



THE GLOBAL ENGINEERING CONFERENCE ON SUSTAINABLE
DEVELOPMENT AND WORLD FEDERATION OF ENGINEERING
ORGANISATIONS EXECUTIVE COMMITTEE MEETINGS.

15th - 18th October 2024, Kigali, Rwanda

Theme: Engineering Innovations for a Sustainable Future

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www.engineersrwanda.rw

geco.ier.rw

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DIGITALIZATION FOR SDG 9

BRIDGING AFRICA'S INFRASTRUCTURE GAP

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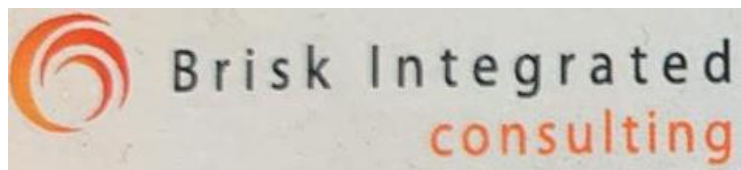
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- 1 Introduction
- 2 SD 9 & Africa Infrastructure
- 3 Construction 4.0 for SDG9
- 4 Examples / Conclusions



Scan to Connect

BIM CoDE•SA

COvention for a Digital South Africa

Workshop 5 • 9 October 2024



Laying the foundation for the digital transformation of South Africa's built environment



SDG 9: INFRASTRUCTURE, INDUSTRY & INNOVATION



- **9.1: Resilient infrastructure**
 - Infrastructure as a foundation
- **9.2: Inclusive and sustainable industrialization**
 - encompasses the production and use of construction materials including sustainable sourcing, waste reduction, local content
 - infrastructure fosters industrialization by creating sustainable, well-connected spaces for industries to operate
- **9.3: Innovation**
 - transforms both infrastructure development and industry to improve productivity, reduce waste, and promote cost-effectiveness
 - leads to advancements in materials, construction techniques, and technologies
 - drives efficiency, productivity, and competitiveness in the manufacturing sector, leading to economic growth and job creation.

AFRICA'S INFRASTRUCTURE CHALLENGE

- Infrastructure underpins economic growth
 - Facilitates trade, connecting markets, and enhancing productivity while creating jobs [7% of global employment (Alaloul et al., 2021); 11-13% of global GDP (Environment, 2017)]
 - Significant source of global carbon emissions - 40% to global energy use; 50% of process-related CO2 emissions.
- The challenge
 - Infrastructure deficit with an estimated annual funding requirement of \$130-170 billion to achieve SDG 9.
 - Construction projects frequently face significant time and cost overruns
 - Industrialization and economic growth hindered by inadequate infrastructure
 - with current policies, less than a quarter of the 450m new jobs needed in the next 20 years will be created [Africa Competitiveness Report, 2024]
- Innovation-Driven Infrastructure Development
 - Africa's infrastructure challenges require innovative solutions to bridge the financing gap and enhance infrastructure resilience, efficiency, and sustainability
 - Africa's innovation ecosystem has grown by 40% in the last 5 years, 30% of African startups focus on infrastructure-related solutions

NOTABLE AFRICAN PROJECT FAILURES

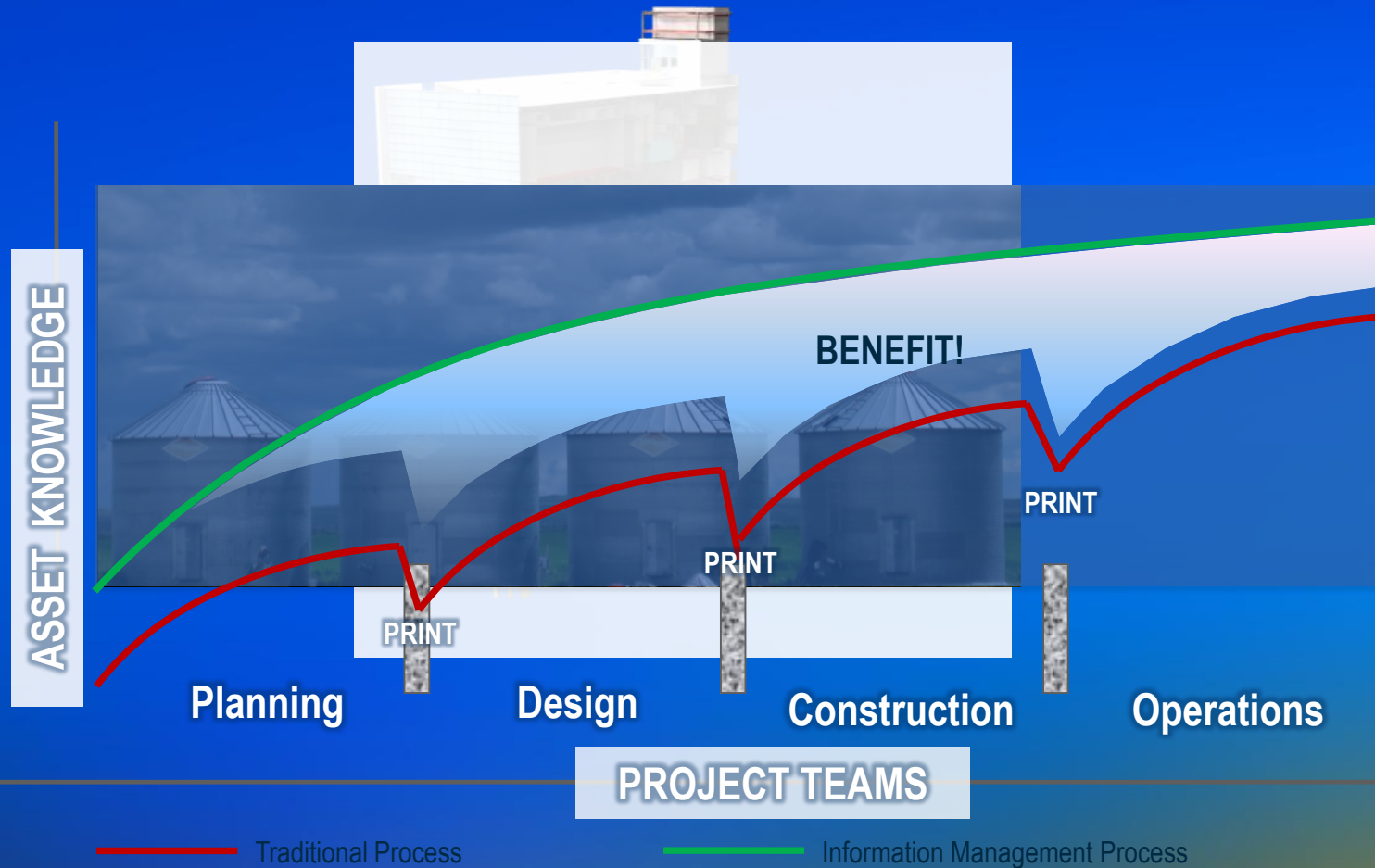
Project Name	Location	Description	Issues	Schedule Slip	Cost Slip
Kampala-Jinja Expressway	Uganda	Major highway to improve connectivity between Kampala and Jinja.	Delays, financing issues, land acquisition problems.	Estimated 2-3 years	Estimated \$500m+
Tazara Railway Upgrades	Tanzania-Zambia	Upgrade existing Tazara Railway to improve efficiency.	Poor management, funding shortfalls, operational challenges.	Estimated 1-2 years	Estimated \$200m+
Grand Renaissance Dam (GERD)	Ethiopia	Massive hydroelectric dam on the Blue Nile River.	Technical delays, political disputes, funding issues.	6+ years	\$4b (initially \$4.8b)
African Union Headquarters	Ethiopia	New headquarters for the African Union.	Corruption concerns, quality control issues.	2 years	\$27m+ (initially \$200m)
Mombasa-Nairobi Standard Gauge Railway (SGR)	Kenya	Major railway connecting Mombasa and Nairobi.	Cost overruns, corruption allegations, economic viability issues.	1-2 years	Approx. \$1.2b (initially \$2.5b)
Cairo Metro Line 3 Extension	Egypt	Extension of Cairo's Metro Line 3.	Construction delays, funding issues, technical challenges.	Estimated 2 years	Estimated \$300 million+
Durban Point Waterfront Development	South Africa	Redevelopment project for Durban's waterfront.	Legal disputes, poor planning, financial mismanagement.	3-5 years	\$1b (initially \$500 million)
Kampala Industrial Park	Uganda	Industrial Park intended to boost industrialization in Kampala.	Delays in infrastructure development, funding shortfalls.	Estimated 2 years	Estimated \$200 million

PROJECT DELIVERY CHALLENGES

1	Skimping on the front-end definition Lack of sound project economics	7	Cost and schedule control
2	Large project functional integration	8	Human capital constraints Resource shortfall
3	Lack of cohesive and trusted project information	9	Increased legal and regulatory compliance
4	Risk identification/assessment and management of the process	10	Scope growth and claims management
5	Global program delivery consistency	11	Inefficiencies in construction and commissioning
6	Sub-contractor delivery reliance and performance	12	Extended production ramp-up time



BENEFITS OF INFORMATION MANAGEMENT PROCESS



• Traditional Process Challenges

- Information silos between project phases
- Risk of information loss or misinterpretation during handover
- Inefficient knowledge transfer between teams
- Potential for rework and increased costs due to missing or incorrect information

• Benefits of IM Processes

- Improved collaboration and knowledge sharing
- Reduced rework and project delays
- Enhanced decision-making
- Efficient asset handover and management
- Cost savings and improved project outcomes

INFRASTRUCTURE TECHNOLOGIES & INNOVATIONS

DIGITAL TWIN

[brings together all the various technologies (pillars)]

Automation

Internet of Things (IoT)

Big Data Analytics (BDA)

Cloud Computing (CC)

Artificial Intelligence (AI)

BIM

Modular Construction

Robotics

3D Printing

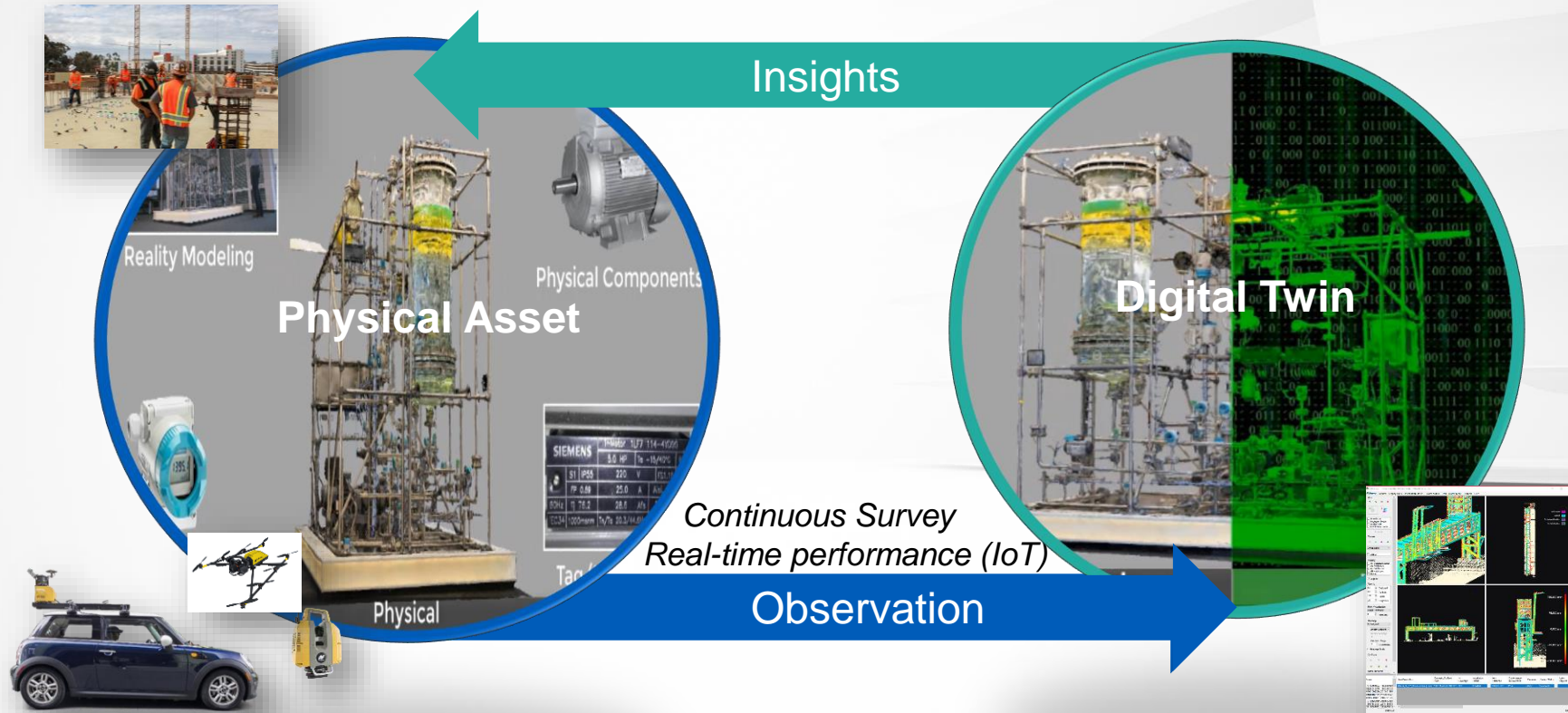
Augmented Reality (AR)

Virtual Reality (VR)

Drones

CONSTRUCTION 4.0

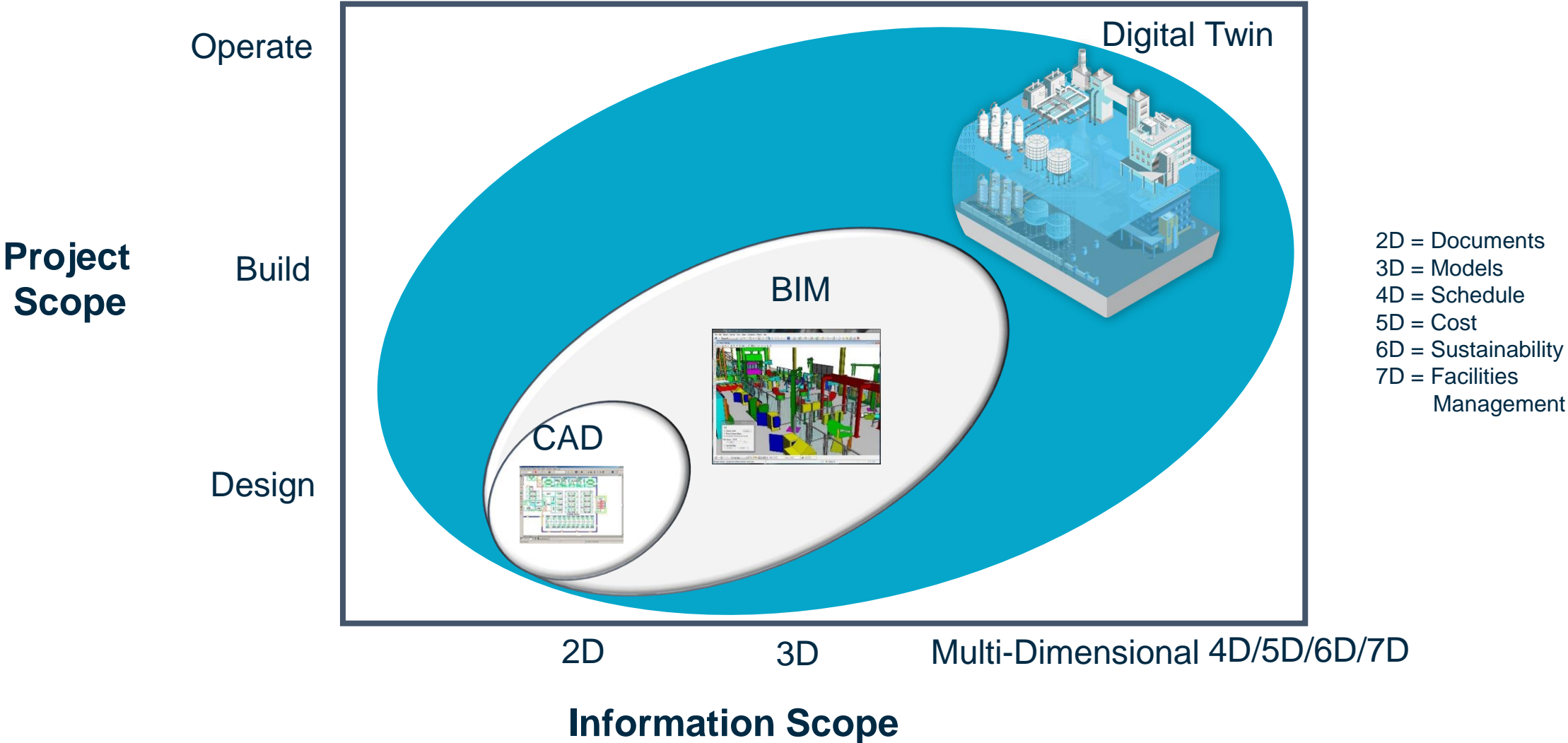
DIGITAL TWINNING



virtual representation of real-world entities and processes, which is synchronized at a specified frequency and fidelity [Digital Twin Consortium]

- representation enables a continuous, data-driven interaction between the physical and digital worlds.
- purpose is to **accelerate holistic understanding**, **optimize decision-making**, and drive **effective actions** by using both **real-time** and **historical data** to represent current and past conditions, while simulating potential future outcomes

INFRASTRUCTURE PROJECT DELIVERY EVOLUTION



DIGITAL TWIN ACROSS LIFECYCLE

Planning

- Site survey
- Reality Capture / 3D Mesh



Design

- Stakeholder engagement
- Planning and visualization
- Quality review
- Change tracking



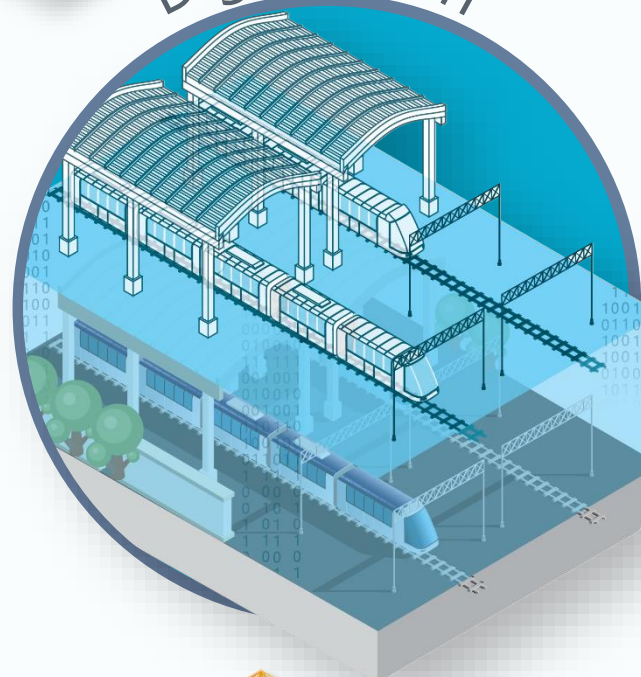
Analysis

- Process Simulation
- Design Simulation
- Cost Simulation
- Pedestrian simulation
- Flood simulation



Construction

- Simulate logistics
- Progress tracking
- Status review



Digital Twin

Operations

- HSSE training
- Operator training



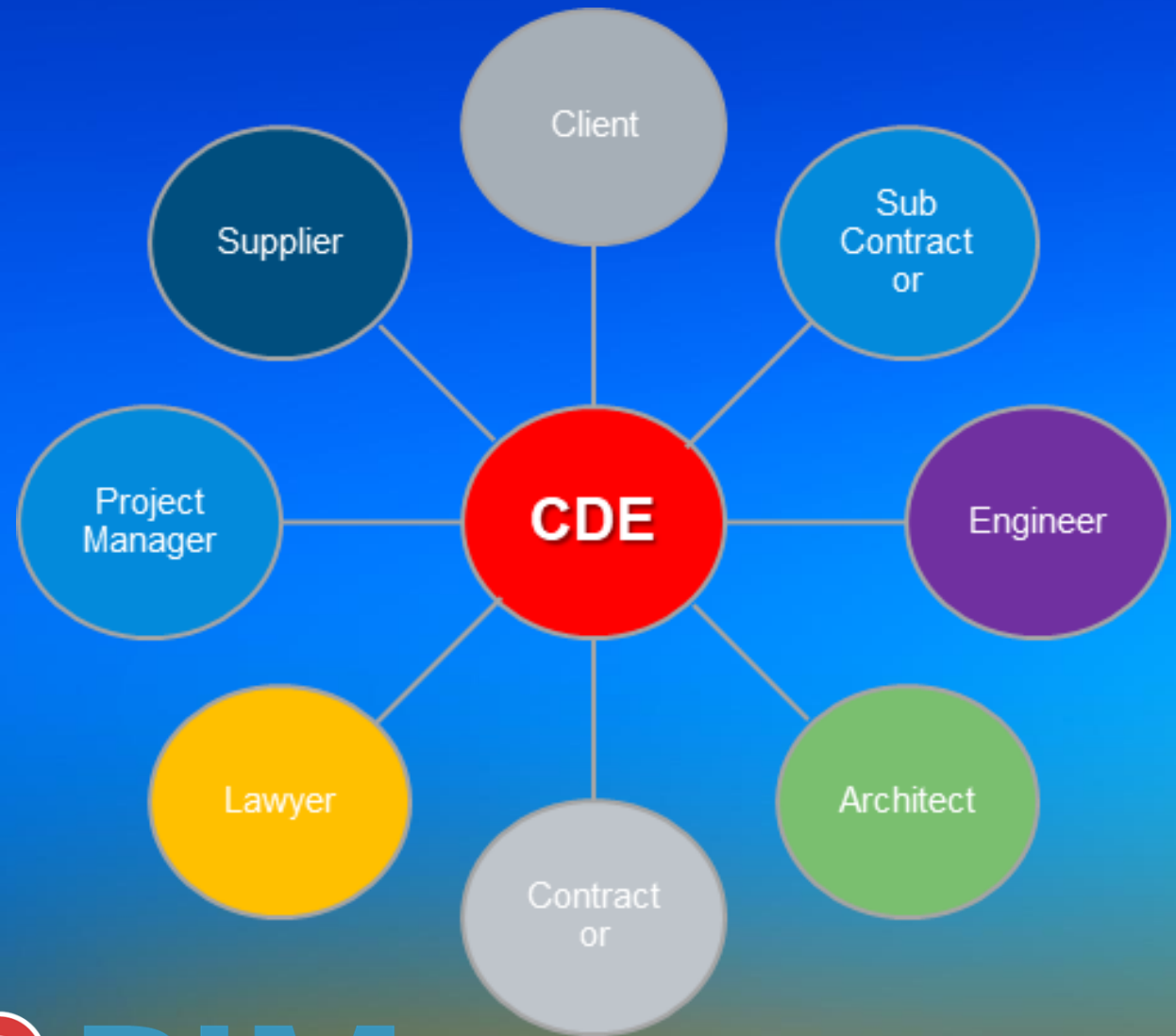
- Maintenance planning
- Shutdowns
- Verify before execution

- Remote inspection
- Leak detection
- Corrosion detection

An iTwin spans the entire asset lifecycle. Users at all stages can make better informed decisions for better outcomes.

AEC SECTOR SOFTWARE

Project Information Management



BIMserver.center

ISO 19650: A FRAMEWORK FOR IM

Collaborating

Exchanging information, altering activities, sharing resources and enhancing each other's capacity for mutual benefit and to achieve a **common goal**. Organisations share risks, responsibilities and rewards. This requires a substantial time **commitment**, high levels of **trust**, direct **interaction** among individuals to produce the outcome, and involves negotiation, discussion and accommodating others' perspectives.



Share



Deliverables Management



Issues Resolution



Project Insights



Field Data Management

Common Data Environment (CDE)

- ✓ Centralized digital platform for managing project information
- ✓ Stores, accesses, and shares project data (models, drawings, documents)
- ✓ Enables real-time collaboration among project stakeholders
- ✓ Supports information exchange throughout the project lifecycle

Workflow

- ✓ Structured processes for information creation, sharing, and approval
- ✓ Defines roles and responsibilities for information management
- ✓ Ensures data integrity and consistency
- ✓ Optimizes information flow and decision-making

Information Requirements – information needed at every stage of project lifecycle

Data Quality - accuracy, reliability, and completeness of project information

Security – protecting sensitive project data and preventing unauthorized access

Interoperability – ensuring information can be exchanged seamlessly across different software applications and systems

BS EN ISO 19650-1:2018

BS EN ISO 19650-2:2018

BSI Standards Publication

Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling

Part 1: Concepts and principles

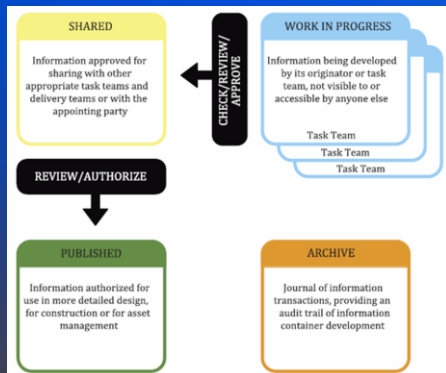
bsi.

BSI Standards Publication

Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling

Information management using building information modelling

bsi.



LEGEND

- AP** Approve (Preliminary)
- RR** Reject / Revise...
- EP** Early Publishing
- AC** Approve (Contractual)



TASK WIP USER



TASK CHECKER

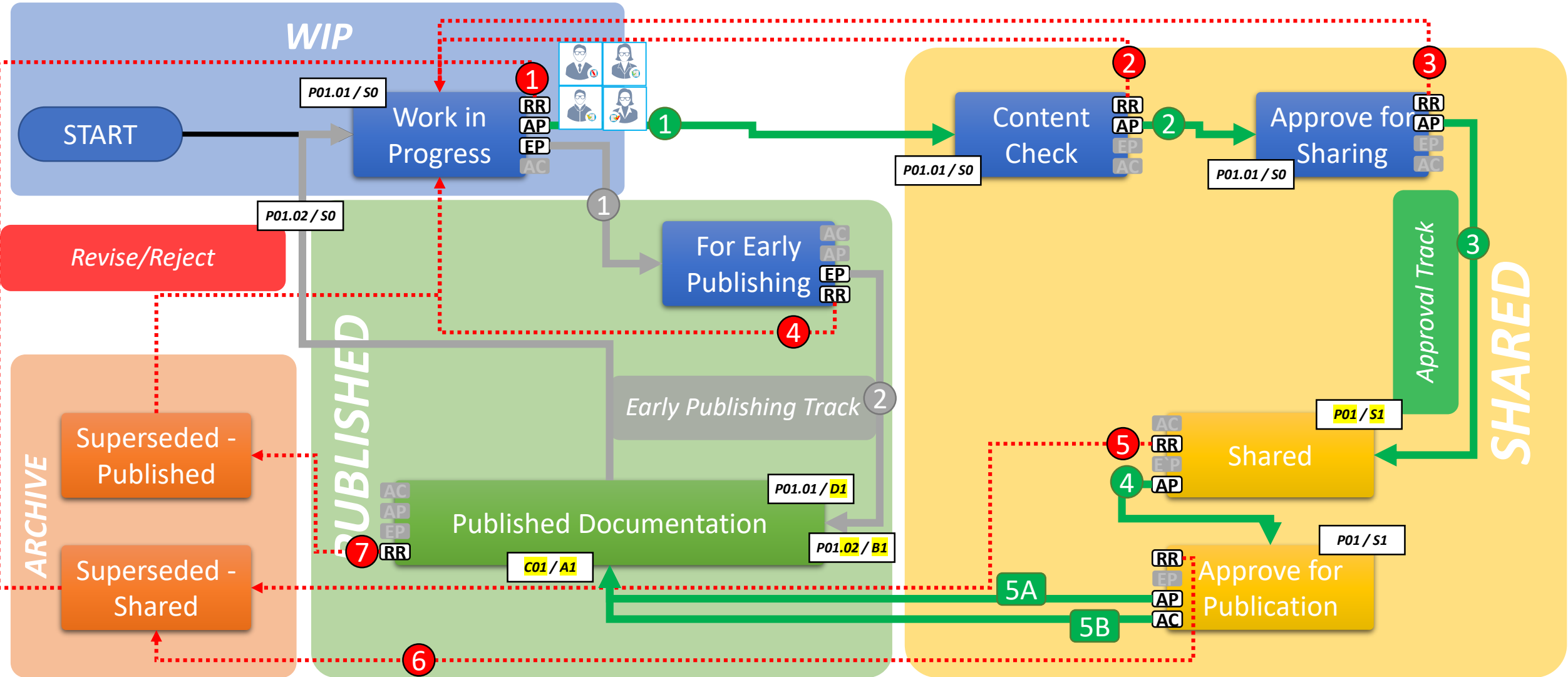


TASK APPROVER



TASK AUTHORIZER

Workflow



Southwest Electric Power Design Institute

Zhaotong Converter Station



Required Centralized Engineering Content Management Solution:

- ✓ Enhance regional power transmission
- ✓ Reduce time searching for engineering documents
- ✓ Ability to share accurate project data from office to field



Comprehensive solution including:

- ✓ Engineering Content Management
- ✓ Comprehensive Work-sharing
- ✓ Collaborative Design Review



- ✓ Reduced engineering design time by 25%
- ✓ Cut project delivery costs by 8%
- ✓ Reduced operating costs by 10%
- ✓ Increased the rate of return on investment by 5%

AEC SECTOR SOFTWARE EXAMPLES

Design & Engineering



Architecture

MEP

Structures

Management

Optional BIM workflow

 **BIM**server.center

The logo for BIMserver.center, consisting of a stylized icon of four interlocking loops in blue, red, green, and yellow, followed by the text "BIMserver.center" in a blue sans-serif font.



Reinforcement ratios, per diameter

BAHARAIN(SRINIVAS)- 27 STOREY BULIDING- RC WA..

Date:03/10/24

Job total

Element	
Pile caps	
Strap beams	
Total	

Element	For (
Flat slabs	
Beams	51
Reinforced concrete walls	
Columns	74
Total	
Index (per m²)	
Total surface area: 30939.90 m²	

Job total

	Reference	Length (m)	Weight (kg)
Pile caps	Ø6	5089.03	1242
	Ø8	592.77	257
	Ø10	2316.89	1571
	Ø12	10937.32	10682
	Ø16	5919.13	10277
	Ø20	2563.55	6954
	Ø25	3684.57	15618
	Ø32	12003.35	83360
	Total + 10%		129961
Strap beams	Ø6	69.00	17
	Ø8	497.26	216
	Ø10	333.40	226
	Ø12	19619.50	19161
	Ø16	126.45	220
	Ø25	1030.76	4369
	Ø32	14074.13	97741
		Total + 10%	
Flat slabs	Ø8	114193.34	49568
	Ø10	260562.27	176712
	Ø12	440654.30	430351
	Ø16	122598.30	212850
	Ø20	74792.72	202894
	Ø25	42687.02	180939
		Total + 10%	
Concrete beams	Ø8	22865.81	9925
	Ø10	19612.99	13296
	Ø12	29471.74	28778
	Ø16	36719.62	63753
	Ø20	4610.45	12512
	Ø25	3480.87	14755
		Total + 10%	
Reinforced concrete walls	Ø6	150.88	37
	Ø8	4208.28	1828
	Ø10	48626.23	32977
	Ø12	7466.46	7292
	Ø16	9626.56	16712
	Ø20	9043.72	24532
	Ø25	318.78	1351
		Total + 10%	
Concrete columns	Ø8	110926.48	48151
	Ø10	10623.53	7205
	Ø12	21982.02	21467
	Ø16	16940.22	29411
	Ø20	16240.02	44056
	Ø25	21565.46	91413
		Total + 10%	

Bars (kg)
129961
121950
251911

Bars (kg)
1253314
143019
84729
241712
1722774
55.68

CAMPUS

cype



cype

40
years

AEC SECTOR SOFTWARE

CONSTRUCTION – 3D Printing , 4D Planning and Scheduling

Affordable Housing through 3D Printing – Industrialisation of Construction

- UJ Project led by Prof J Mahachi
 - Goal: innovative technology that addresses:
 - Time to construct houses;
 - Cost of energy in production;
 - Sustainability (Reduction in carbon emissions);
 - Cost reduction;
 - High quality of end-product
 - Attraction of youngsters and women to the industry
- Fly ash beneficiation – Prof Onkonta
- Use fly ash from power plants

SPRINGER LINK

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Home > Discover Sustainability > Article

Durability properties of ambient-cured fly ash-phosphogypsum blended geopolymers in terms of water absorption, porosity, and sulfate resistance

Research | Open access | Published: 16 October 2024

Volume 5, article number 330, (2024) Cite this article

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Jabulani Matsimbe, Megersa Dinka, David Olukanni & Innocent Musonda



Discover Sustainability

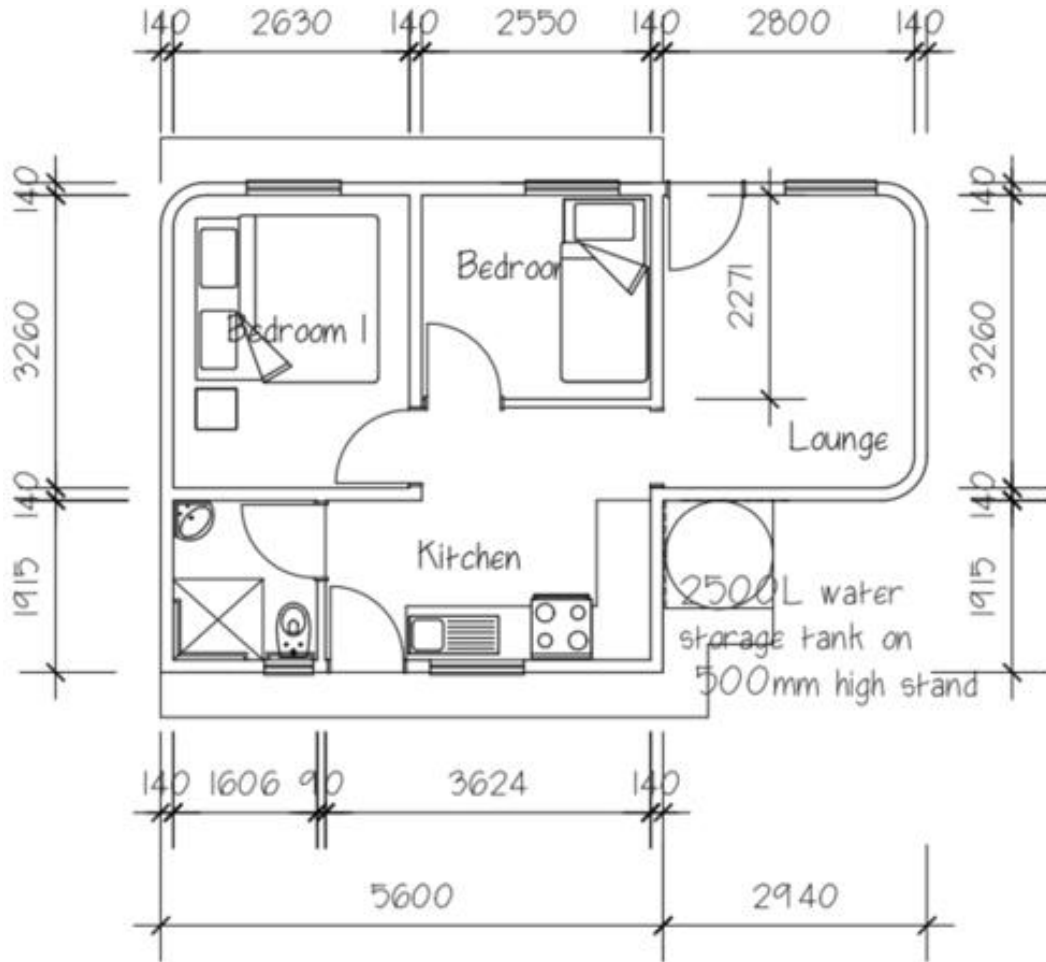
Aims and scope →

Submit manuscript →

Use our pre-submission checklist →
Avoid common mistakes on your manuscript.



Construction 3D Printing - CAD 2 3D Model



CYPE Architecture
Architectural modelling

Architectural modelling is the first step in most BIM projects. During this phase, the building concept begins to take shape, and the spaces, uses, ergonomics, configuration and aesthetics of the building are established. Within CYPE software, this task is carried out in CYPE Architecture, which allows professionals to develop an architectural model from the sketch phase through to the development of a detailed BIM model.



Completed House



First 3D Printed House in South Africa

Time to complete walls
(Aggregated to an
equivalent 8 hours). A
wall takes approx. 45
minutes to complete

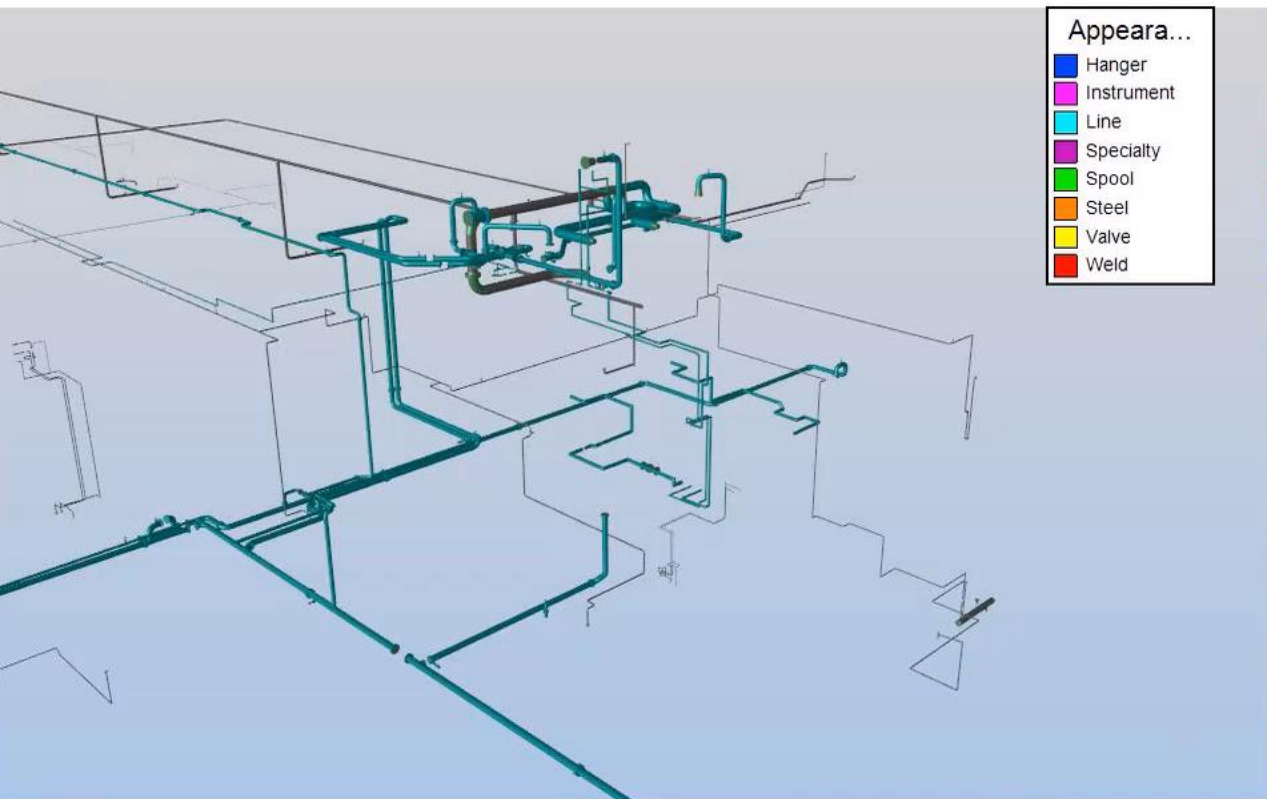


MIXED REALITY

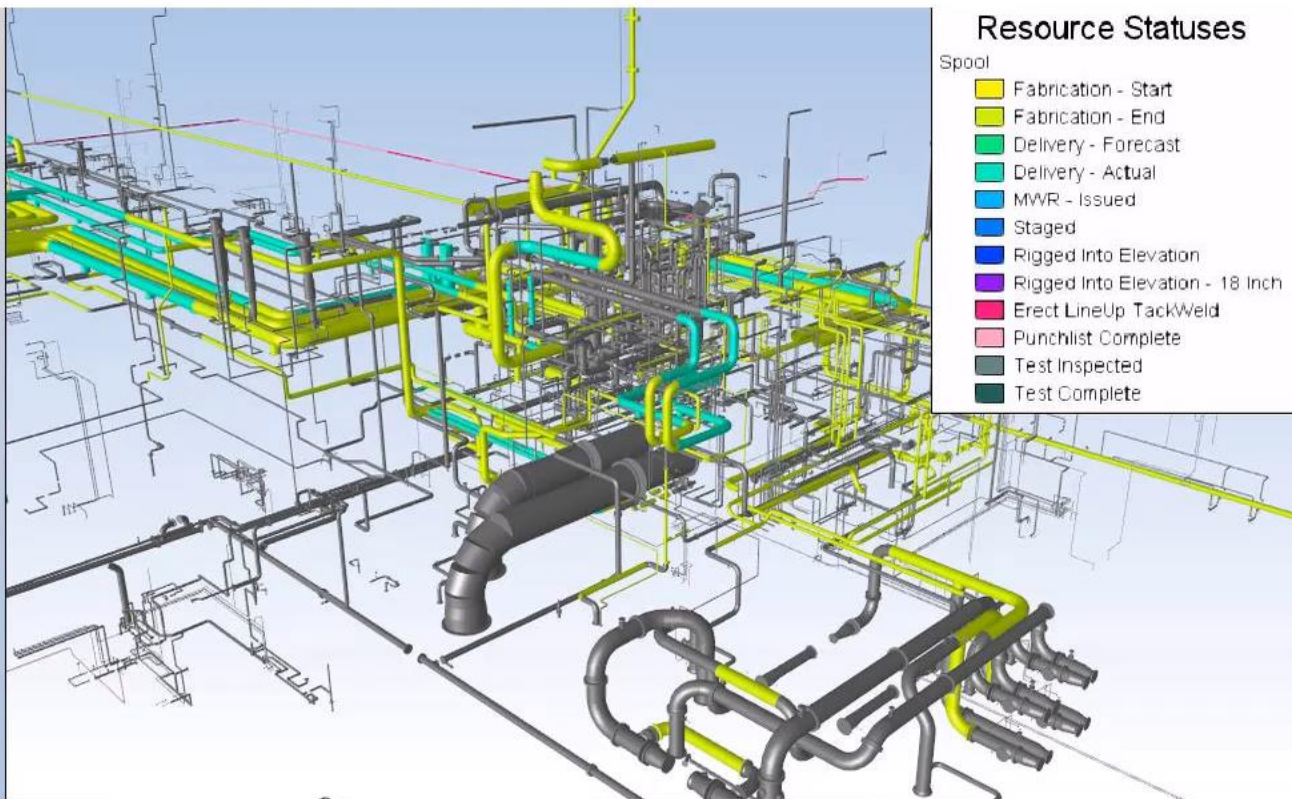
- 3D design models transformed into VR walkthroughs.
- Designer and contractor able to experience designs in first person.
- Improved design engagement with operators & maintainers.
- Great for stakeholder and public engagement.



ID	Name	Duration	Start	Finish	3D Resources	P6 Schedule	Jul 2016				Aug 2016			Sep 2016						
							19th	26th	3rd	10th	17th	24th	31st	7th	14th	21st	28th	4th	11th	
							wk 33	wk 34	wk 35	wk 36	wk 37	wk 38	wk 39	wk 40	wk 41	wk 42	wk 43	wk 44	wk 45	wk 46



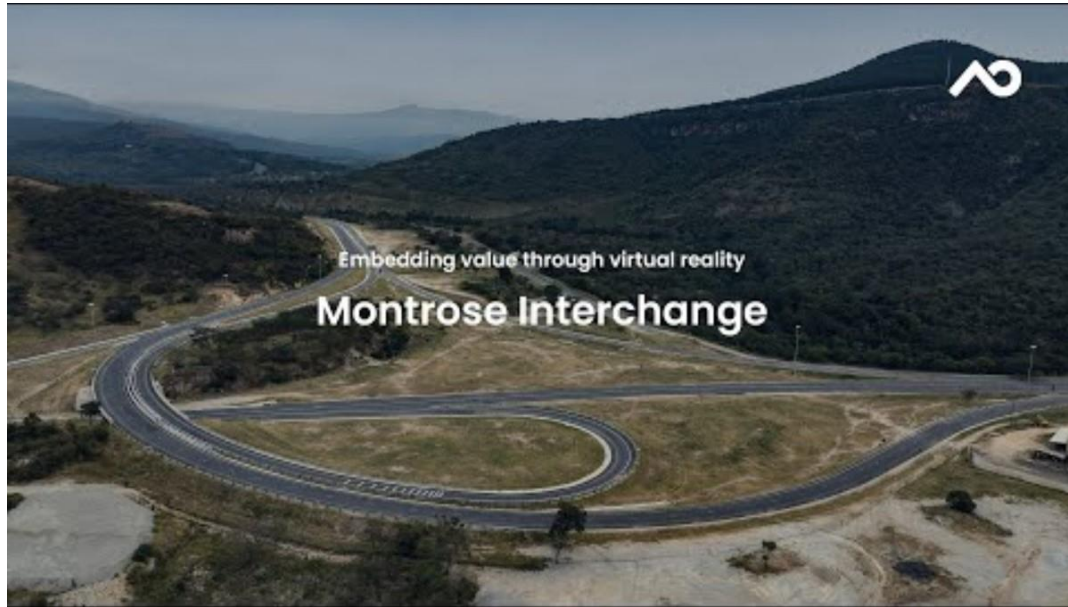
- Appeara...**
- Hanger
 - Instrument
 - Line
 - Specialty
 - Spool
 - Steel
 - Valve
 - Weld



- Resource Statuses**
- Spool
- Fabrication - Start
 - Fabrication - End
 - Delivery - Forecast
 - Delivery - Actual
 - MWR - Issued
 - Staged
 - Rigged Into Elevation
 - Rigged Into Elevation - 18 Inch
 - Erect LineUp TackWeld
 - Punchlist Complete
 - Test Inspected
 - Test Complete

Jan 2015			Jan 2016			Jan 2017			Jan 2018		
Apr	Jul	Oct	Apr	Jul	Oct	Apr	Jul	Oct	Apr	Jul	Oct
wk -31	wk -18	wk -5	wk 9	wk 22	wk 35	wk 48	wk 62	wk 74	wk 87	wk 101	wk 114

7/3/2016
Week: 36



PROJECT FACTS

- ✓ Realignment and upgrade of 600m of existing N4-6y to facilitate new ramp positions.
- ✓ 1800m of new directional ramps to facilitate free-flow movements in all directions.
- ✓ Widening existing 160m Crocodile River bridge from 2-5 lanes.
- ✓ Two new deck-stiffened arch bridges.
- ✓ 100% reduction in stopped delay for vehicles..



SOLUTION

- ✓ Reality Modelling
- ✓ Visualization
- ✓ 4D Planning



Working in a collaborative digital environment saved approximately 2,500 hours and approx. 150,000 USD in design costs.

AEC SECTOR SOFTWARE

CONSTRUCTION – Progress Monitoring



View



Progress as of

← Apr 24, 2023 →

Sheet

TIC3.1 - Level 1

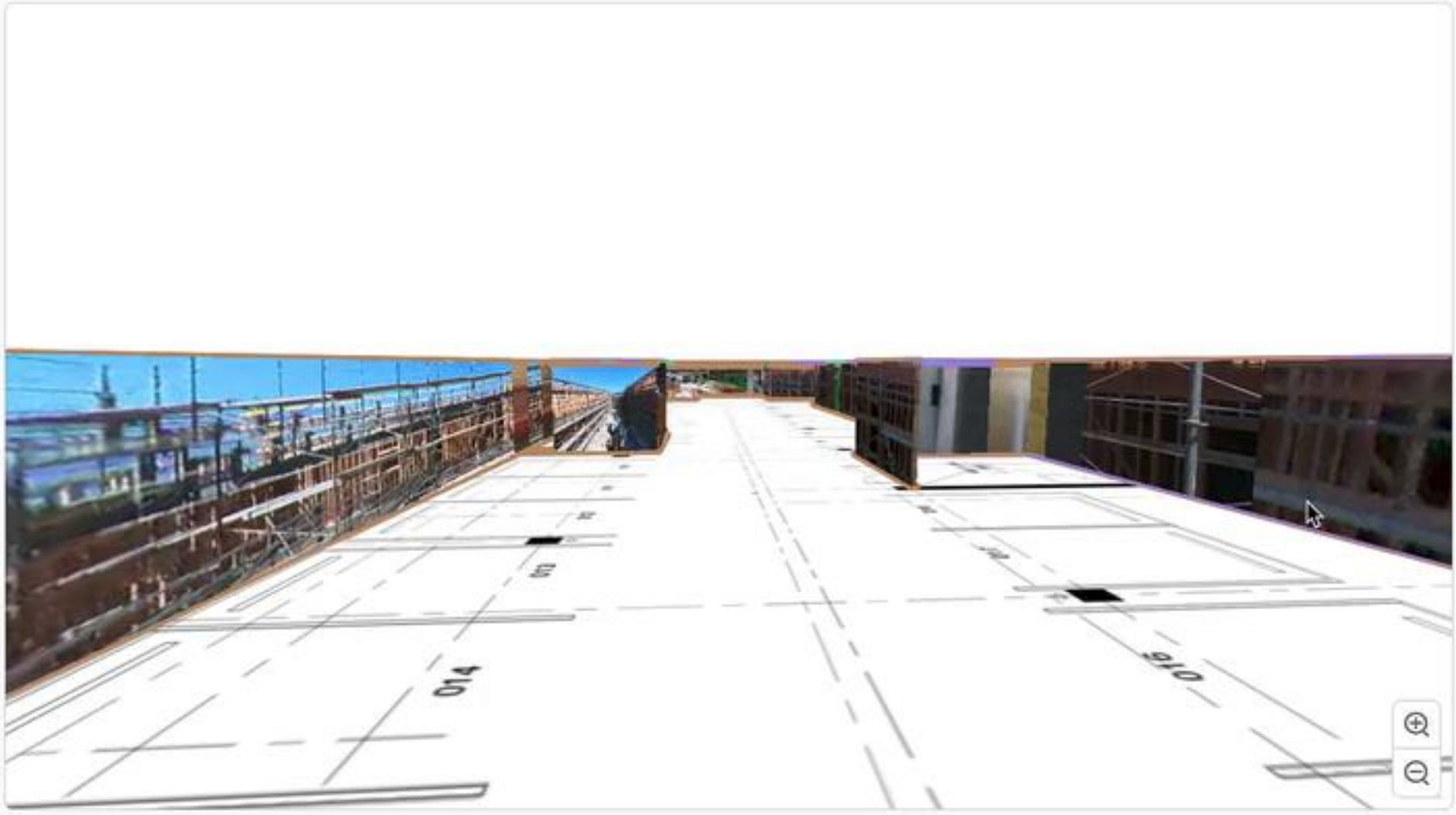
Show capture track

Show Dollhouse

Type

Wall

Export PDF

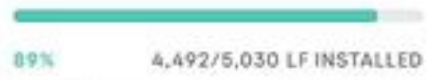


Wall Progress Breakdown

As of Apr 24, 2023

SELECT ALL CLEAR ALL SELECTIONS

Top Track



Show not started

Framing



Show not started

Drywall - Hung



Show not started



AEC SECTOR SOFTWARE

Operations & Maintenance



SCHEMA DE PRINCIPE

BT

HT

JEUMONT-SCHNEIDER

TRANSFORMATEUR

SCHEMA HYDRAULIQUE

OTHER SUCCESS STORIES

Imagine the Possibilities

What are your goals for improving operational efficiency and cost reduction?

↓40%

Reduction in design costs and 80% reduction in design time

Creating a hydraulic model and reviewing innumerable scenarios saved DTK Hydronet Solutions 40 percent in design costs and 80 percent in design time at Bankura, West Bengal, India.

↓22.9%

Reduction in Water Supply Interruptions

Forecasts, alerts, and what-if scenario modeling lowered water supply interruptions by 22.9% at Águas do Porto.

↓20%

Reduction in Pumping Energy Costs

American Water, reduced operating costs by 20% primarily through improved energy efficiency.

Source: AWWA Ace Conference Presentation, Jian Yang Ph.D., P.E., and James Chelius P.E. American Water - Corporate Engineering, Jun 11, 2019

Sabesp, S.Paulo

Problem

- 50% water loss
- Poor service (frequent supply disruptions)

Solution

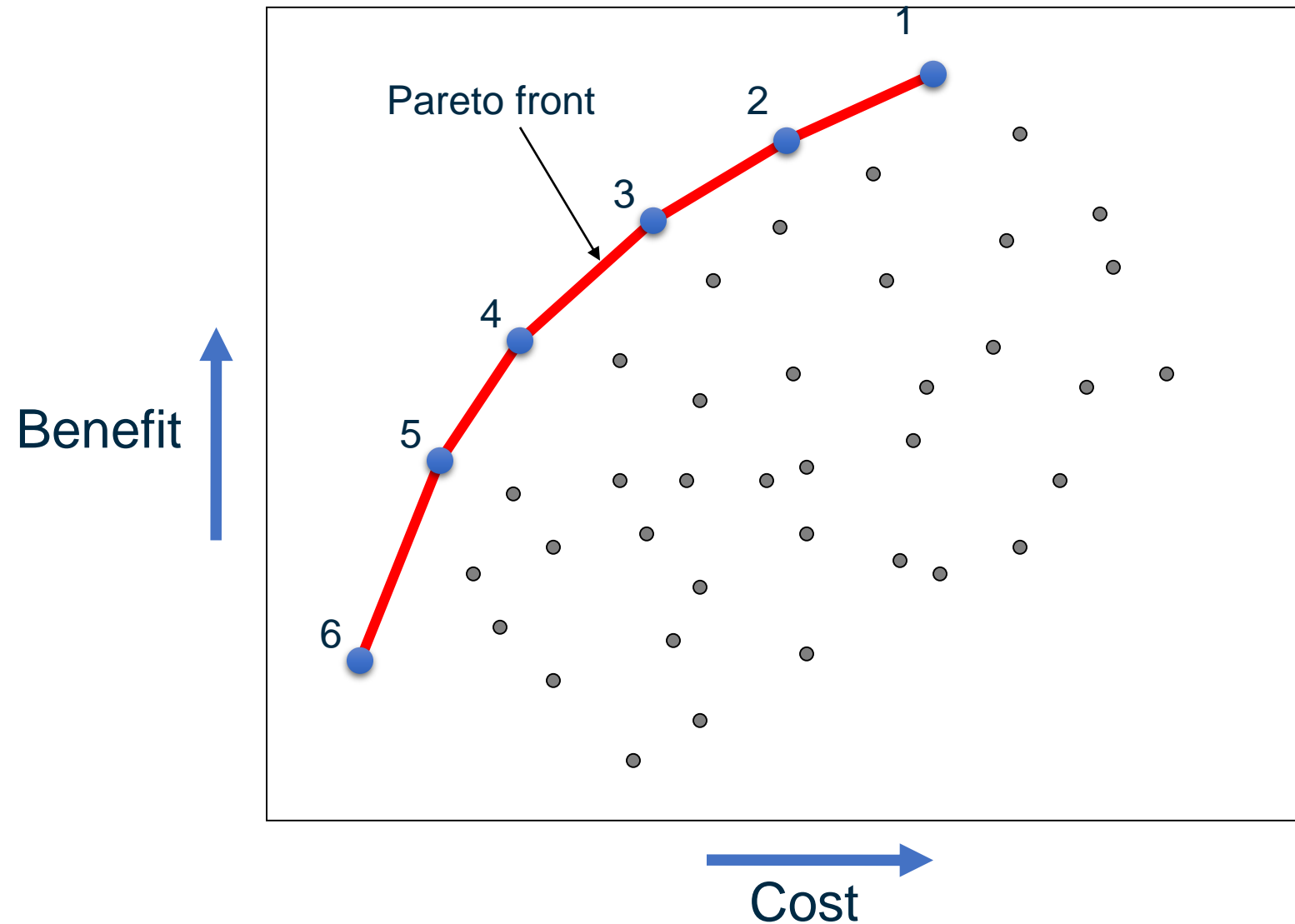
- Pump management
- New Pressure Reduction Valves (PRV) in critical points

Result

- 36.74 % water loss
- **~12.000.000m³ ~3 000 000 USD**
- Improved service

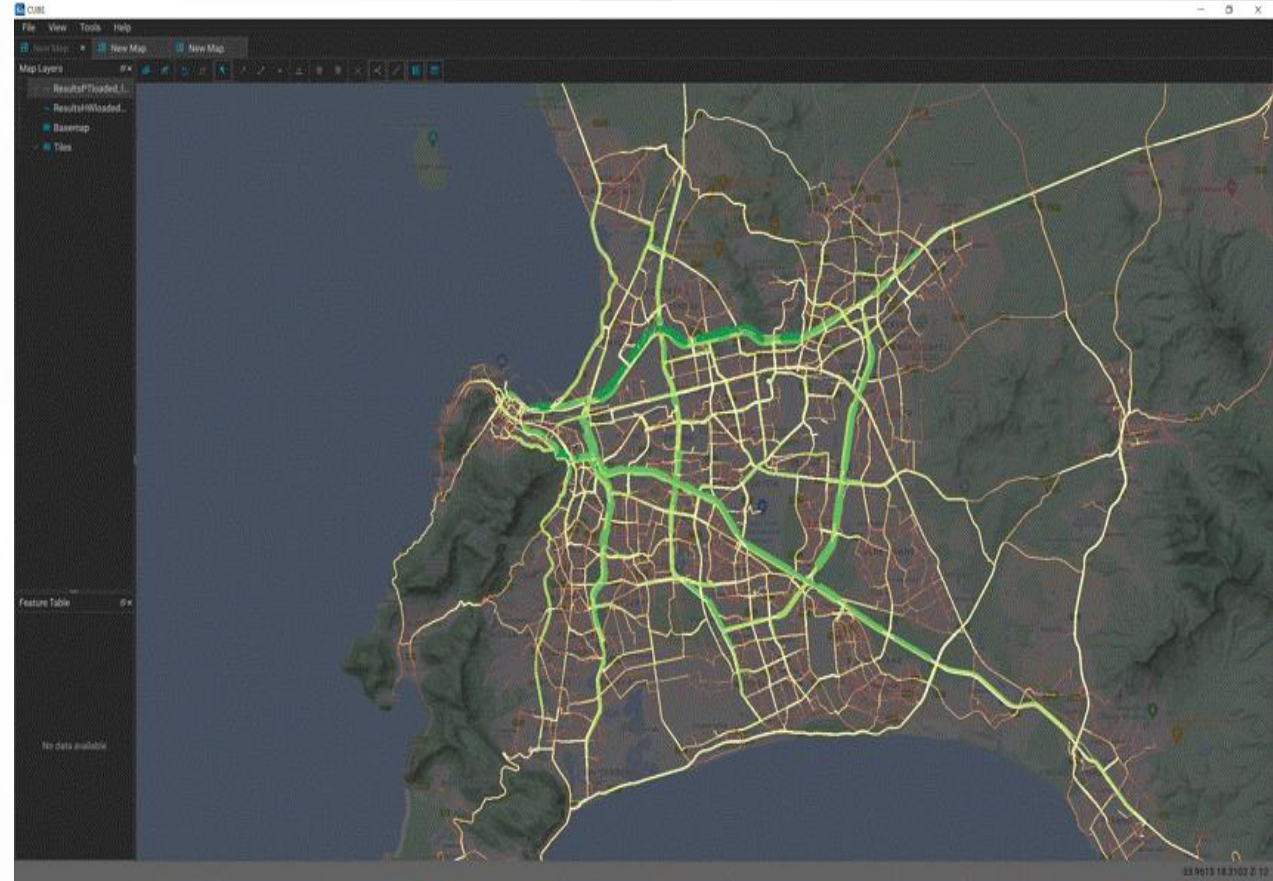
Next Steps

- Efficient Leakage Detection (Darwin Calibrator)
- Extending the modeling experience to the full East Sector



Manual Solution - £4.16M; Optimized Bentley Solution £2.14M

TRAVEL DEMAND MODEL FOR WESTERN CAPE PROVINCE, RSA



CONCLUSION

1. Africa's Infrastructure Challenge

- ✓ 50% of Africa's population lacks access to reliable energy
- ✓ 70% of Africa's rural population lacks access to all-season roads
- ✓ Africa's infrastructure spending as a percentage of GDP is lower than other developing regions
- ✓ Infrastructure deficit requires an annual funding of **\$130–\$170 billion** to achieve SDG 9.

2. The Role of Digitalization

- ✓ Digital transformation of the built environment = construction 4.0
- ✓ **Construction 4.0** enhances project efficiency and resilience to reduce cost **overruns** and **carbon emissions**.

3. Actionable Steps for SDG 9

- ✓ Adopt digital technologies to improve project delivery and sustainability.
- ✓ Avoid “technology fallacy” and consider organizational and market factors.

4. Policy Recommendations

- ✓ Promote policies that encourage construction 4.0
- ✓ BIM mandate on projects above a minimum threshold

Start a Conversation About Your Journey to Digital Integration



Scan to contact
us



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