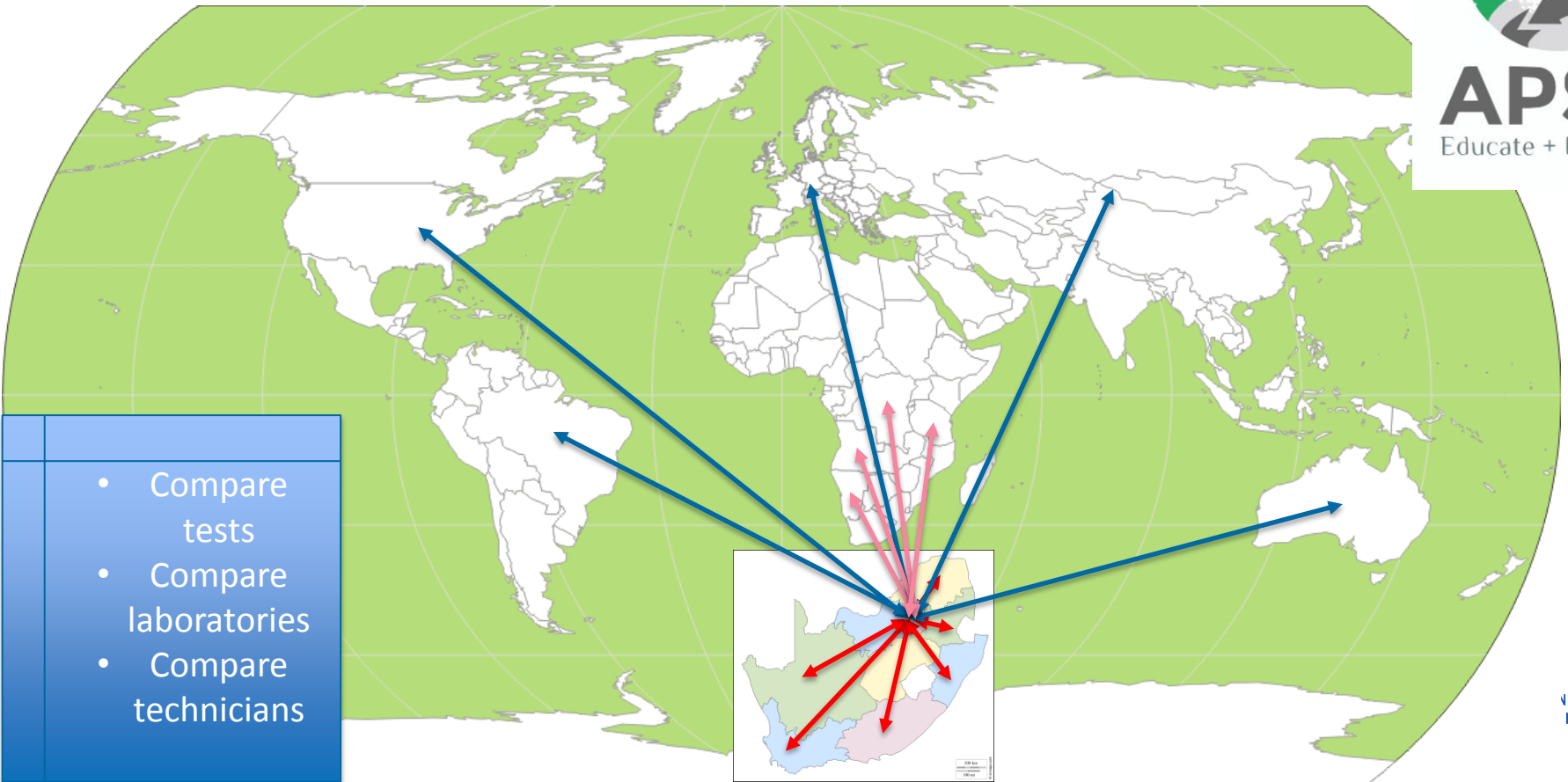


Duplicate testing

- All results to SARDS database
- Long-term database of material properties
- ANN type analyses for future designs?



Proficiency testing



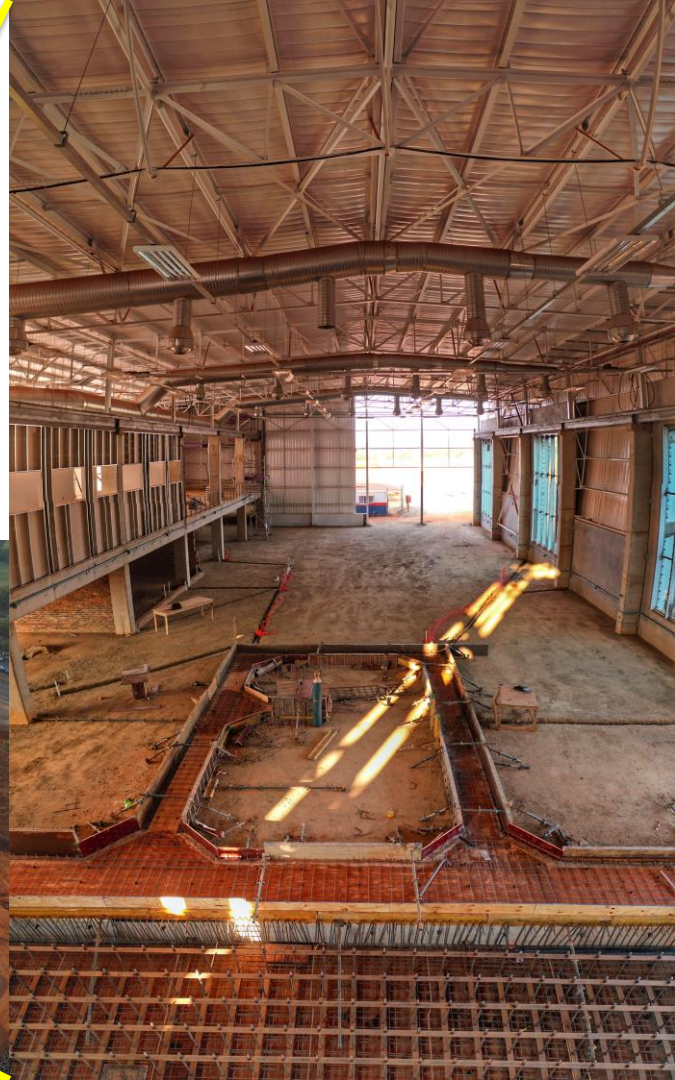
- Compare tests
- Compare laboratories
- Compare technicians

APSE
Educate + Innovate

PRETORIA
PRETORIA
PRETORIA

Concrete laboratory

- Concrete research & education
- Preparation, curing, testing areas
  - 5°C to 85°C, up to 100% humidity
- Strongfloor & wall

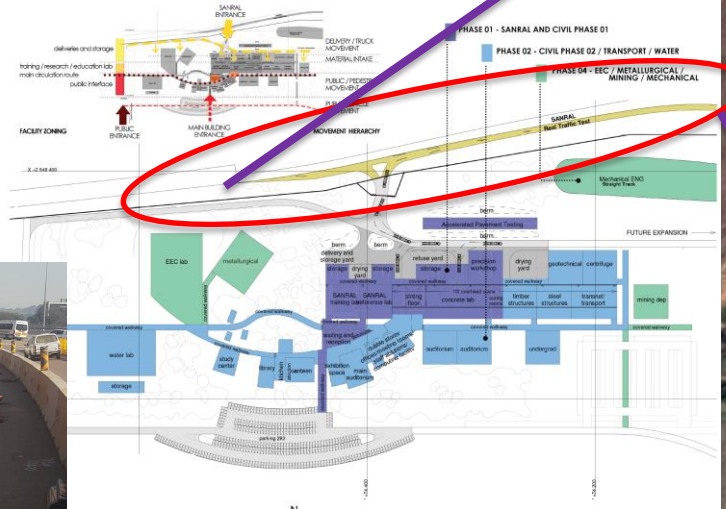


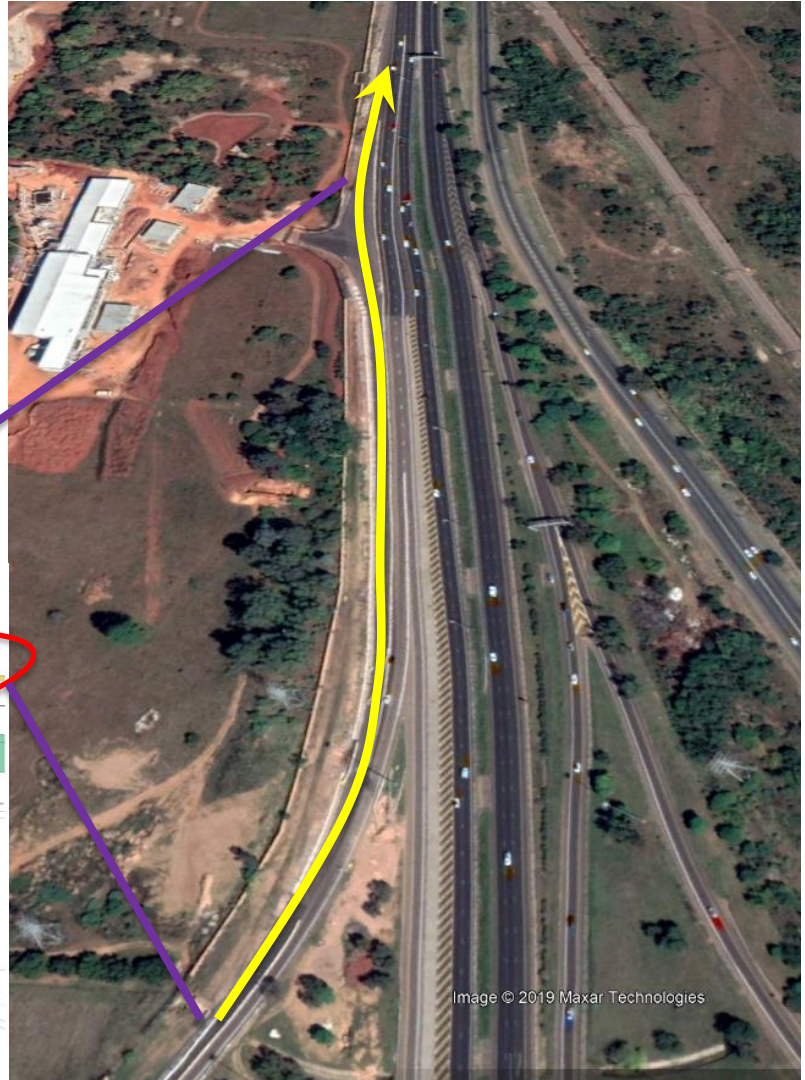
APT facility

- Area designated for Accelerated Pavement Testing evaluations
- Accelerated evaluation of pavement performance

Active traffic

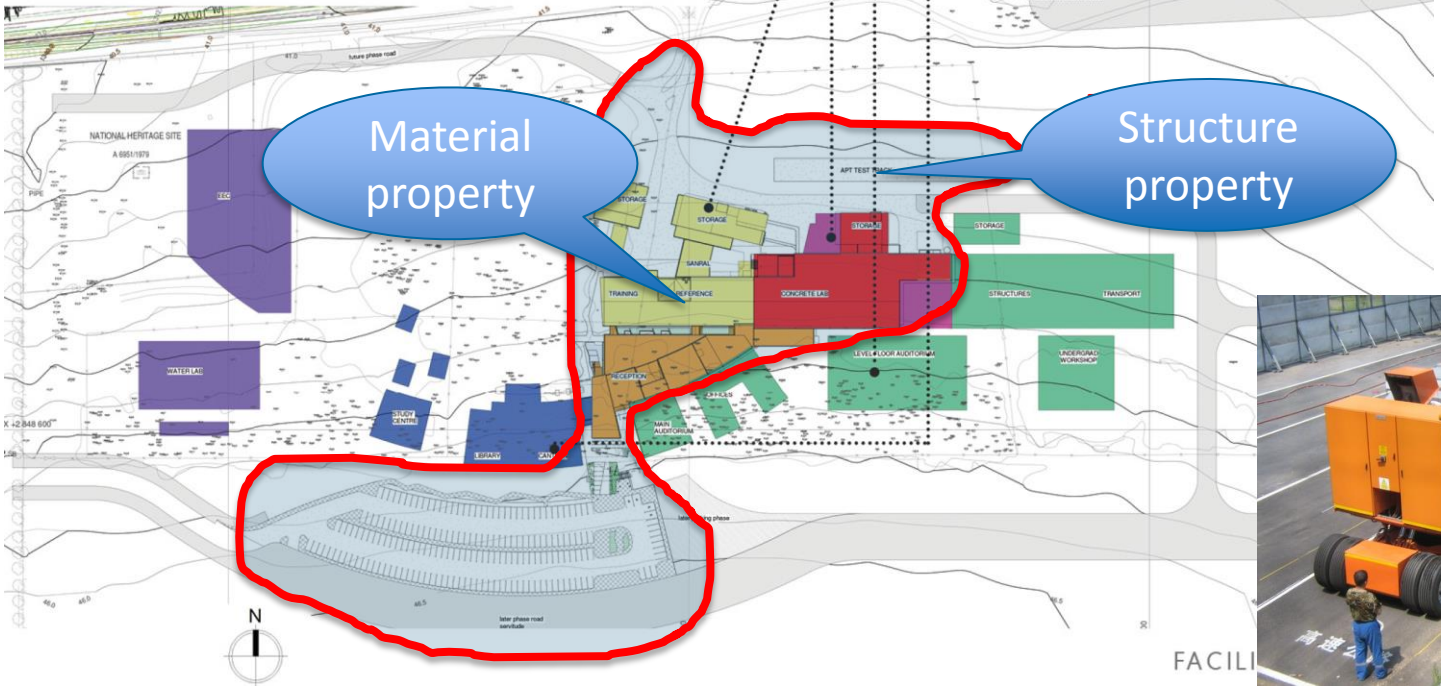
- Active traffic on real highway
- Sensors inside, next to, over etc.





Real pavement property

PHASE 1.1A - SANRAL FACILITY
PHASE 1.1B - RECEPTION/ABLUTIONS/AUDITORIUM/PART UP CONCRETE LAB
ASE 1.2A - UP ENG 4 CIVIL CONCRETE LAB
2B - REMAINDER OF UP ENG 4 CIVIL CONCRETE LAB
SECTION 2 - UP ENG 4 CIV ENG REMAINDER
SECTION 3- UP ENG 4 SUPPORTING FACILITIES
SECTION 4 - EEC / METALLURGICAL / MINING / MECHANICAL



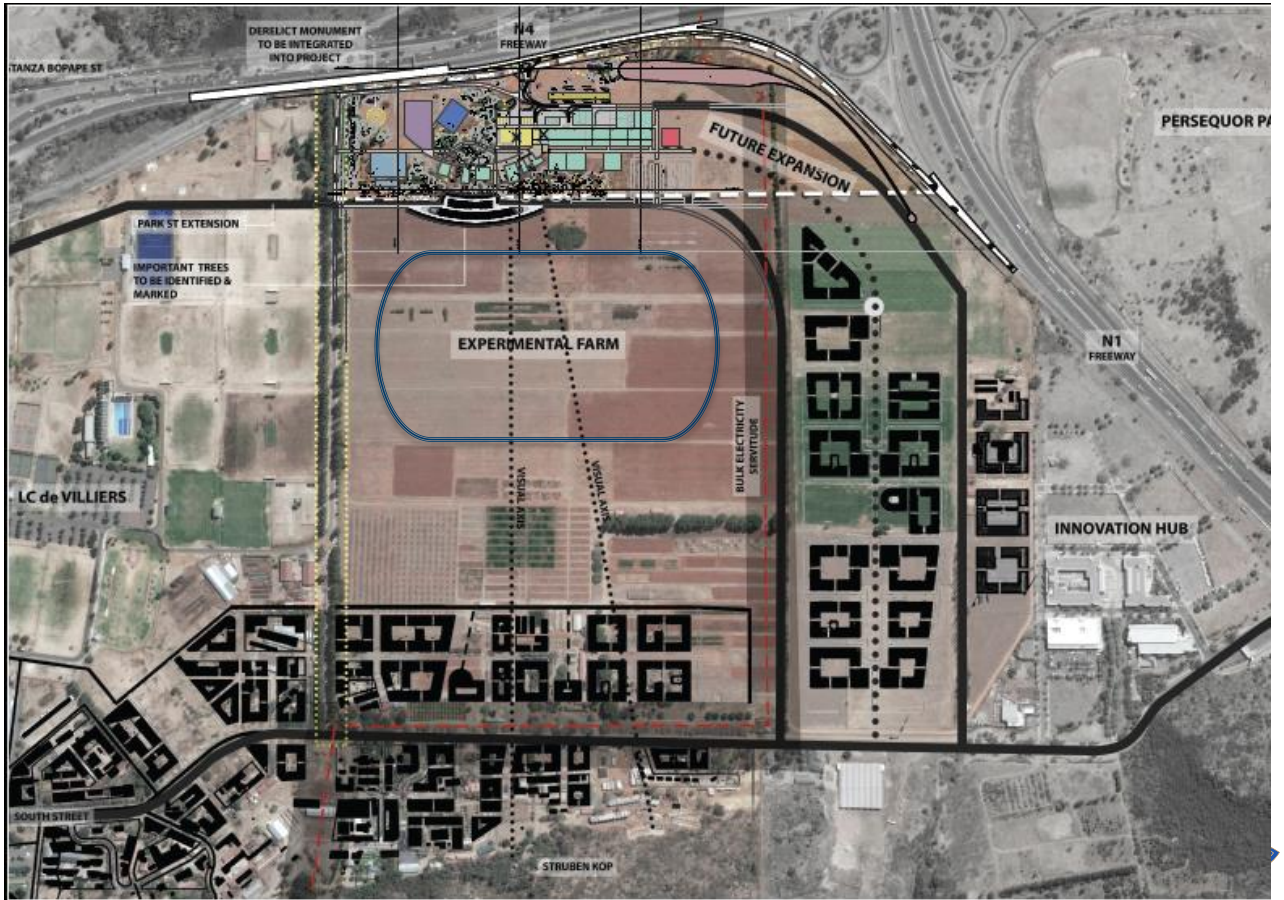
Material property

Structure property

Innovation Africa at UP campus - Other laboratories

- Innovation Africa at UP campus
- Natural & Agricultural Sciences
- Structural timber – Sponsored Chair & equipment
- Rail
- Water
- Geotechnical

Smart City and Future Transportation
Education, Research & Innovation Corridor
Innovation Africa at UP



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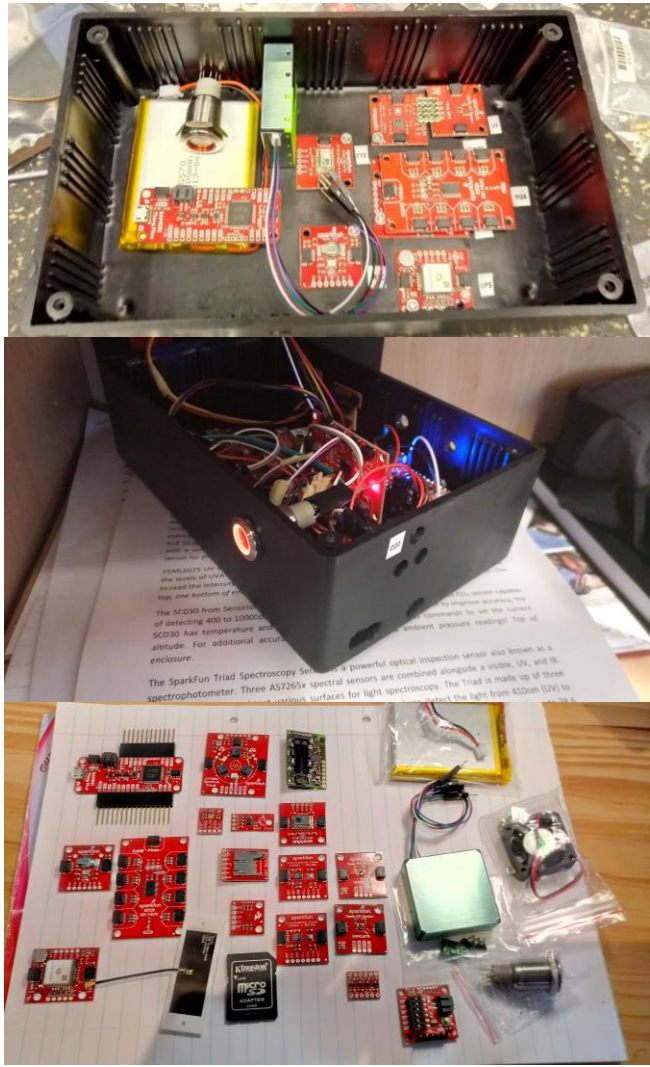
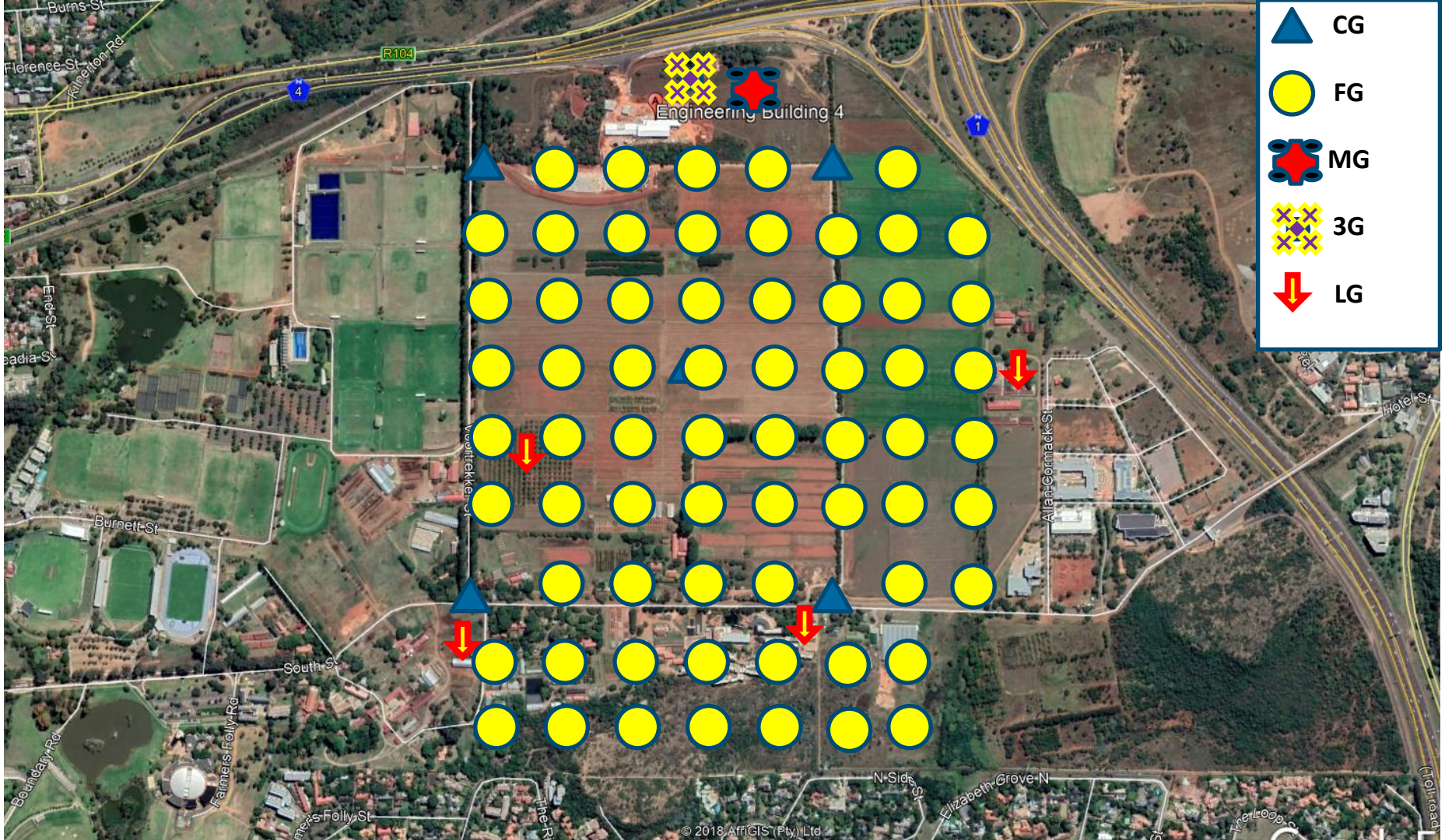
Civiltronics

- Sensor applications in support of Civil engineering applications
- IOT / Data science / Big data links
- Low-cost distributed networks of immersive sensors
- What do the data mean?

SNOET

- **RGB** (Red/Green/Blue) **Light** Sensor
- 9 DoF IMU (Tri-axis **accelerometer**, **gyroscope**, magnetometer)
- High accuracy environmental parameters
  - **Barometric pressure, Relative Humidity, Temperature**
  - **Total Organic Volatile Compounds** (TVOCs)
  - **CO_2**
- Ambient **light intensity**
- **GPS** (±2.5 m)
- **Infrared** thermal camera
- **UV Index**
- **Spectrophotometer**
- **Particle Matter** Sensor: Concentration and number of particles - 1 to 10 µg/m^3




CG
FG
MG
3G
LG
Engineering Building 4
Burns St
Florence St
Kingston Rd
R104
Burnett St
South St
Boundary Rd
Farmers Folly Rd
Farmer's Folly St
Vegottrekker Cr
Allan Cormack St
Hotel St
N Side St
Elizabeth Grove N
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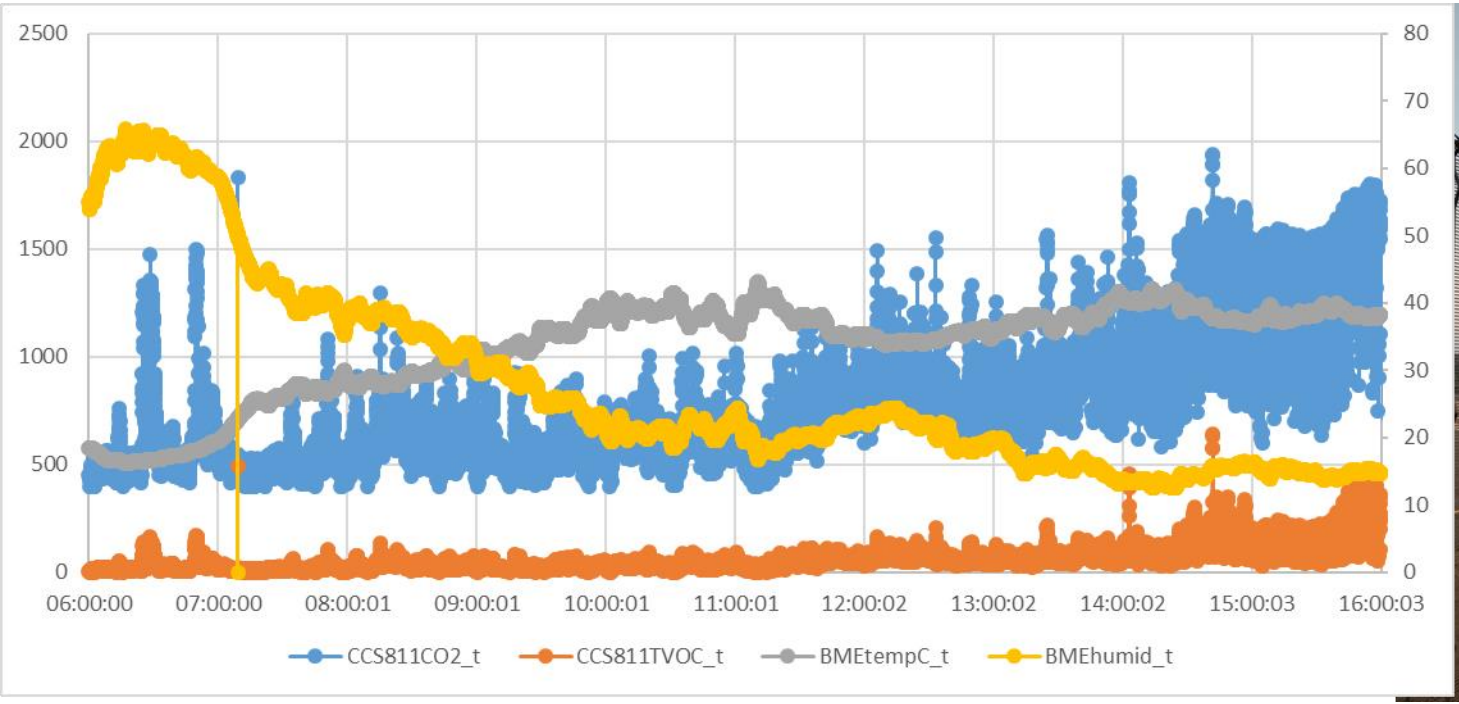
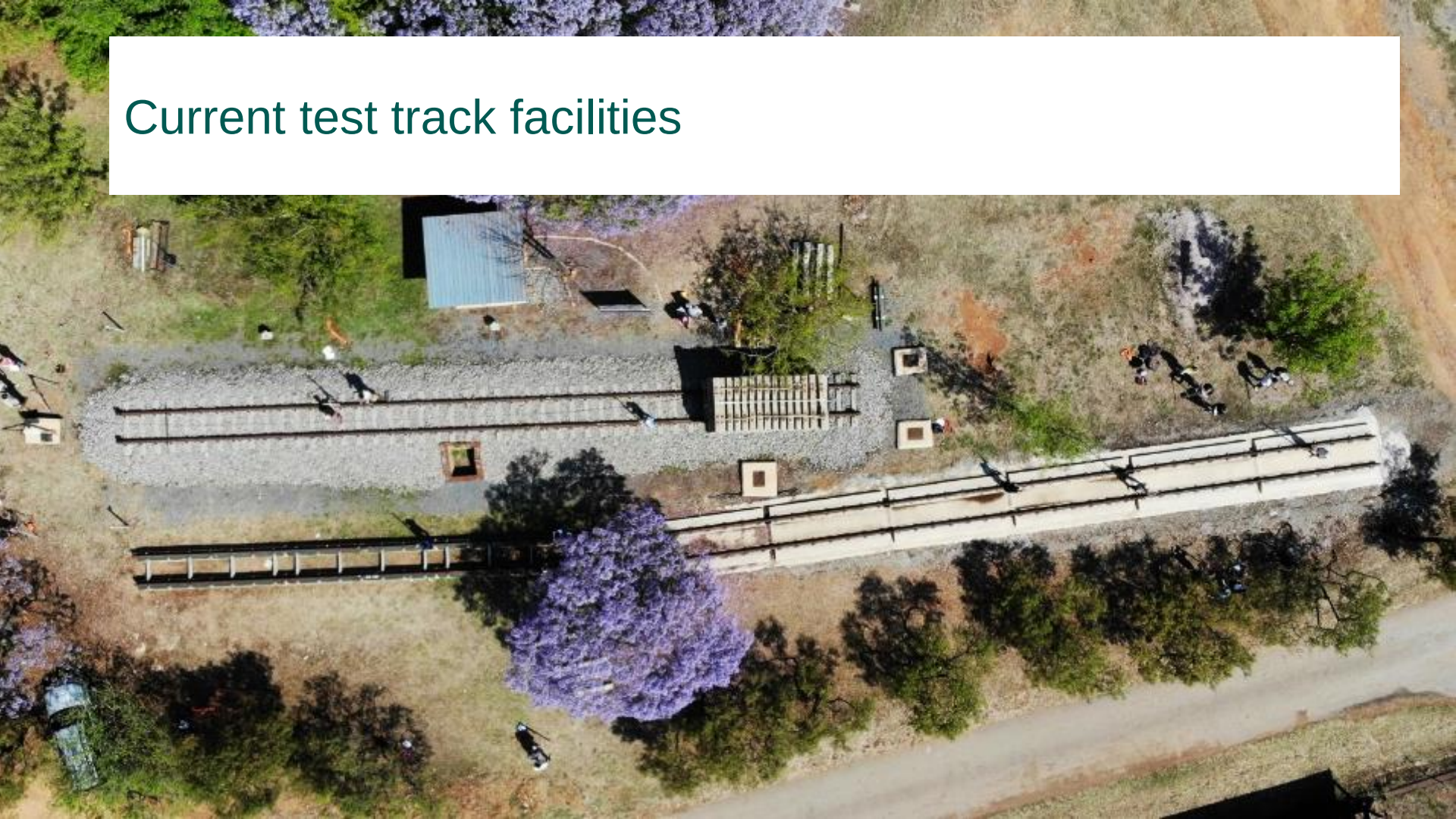
SNOET 3D Grid

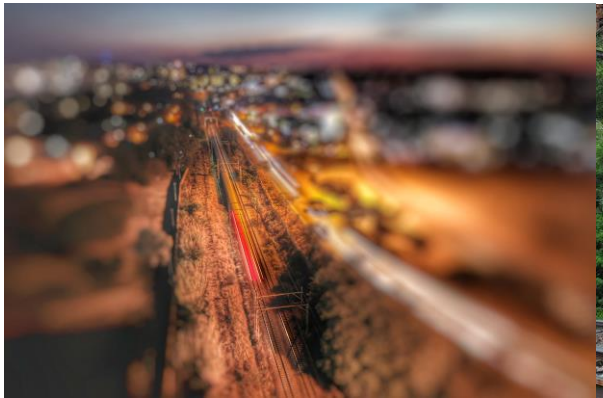


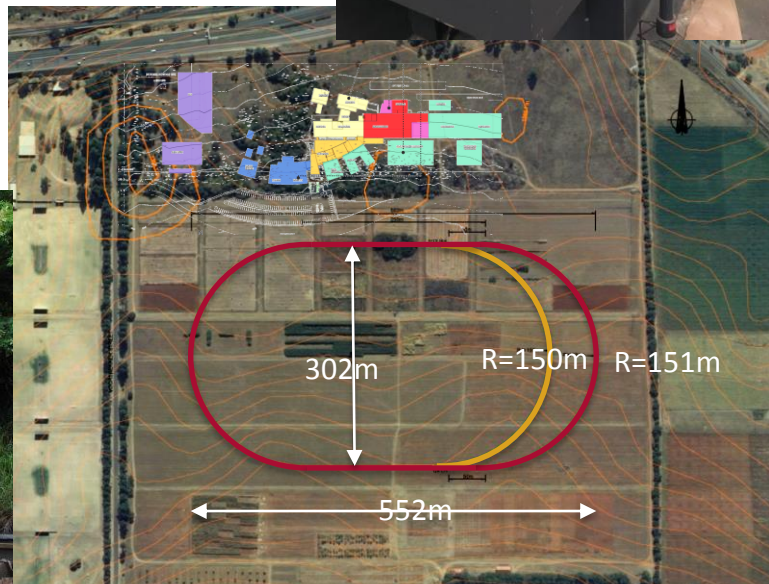
Current test track facilities



Railway Research Laboratory – Phase 2

- Full-scale track trench in laboratory with multiple actuators
- 2.0 km test track with rolling stock, signalling & related infrastructure
- NRF-funded Road/Rail Infrastructure Monitoring System - custom-built road/rail vehicle





Road/Rail Vehicle for Infrastructure monitoring

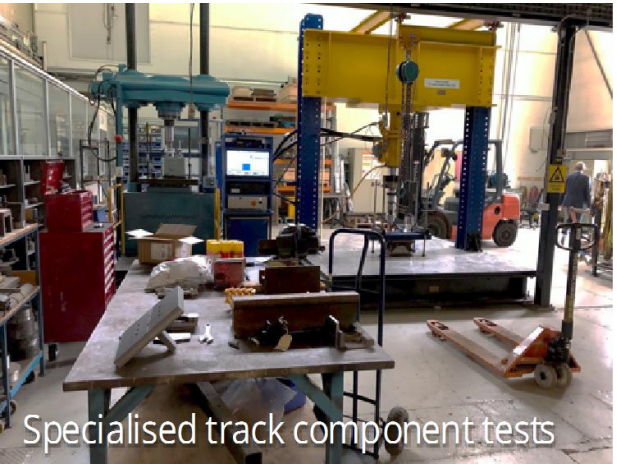
- Funded - NRF & University of Pretoria
- Collaboration Mechanical & Systems & Industrial Engineering
- Condition monitoring, characterisation & maintenance of road & rail infrastructure, measurement of vehicle dynamics
- Four main measurement components
  - GPS
  - High-accuracy LiDAR
  - 360° Video Camera
  - Vehicle Response Measurement system (VRMS)
- Platform for development of autonomous instrumented rail vehicles

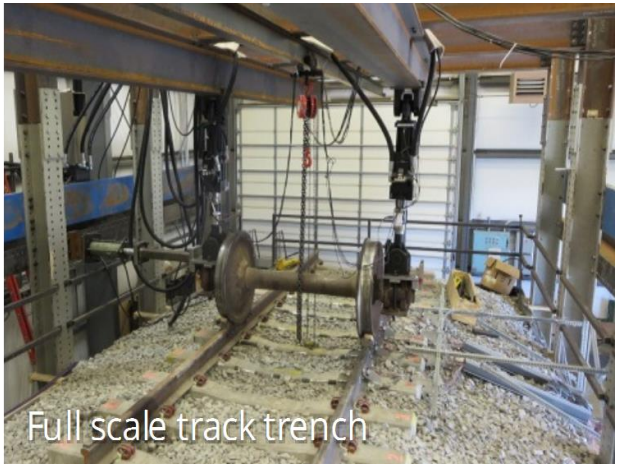
Track Testing Laboratory


Track panel tests


Large-scale dynamic tests


Rail and weld testing

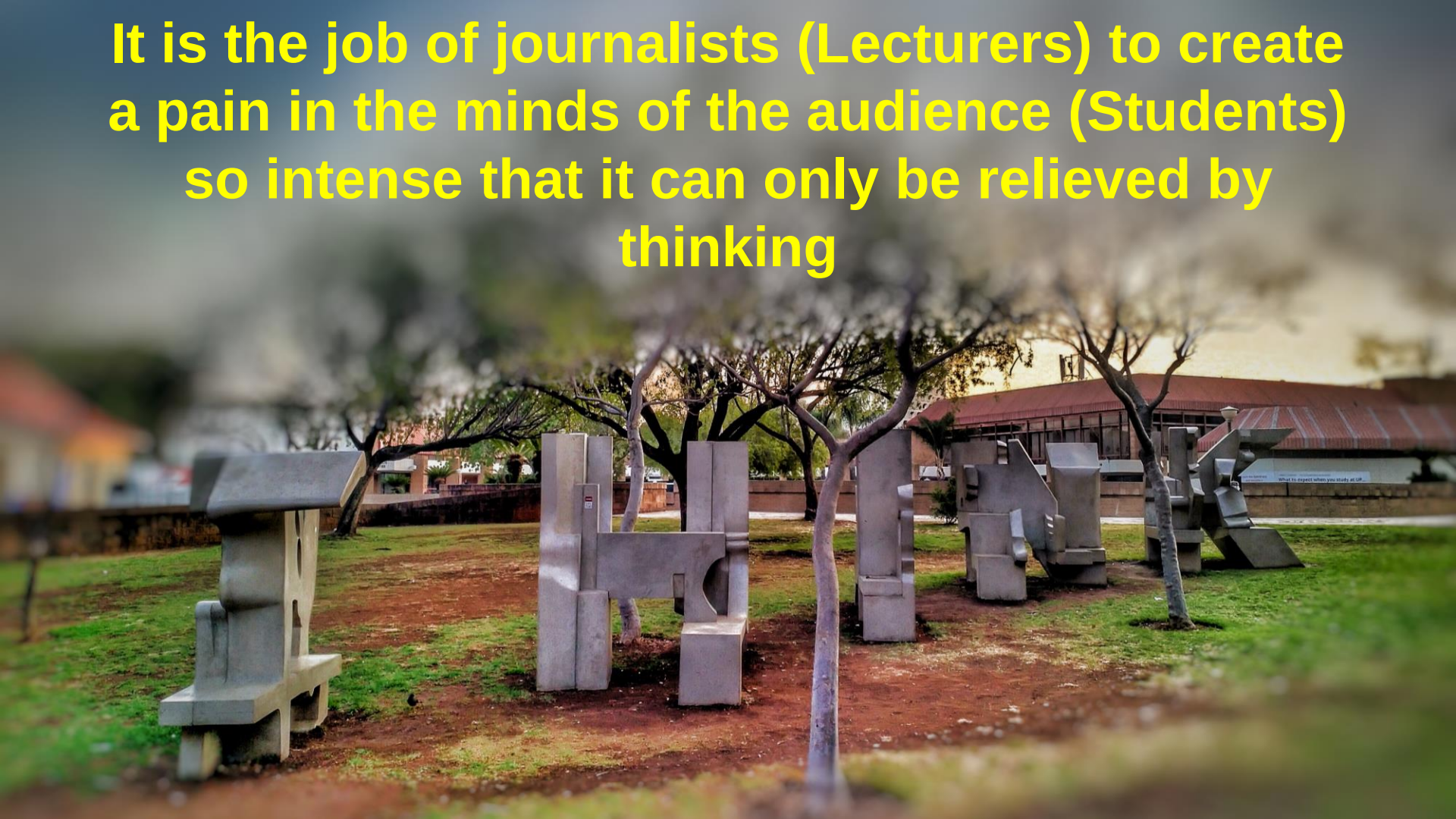

Specialised track component tests


Full scale track trench


Sleeper & fastener testing

Van Ryneveld memorial

- Pierre van Ryneveld & Quintin Brand
- 17 March 1920


It is the job of journalists (Lecturers) to create a pain in the minds of the audience (Students) so intense that it can only be relieved by thinking

Questions

www.up.ac.za/eng4