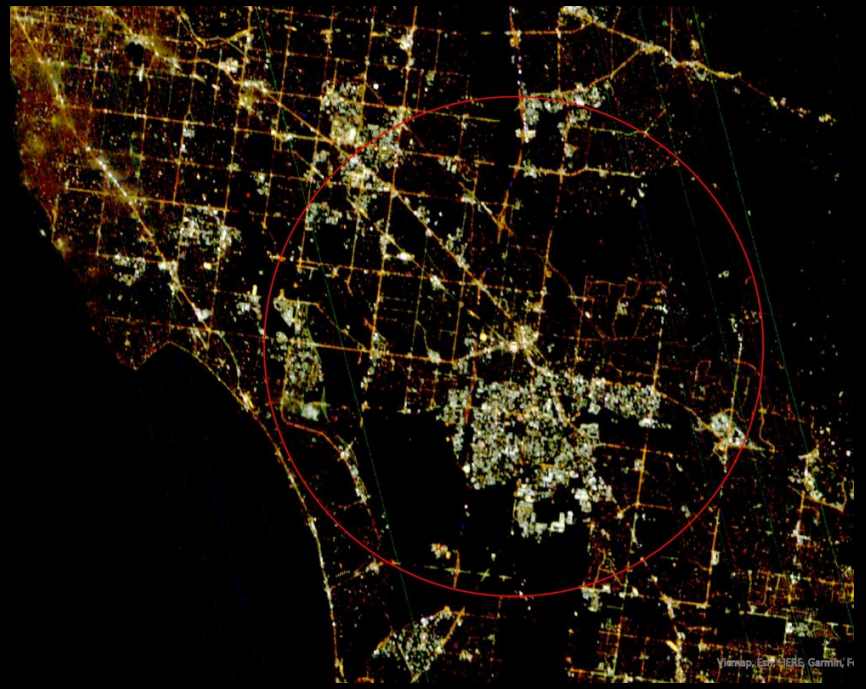
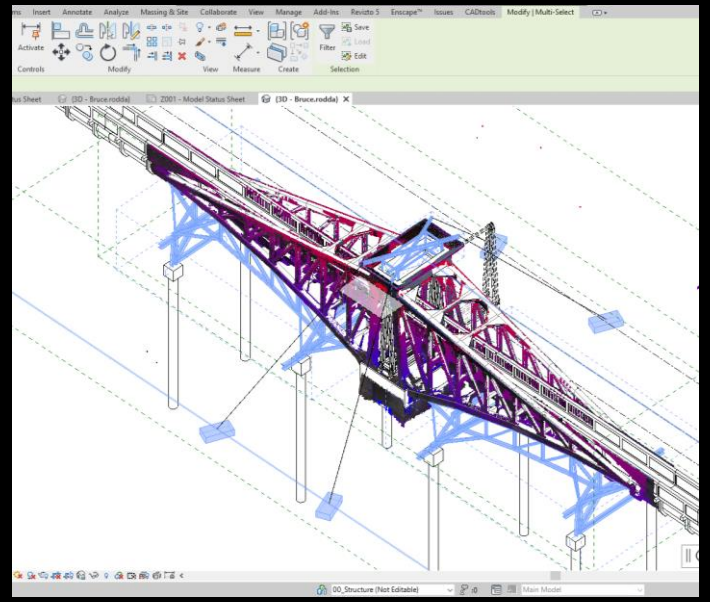
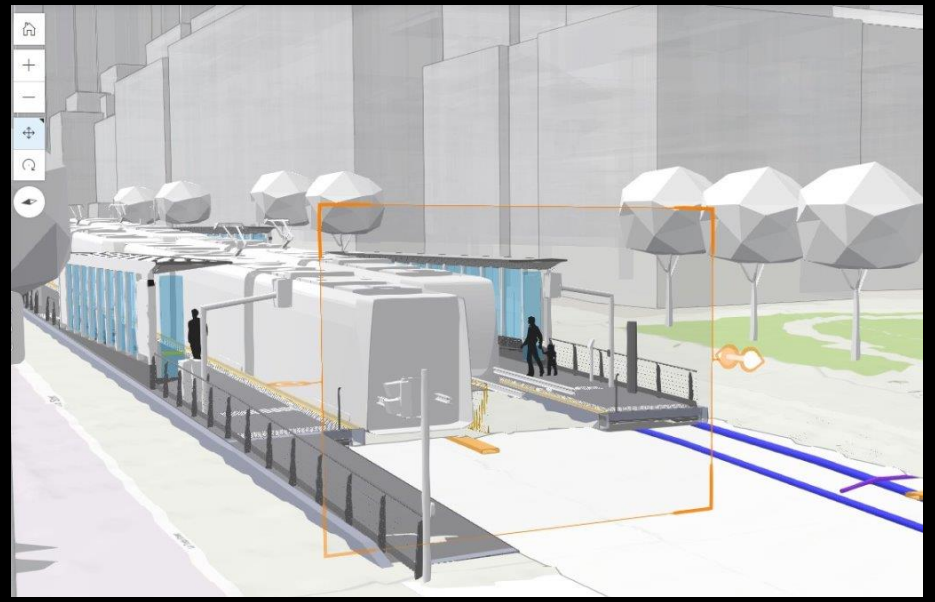
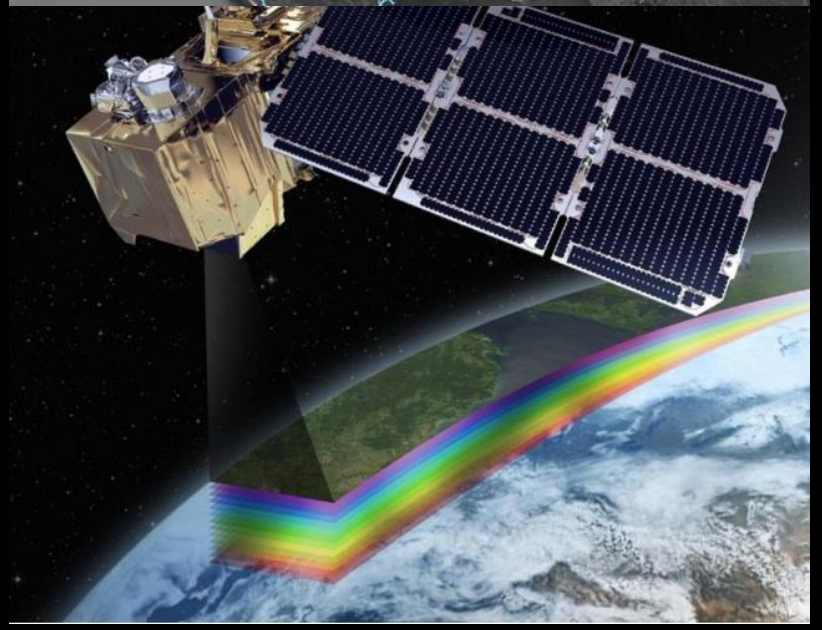
Ensuring data quality & relevance in a data-rich environment

Serryn Eagleson



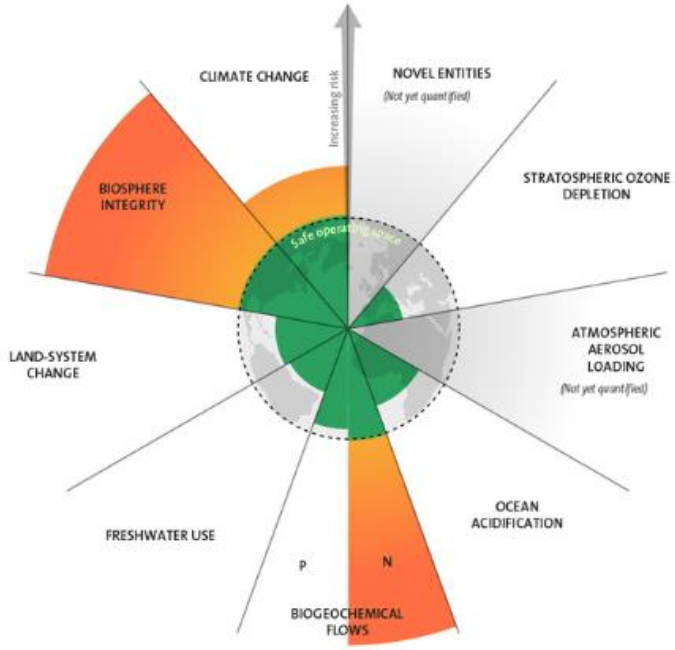






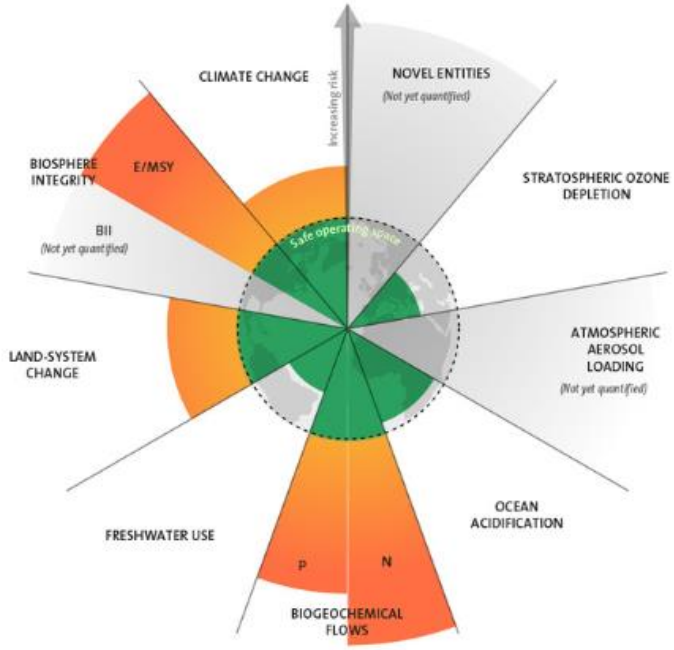
ARUP

2009



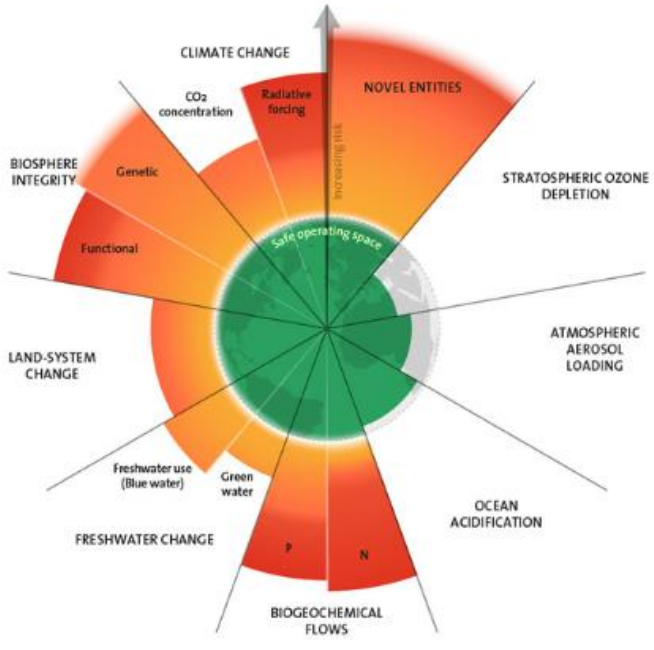
7 boundaries assessed,
3 crossed

2015



7 boundaries assessed,
4 crossed

2023



9 boundaries assessed,
6 crossed

Credit: Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009

ARUP

Opportunities for data in the asset life

Strategic Planning

- ✓ Business Cases
- ✓ Whole Life Costing
- ✓ Data & Visualisation

Design/ Construction

- ✓ Optimisation of Design
- ✓ Carbon tracking
- ✓ Increased team coordination
- ✓ Fast track design program with early fabrication and manufacture input (DfMA)

Operational Planning

- ✓ Accurate representation of the asset
- ✓ Scenario testing
- ✓ Resource optimisation and planning of staff
- ✓ Increased efficiency of handover into live operations

Operations

- ✓ Twin of twins
- ✓ Right time monitoring and Integrated feedback loop
- ✓ Increased efficiency of operational processes
- ✓ Enhanced engagement and experience

Legacy / Maintenance

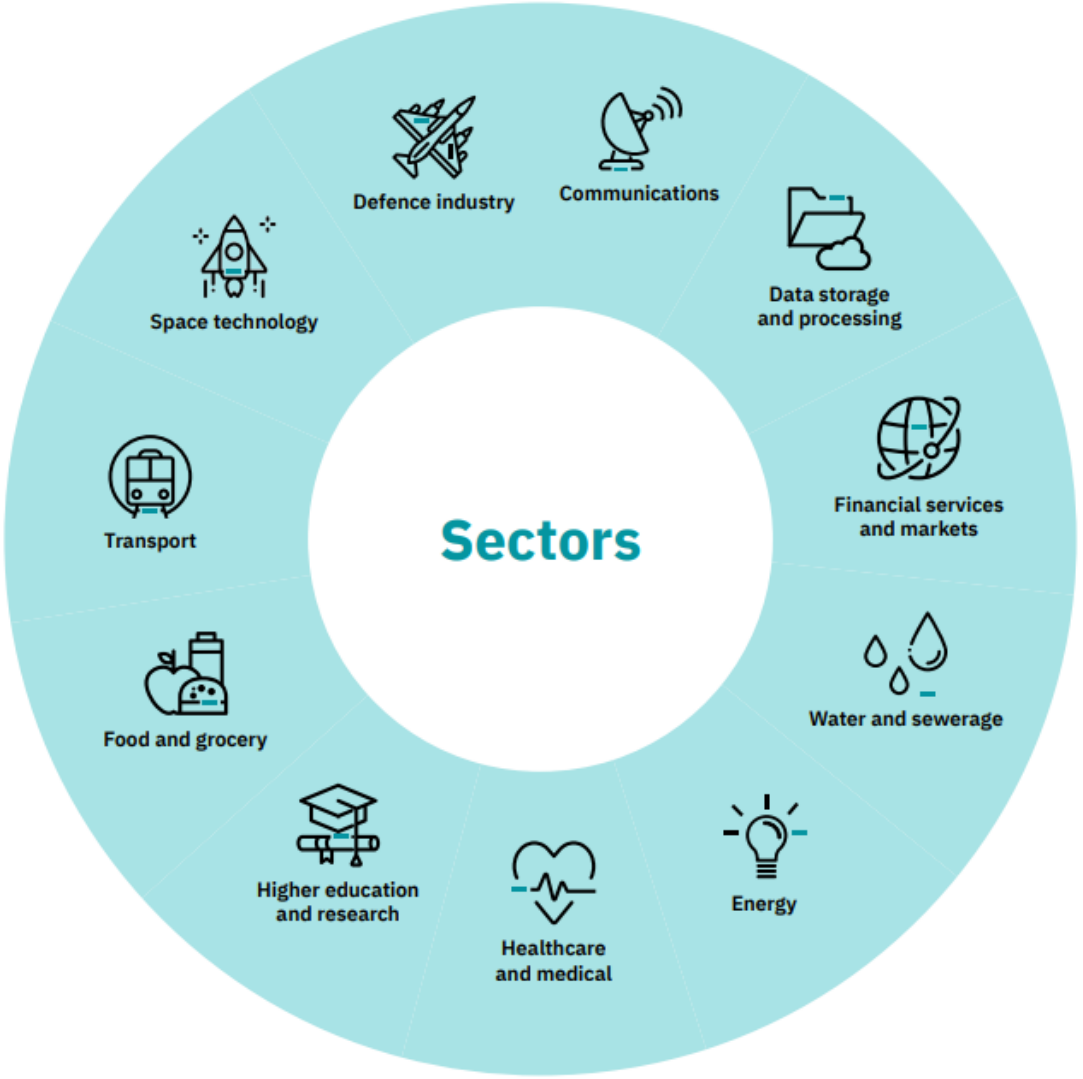
- ✓ Increase in asset performance
- ✓ Automated status collection
- ✓ Real-time condition monitoring and preventative and predictive maintenance
- ✓ More accurate and efficient planning of future renewals and enhancements

Legislation

In Australia, the

Security of Critical Infrastructure Act 2018 (SOCI) now requires private asset owners that are defined as critical infrastructure to minimise or eliminate a material risk, and mitigate the impact, of natural hazards on the critical infrastructure.

Mandatory climate-related financial disclosures, providing Australians and investors with greater transparency and more comparable information about an entity exposure to climate-related financial risks and opportunities and climate-related plans and strategies. *(*Mandatory climate-related financial disclosures - Policy position statement)

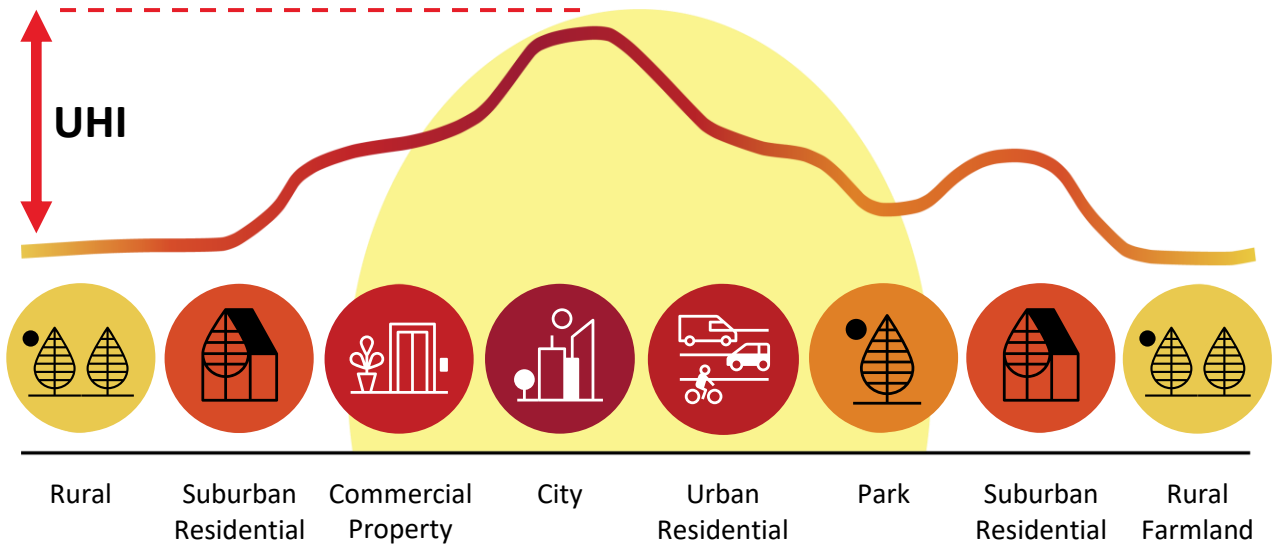


SOCI Act sectors and asset classes

ARUP

Urban Heat Island (UHI) Effect

Contributing factors



Building geometry

- ✓ Height to area ratio of buildings
- ✓ Building density
- ✓ Sky view factor

Building fabric

- ✓ Albedo distribution
- ✓ Impervious surface area
- ✓ Thermal mass

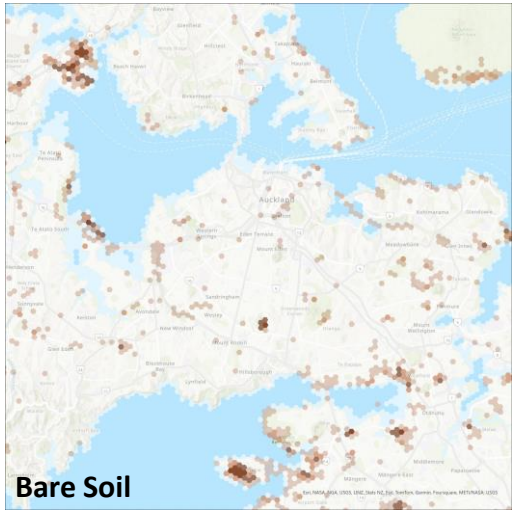
Anthropogenic heat

- ✓ From buildings
- ✓ From people
- ✓ From transport

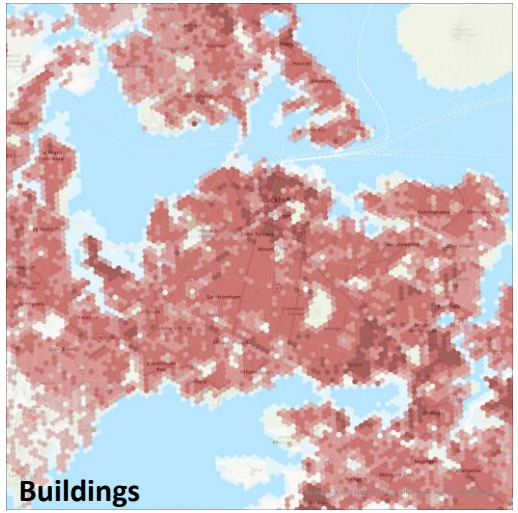
Surface Cover

- ✓ Tree cover
- ✓ Percentage Green space
- ✓ Impervious surface area

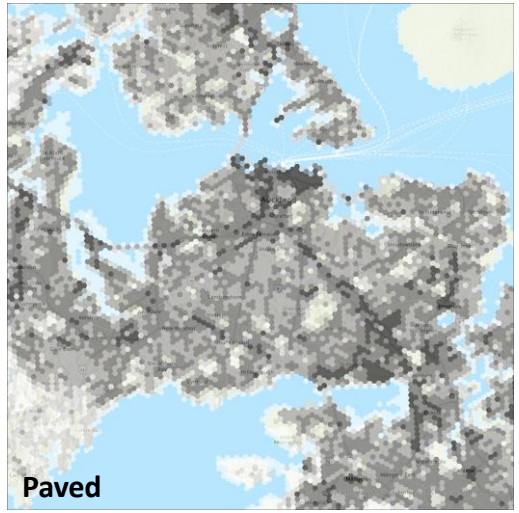
Land cover classification – urban area



Fraction of Base Soil
0.00 - 0.03
0.04 - 0.13
0.14 - 0.28
0.29 - 0.53
0.54 - 1.00



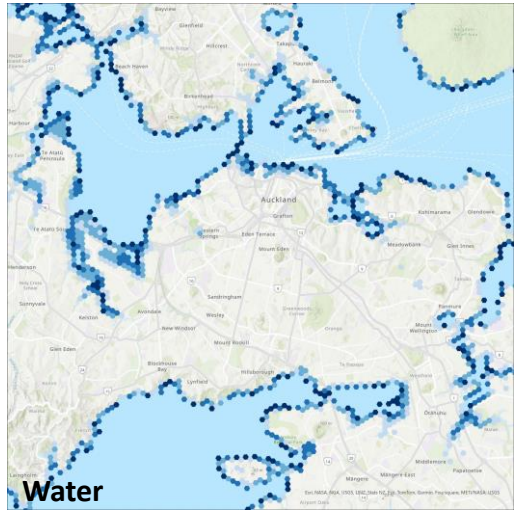
Fraction of Buildings
0.00 - 0.03
0.04 - 0.11
0.12 - 0.20
0.21 - 0.34
0.35 - 0.84



Fraction of Paved
0.00 - 0.06
0.07 - 0.19
0.20 - 0.33
0.34 - 0.49
0.50 - 0.99

Fraction of Grass
0.00 - 0.14
0.15 - 0.35
0.36 - 0.57
0.58 - 0.80
0.81 - 1.00

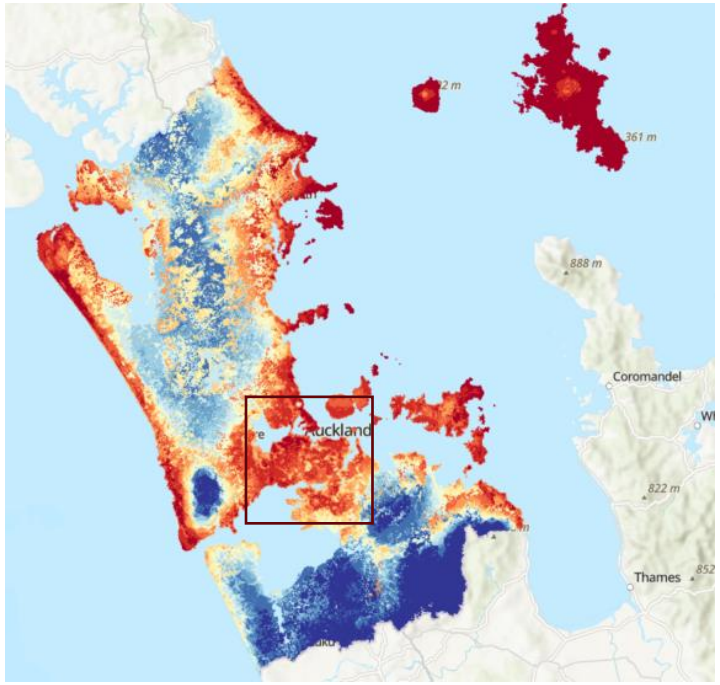
Fraction of Trees
0.00 - 0.10
0.11 - 0.29
0.30 - 0.54
0.55 - 0.80
0.81 - 1.00



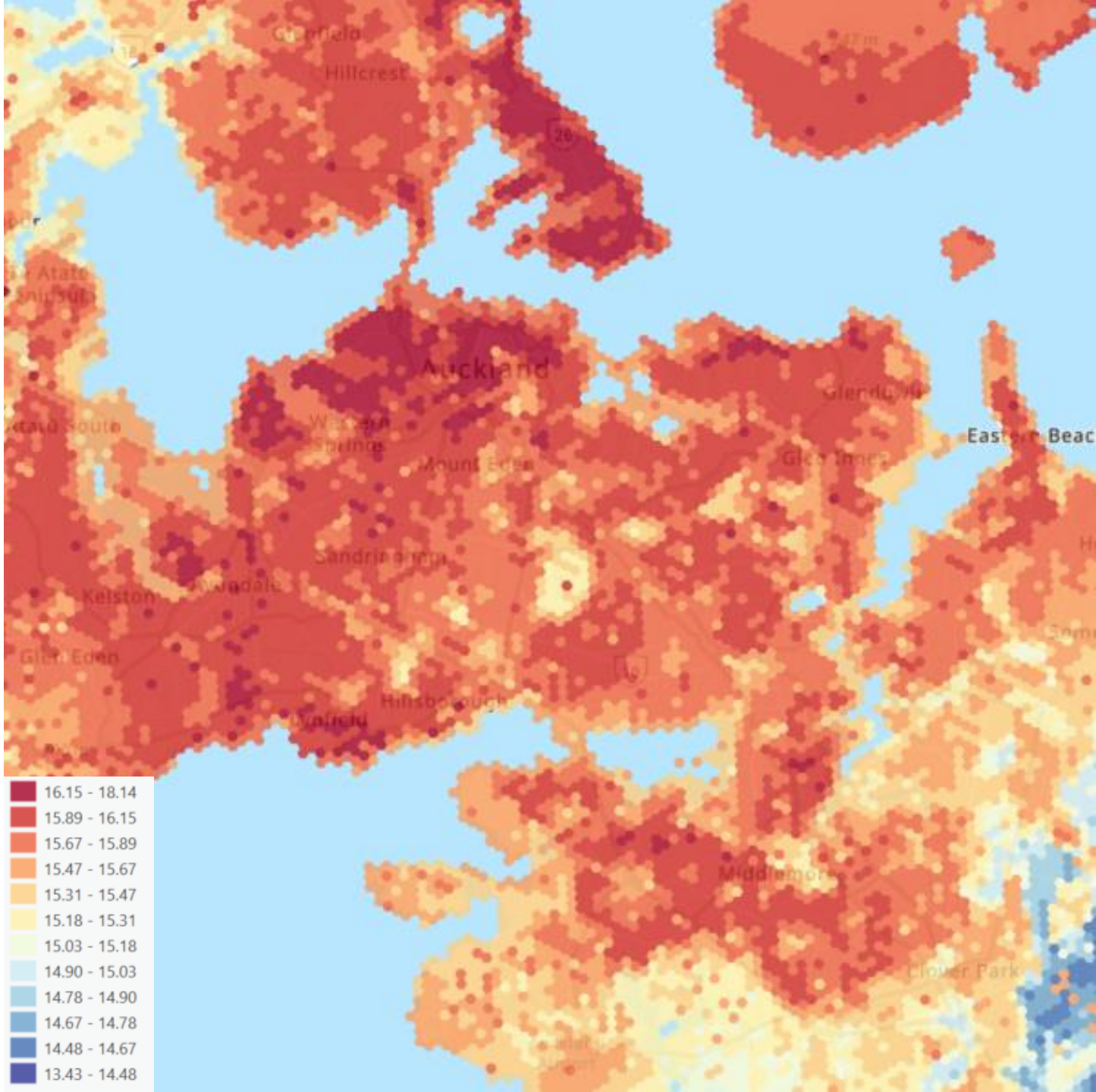
Fraction of Water
0.00 - 0.11
0.12 - 0.34
0.35 - 0.62
0.63 - 0.88
0.89 - 1.00

Further information - Auckland Urban Heat Assessment - Arup

Aggregated Results Daily Minimum Temperatures

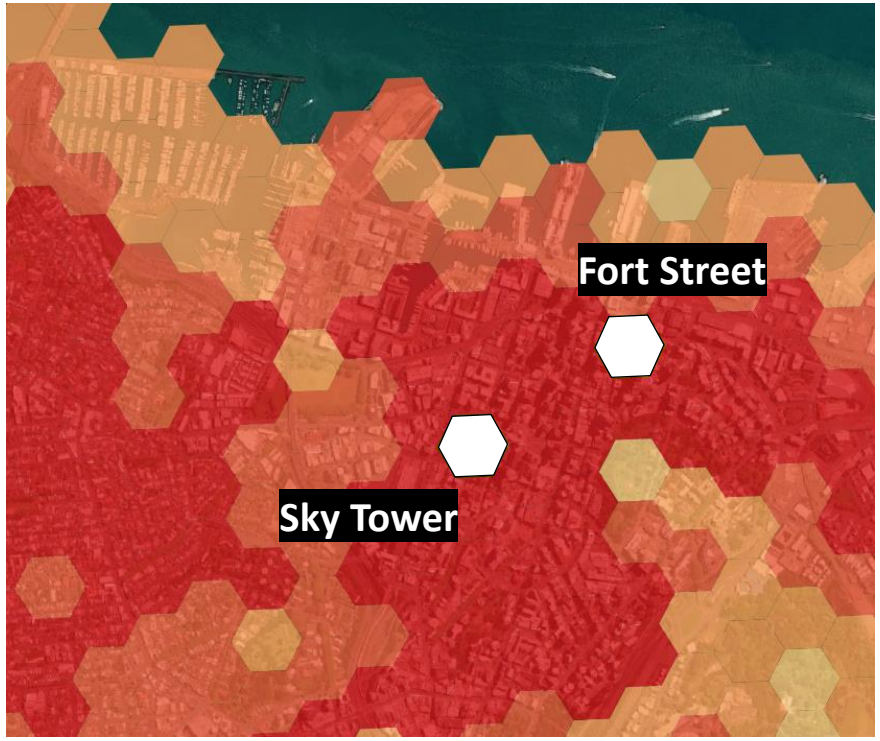


Plots of the daily minimum temperatures for five-month period (Nov 2021-March 2022)

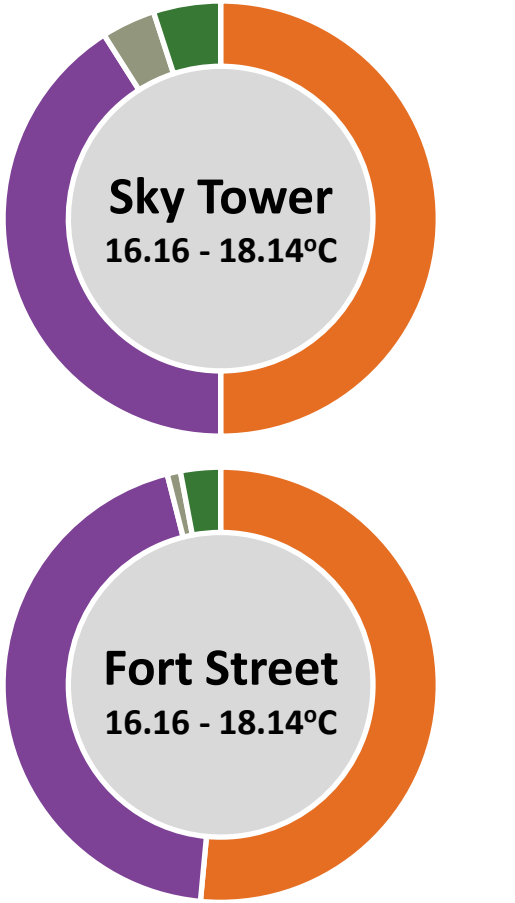


Land cover and temperature

Urban sample



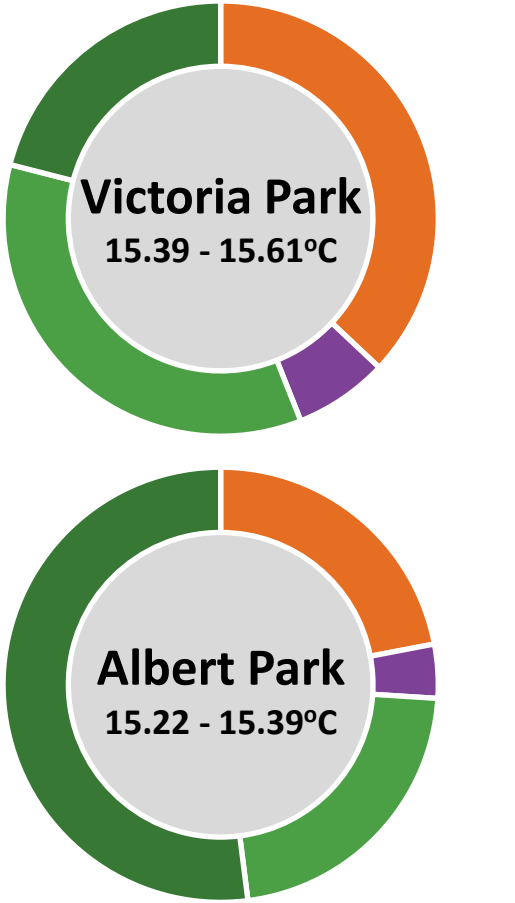
Aggregated Mean Daily Minimum Temperature



Land cover and temperature

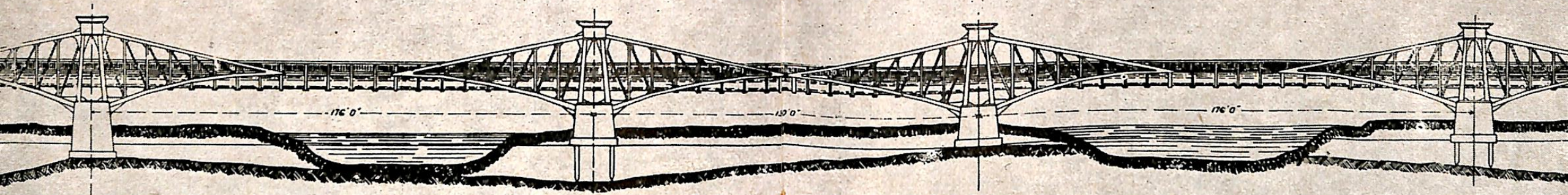
Green space sample

Aggregated Mean Daily Minimum Temperature



OVOID SEWER AQUEDUCT

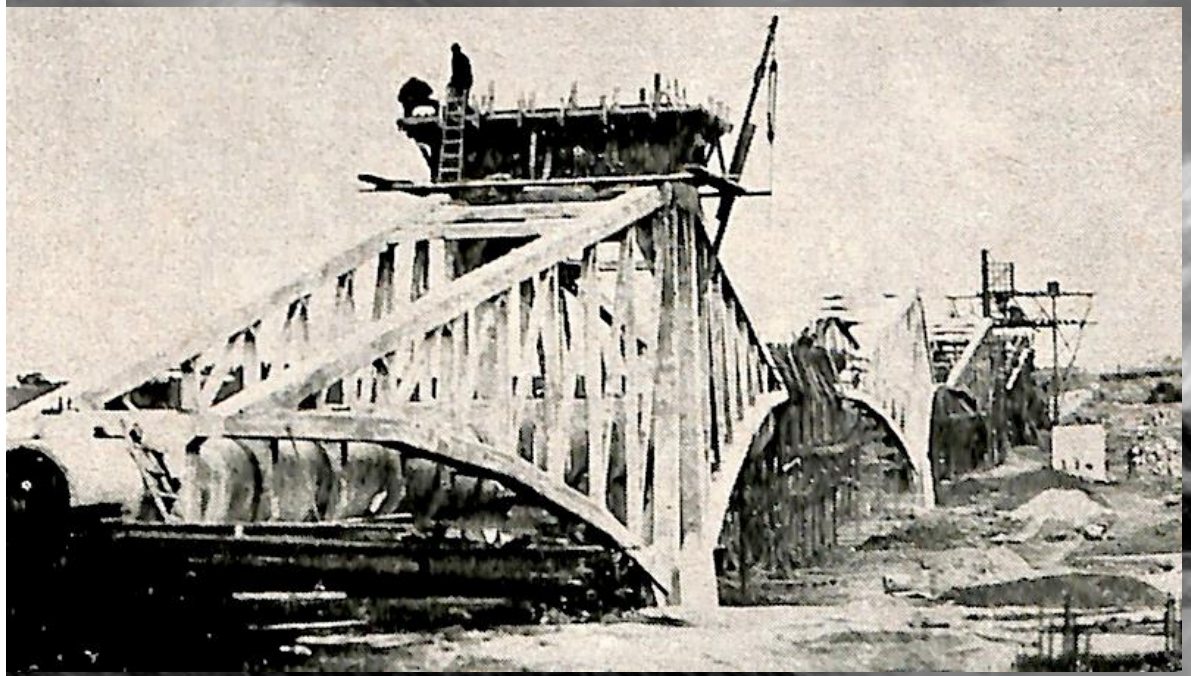
ELEVATION

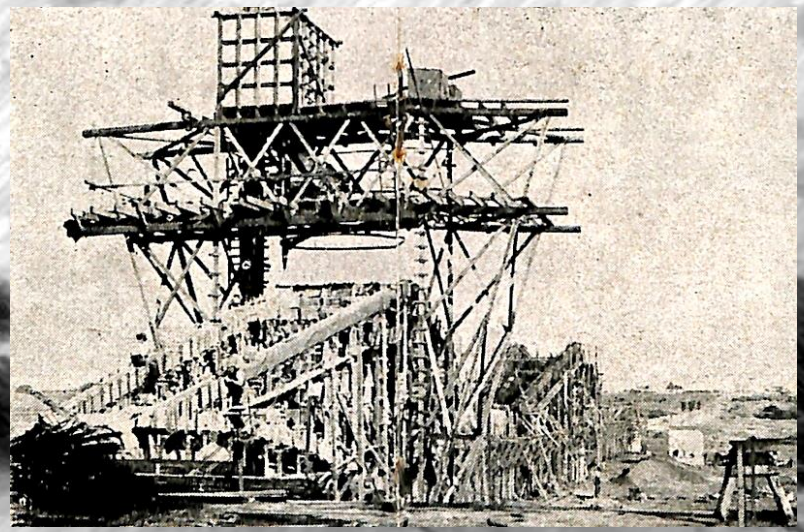


Geelong Waterworks and Sewerage Trust.

REINFORCED CONCRETE AQUEDUCT ACROSS THE BARWON VALLEY

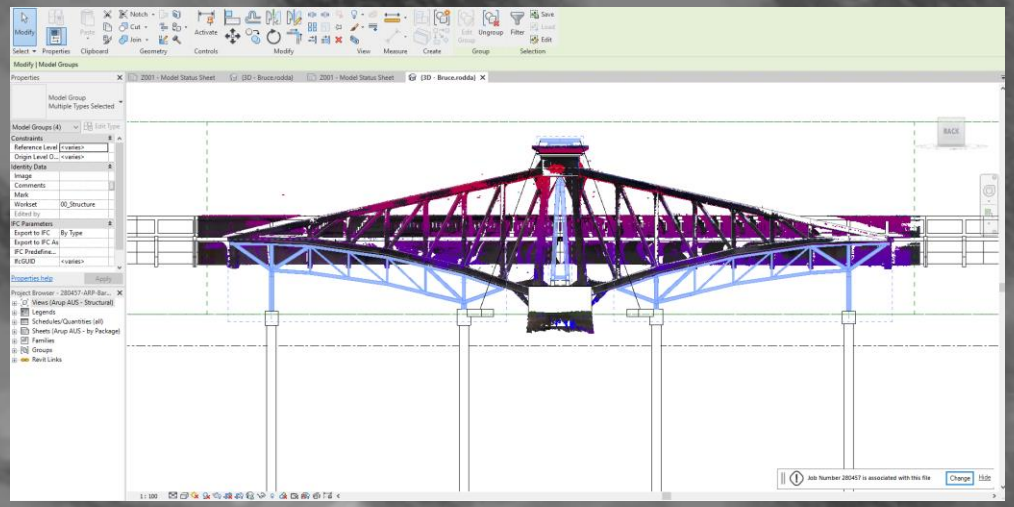
14 Spans—Total Length 2400 ft.

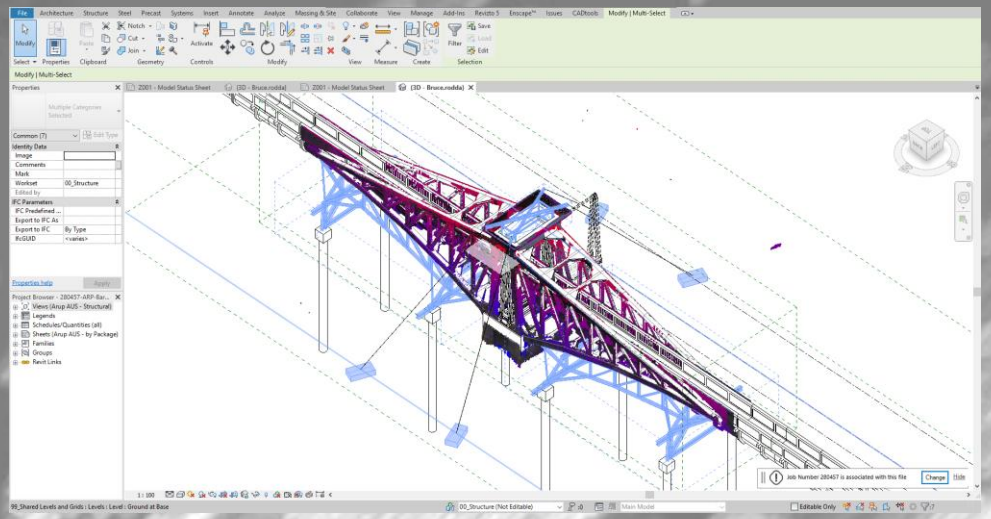


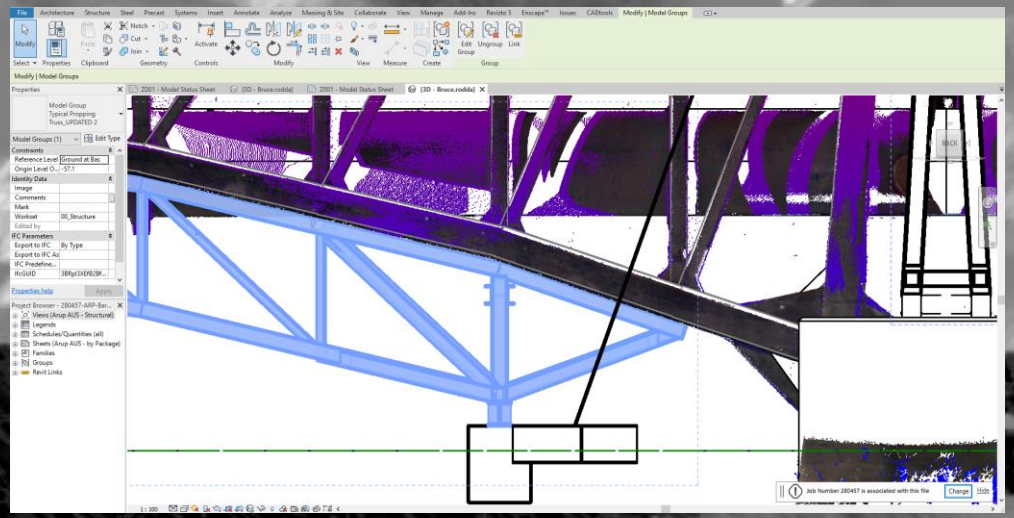


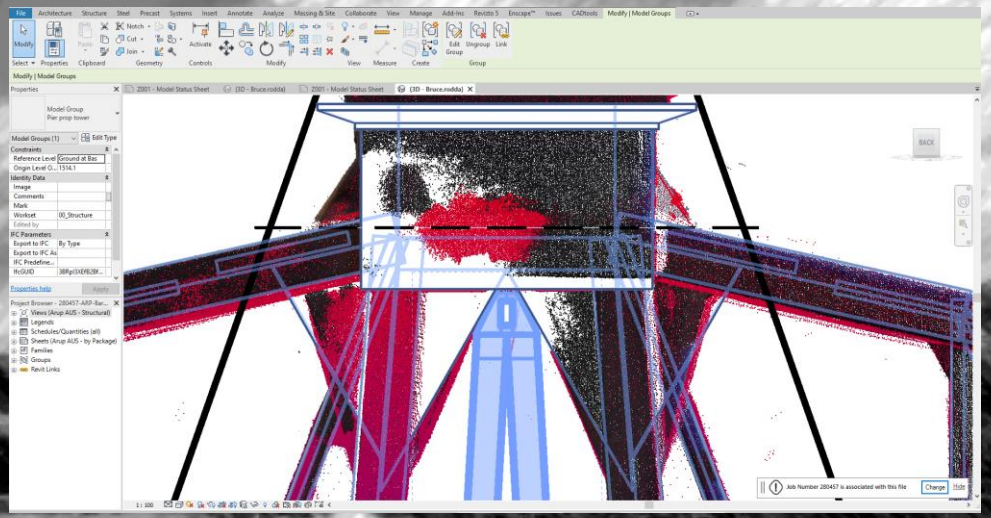
app.pointerra.io/pointclouds/23au074-barwon-aqueduct/?guest_token=pc_cnwGPo7vdwry7MZcpiSzeQ
DATASETS
Point cloud
Base map/Terrain
Barwon Aqueduct...
Barwon Aqueduct...
Barwon Aque...
Barwon Aque...
BOOKMARKS
+ Bookmark the current view
POINTS OF INTEREST [6]
CLASSIFICATIONS

[3d model] E: 269910.686m N: 5769489.330m H: 4.381m FoV: 60°







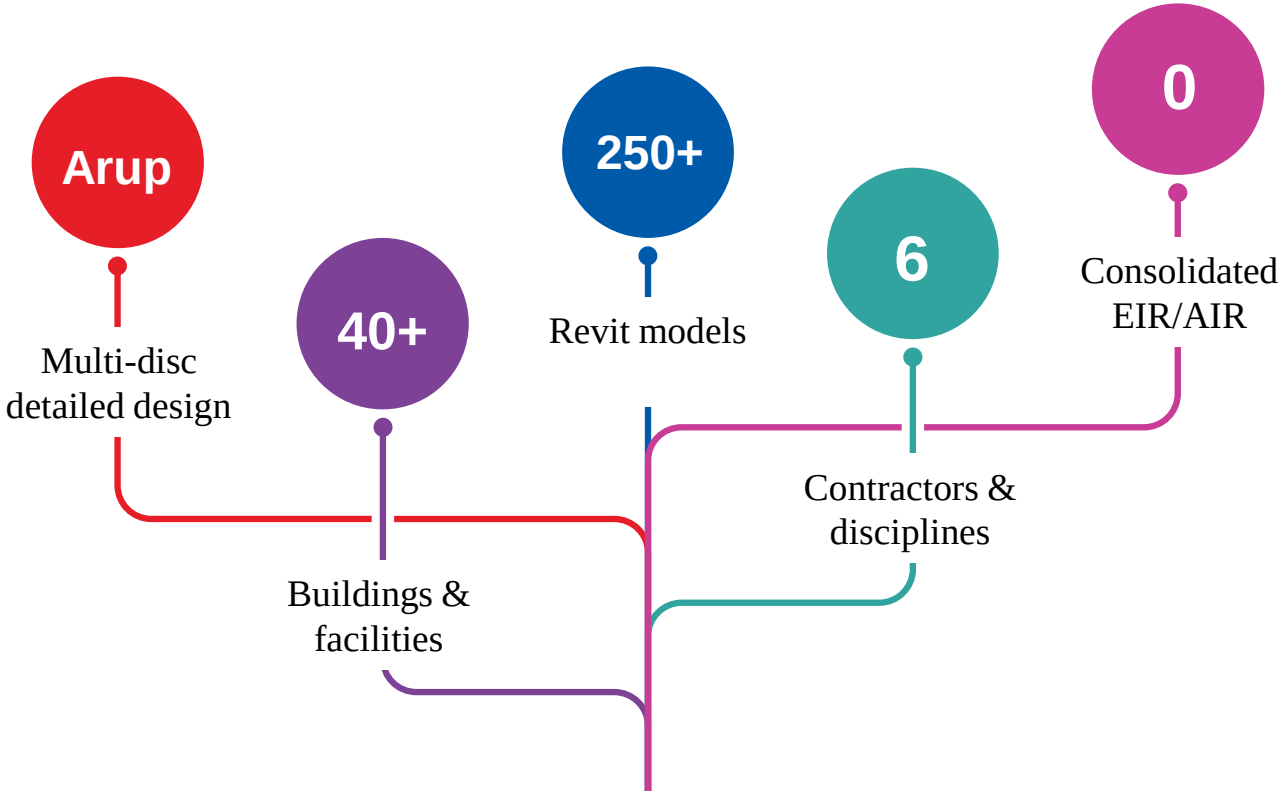


Using automation, AI and BIM for consistent asset information delivery

A new precinct – size major government project in Australia

ARUP

Project Background



BIM data validation and rectification

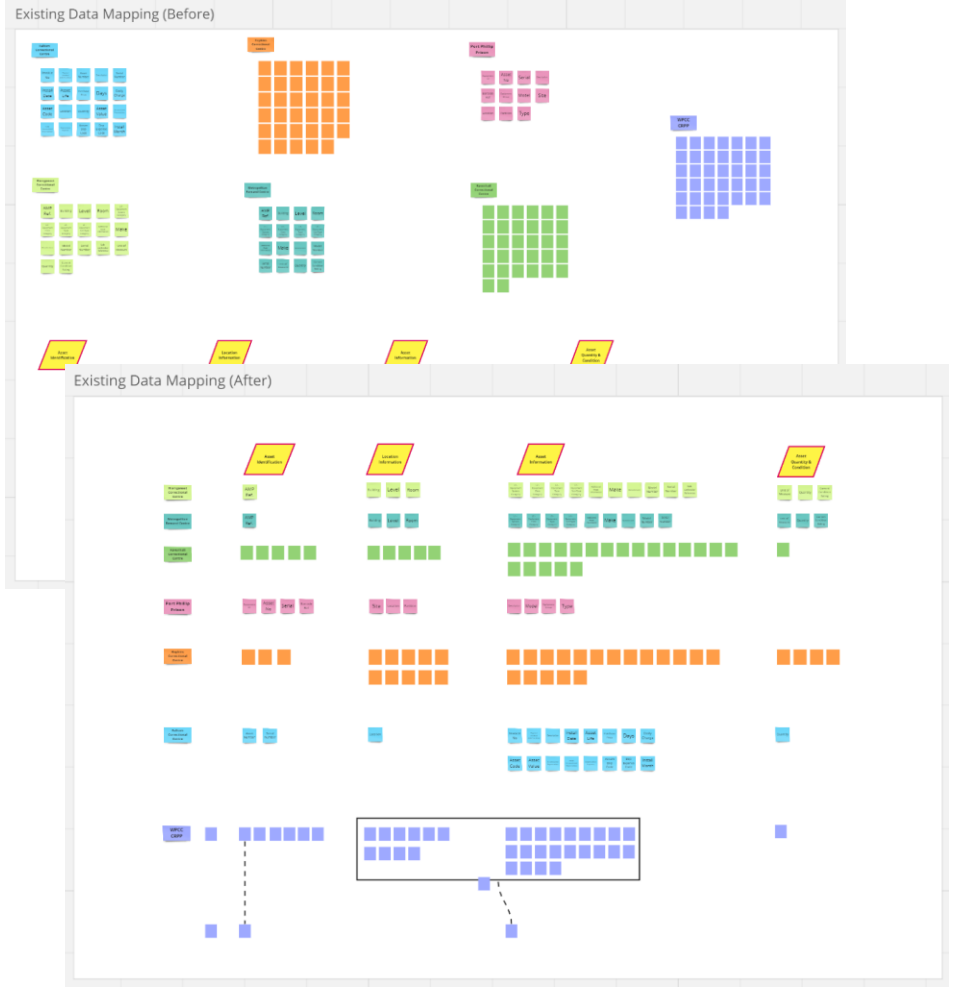
Stakeholder engagement and requirements gathering

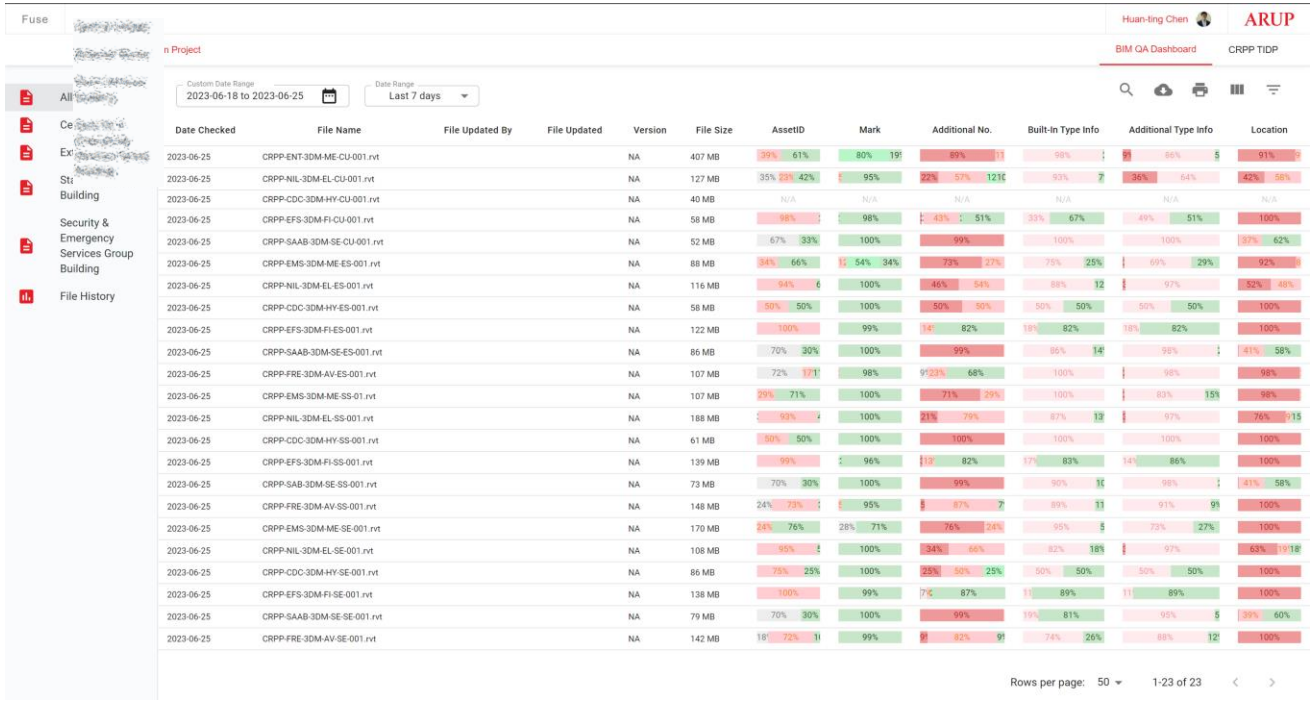
BIM data migration and handover

Closing the data gap and identifying missing pieces

ARUP

Initial data discovery among 7 asset registers and 500+ IFC & Revit models





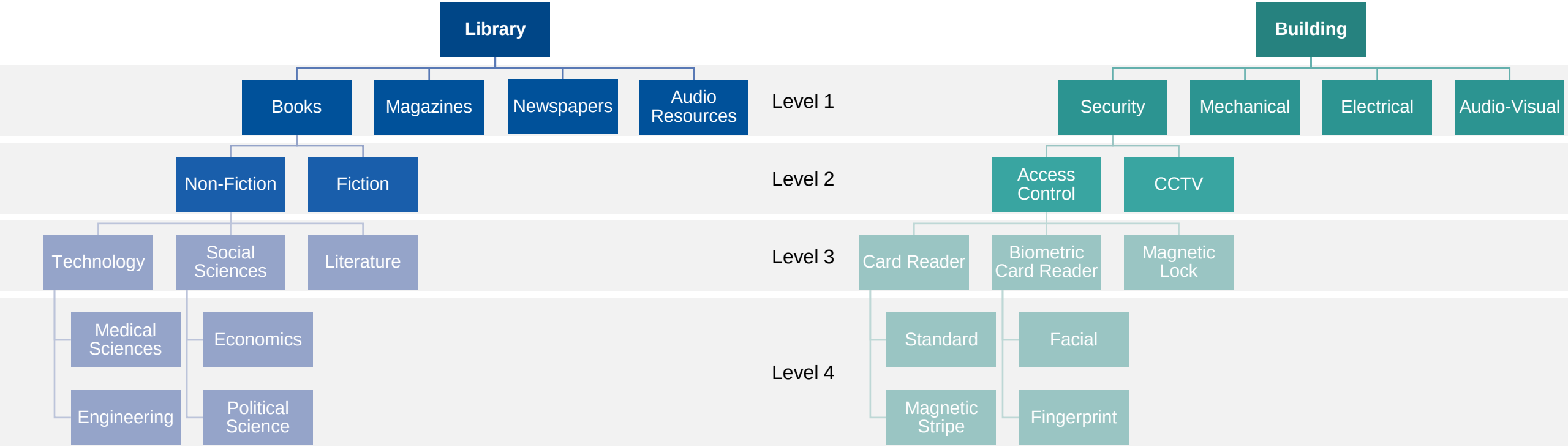
100+ parameters
analysed and consolidated into 6 categories.

20 rules
defined and applied for data quality checking.

Asset Data and Classification

ARUP

Analogy



Book Metadata

- **ISBN - International Standard Book Number (ISBN)** - a national and international standard identification number for uniquely identifying books
- **Author**
- **Publication date**

Asset Information

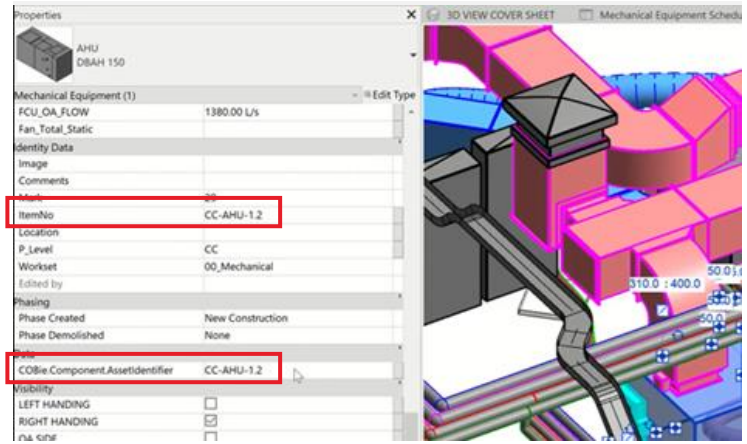
- **Asset ID**
- **Size (length, width, diameter)**
- **Material**
- **Air flow**
- **Concrete strength**

Rectifying BIM model content in alignment with a new asset data schema

ARUP

Application of industry standards

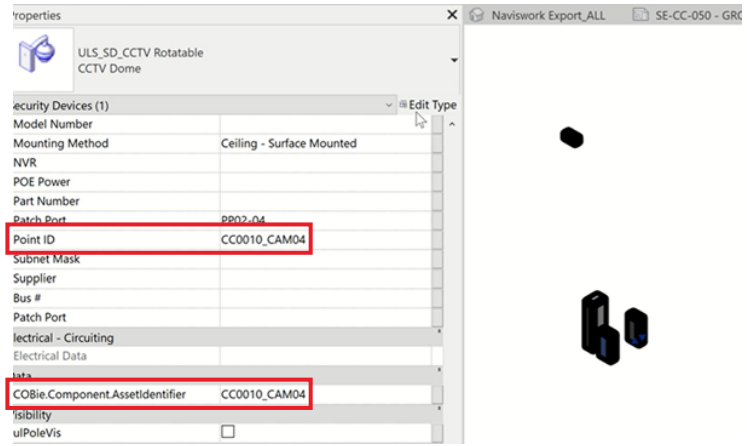
Asset ID mapping



COBie

ItemNo

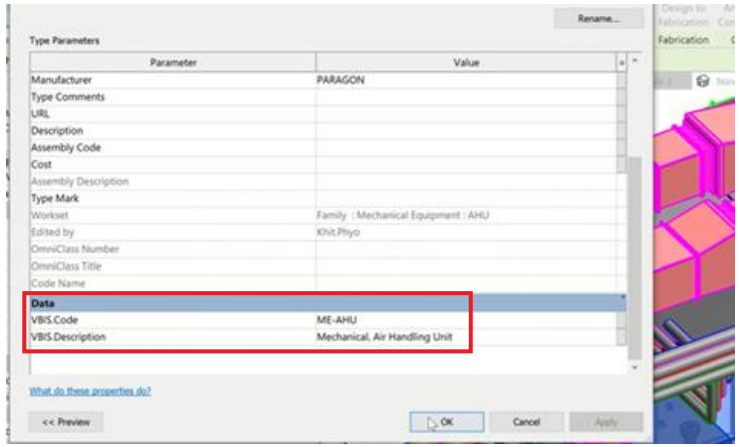
➔ **COBie.Component.AssetIdentifier**



Point ID

➔**COBie.Component.AssetIdentifier**

Asset classification



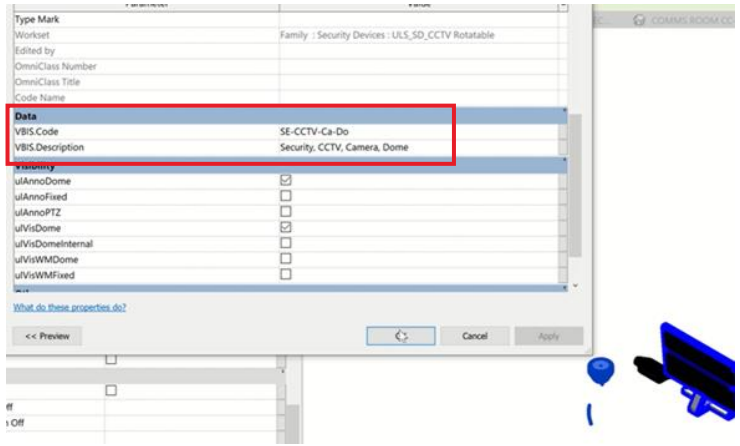
VBIS
VIRTUAL BUILDINGS INFORMATION SYSTEM

VBIS.Code

ME-AHU

VBIS. Description

Mechanical, Air Handling Unit



VBIS.Code

SE-CCTV-Ca-Do

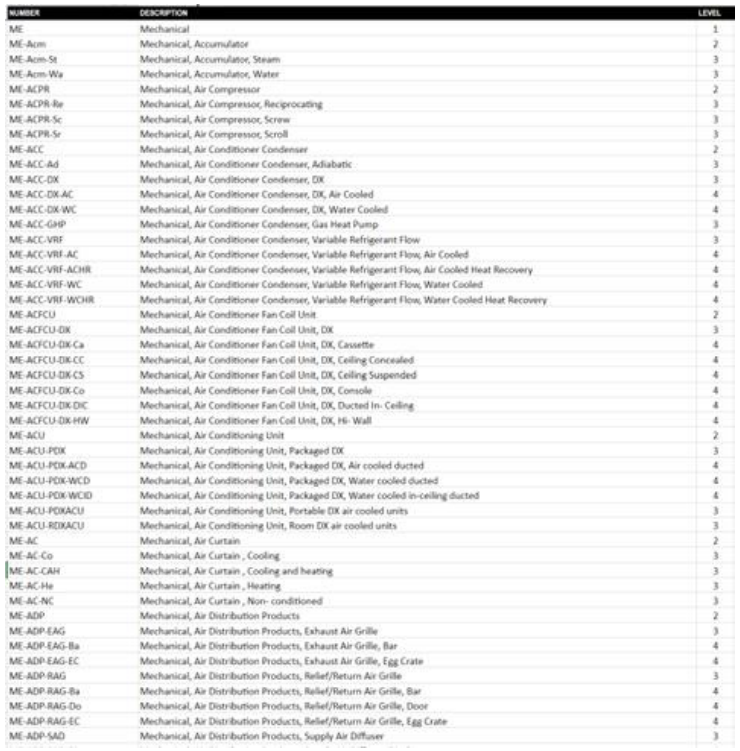
VBIS. Description

Security, CCTV, Camera, Dome

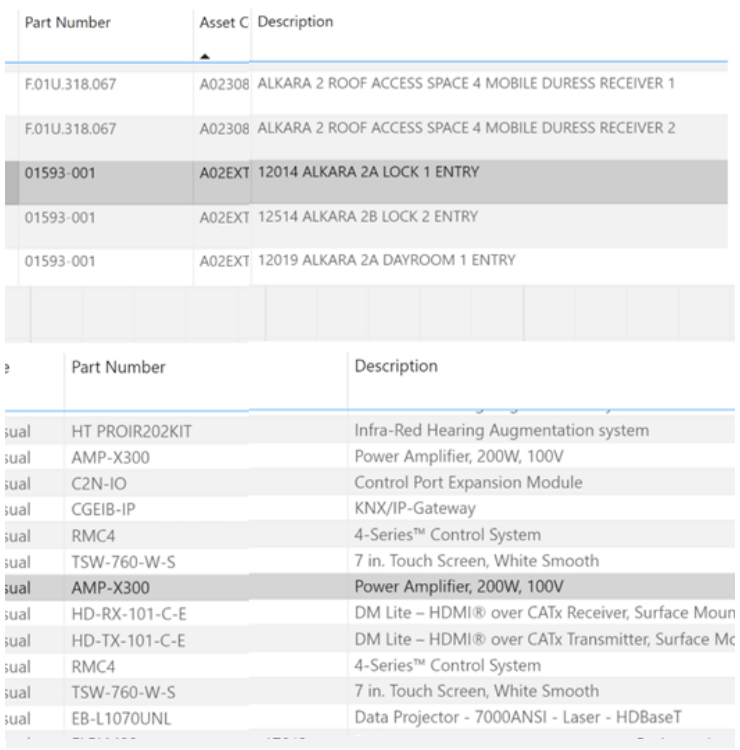
But facing a huge challenge in how complicated and intensive the VBIS data standard is

ARUP

Product	Sub-Type	Sub-Sub-Type	VBIS Tag	REV DATE
	Conductor Cables		EP-LP-CC	Apr-20
	Ground Rods		EP-LP-GR	Apr-20
Load Bank			EP-LB	Apr-20
	Connection Cabling		EP-LB-CC	Apr-20
	Fixed		EP-LB-Fi	Apr-20
	Portable		EP-LB-Po	Apr-20
Meters			EP-Me	Apr-20
	Ammeter		EP-Me-Am	Apr-20
	Authority		EP-Me-Au	Apr-20
	Embedded Network Meter		EP-Me-ENM	Apr-20
	Multi Function Meter		EP-Me-MFM	Apr-20
	Power		EP-Me-Po	Apr-20
	Voltmeter		EP-Me-Vo	Apr-20
Power Converter			EP-PC	Apr-20
Power Factor Correction			EP-PFC	Apr-20
	Active		EP-PFC-Ac	Apr-20
	Passive		EP-PFC-Pa	Apr-20
Programmable Logic Controller			EP-PLC	Apr-20
	Display		EP-PLC-Di	Apr-20
	Distributed Controller		EP-PLC-DCon	Apr-20
	Distributed IO		EP-PLC-DIO	Apr-20
	Gateway		EP-PLC-Ga	Apr-20
	Main Controller		EP-PLC-MCon	Apr-20
	Standalone		EP-PLC-St	May-20
Solar power system			EP-SPS	Apr-20
	Control System		EP-SPS-ConS	Apr-20
	Inverter		EP-SPS-In	Apr-20
		Battery	EP-SPS-In-Ba	Jun-22
		Central	EP-SPS-In-Ce	Jun-22
		Microinverter	EP-SPS-In-Mi	Jun-22
		Optimised String	EP-SPS-In-OS	Jun-22
		String	EP-SPS-In-St	Jun-22
	Panels		EP-SPS-Pa	Apr-20
		Mono Crystalline	EP-SPS-Pa-MC	Jun-22
		Mono PERC	EP-SPS-Pa-MPERC	Jun-22
		Poly Crystalline	EP-SPS-Pa-PC	Jun-22
		Thin- Film	EP-SPS-Pa-TF	Jun-22
Switchboard			EP-SB	Apr-20
	Co- Gen Switchboard		EP-SB-CGSB	Apr-20
	Distribution Board		EP-SB-DB	Apr-20
	Generator Switchboard		EP-SB-GSB	Apr-20
	HV Switchboard		EP-SB-HVSB	Apr-20
	Main Switch Board		EP-SB-MSB	Apr-20
	Mechanical Services Switch Board		EP-SB-MSSB	Apr-20
	Meter Panel		EP-SB-MP	Apr-20
	Ring Main Unit		EP-SB-RMU	Apr-20
	Tee- Off Box		EP-SB-TOB	Apr-20
	Temporary Connection Pillar		EP-SB-TCP	Apr-20
	UPS Bypass		EP-SB-UB	Apr-20



NUMBER	DESCRIPTION	LEVEL
ME	Mechanical	1
ME-Acm	Mechanical, Accumulator	2
ME-Acm-St	Mechanical, Accumulator, Steam	3
ME-Acm-Wa	Mechanical, Accumulator, Water	3
ME-ACPR	Mechanical, Air Compressor	2
ME-ACPR-Re	Mechanical, Air Compressor, Reciprocating	3
ME-ACPR-Sc	Mechanical, Air Compressor, Screw	3
ME-ACPR-Sr	Mechanical, Air Compressor, Scroll	3
ME-ACC	Mechanical, Air Conditioner Condenser	2
ME-ACC-Ad	Mechanical, Air Conditioner Condenser, Adiabatic	3
ME-ACC-DX	Mechanical, Air Conditioner Condenser, DX	3
ME-ACC-DX-AC	Mechanical, Air Conditioner Condenser, DX, Air Cooled	4
ME-ACC-DX-WC	Mechanical, Air Conditioner Condenser, DX, Water Cooled	4
ME-ACC-GHP	Mechanical, Air Conditioner Condenser, Gas Heat Pump	3
ME-ACC-VRF	Mechanical, Air Conditioner Condenser, Variable Refrigerant Flow	3
ME-ACC-VRF-AC	Mechanical, Air Conditioner Condenser, Variable Refrigerant Flow, Air Cooled	4
ME-ACC-VRF-ACHR	Mechanical, Air Conditioner Condenser, Variable Refrigerant Flow, Air Cooled Heat Recovery	4
ME-ACC-VRF-WC	Mechanical, Air Conditioner Condenser, Variable Refrigerant Flow, Water Cooled	4
ME-ACC-VRF-WCHR	Mechanical, Air Conditioner Condenser, Variable Refrigerant Flow, Water Cooled Heat Recovery	4
ME-ACFCU	Mechanical, Air Conditioner Fan Coil Unit	2
ME-ACFCU-DX	Mechanical, Air Conditioner Fan Coil Unit, DX	3
ME-ACFCU-DX-Ca	Mechanical, Air Conditioner Fan Coil Unit, DX, Cassette	4
ME-ACFCU-DX-CC	Mechanical, Air Conditioner Fan Coil Unit, DX, Ceiling Concealed	4
ME-ACFCU-DX-CS	Mechanical, Air Conditioner Fan Coil Unit, DX, Ceiling Suspended	4
ME-ACFCU-DX-Co	Mechanical, Air Conditioner Fan Coil Unit, DX, Console	4
ME-ACFCU-DX-DIC	Mechanical, Air Conditioner Fan Coil Unit, DX, Ducted In- Ceiling	4
ME-ACFCU-DX-HW	Mechanical, Air Conditioner Fan Coil Unit, DX, Hi- Wall	4
ME-ACU	Mechanical, Air Conditioning Unit	2
ME-ACU-PDX	Mechanical, Air Conditioning Unit, Packaged DX	3
ME-ACU-PDX-ACD	Mechanical, Air Conditioning Unit, Packaged DX, Air cooled ducted	4
ME-ACU-PDX-WCD	Mechanical, Air Conditioning Unit, Packaged DX, Water cooled ducted	4
ME-ACU-PDX-WCID	Mechanical, Air Conditioning Unit, Packaged DX, Water cooled in-ceiling ducted	4
ME-ACU-PDXACU	Mechanical, Air Conditioning Unit, Portable DX air cooled units	3
ME-ACU-RDXACU	Mechanical, Air Conditioning Unit, Room DX air cooled units	3
ME-AC	Mechanical, Air Curtain	2
ME-AC-Co	Mechanical, Air Curtain , Cooling	3
ME-AC-CAH	Mechanical, Air Curtain , Cooling and heating	3
ME-AC-He	Mechanical, Air Curtain , Heating	3
ME-AC-NC	Mechanical, Air Curtain , Non- conditioned	3
ME-ADP	Mechanical, Air Distribution Products	2
ME-ADP-EAG	Mechanical, Air Distribution Products, Exhaust Air Grille	3
ME-ADP-EAG-Ba	Mechanical, Air Distribution Products, Exhaust Air Grille, Bar	4
ME-ADP-EAG-EC	Mechanical, Air Distribution Products, Exhaust Air Grille, Egg Crate	4
ME-ADP-RAG	Mechanical, Air Distribution Products, Relief/Return Air Grille	3
ME-ADP-RAG-Ba	Mechanical, Air Distribution Products, Relief/Return Air Grille, Bar	4
ME-ADP-RAG-Do	Mechanical, Air Distribution Products, Relief/Return Air Grille, Door	4
ME-ADP-RAG-EC	Mechanical, Air Distribution Products, Relief/Return Air Grille, Egg Crate	4
ME-ADP-SAD	Mechanical, Air Distribution Products, Supply Air Diffuser	3



Part Number	Asset C	Description
F.01U.318.067	A02308	ALKARA 2 ROOF ACCESS SPACE 4 MOBILE DURESS RECEIVER 1
F.01U.318.067	A02308	ALKARA 2 ROOF ACCESS SPACE 4 MOBILE DURESS RECEIVER 2
01593-001	A02EXT	12014 ALKARA 2A LOCK 1 ENTRY
01593-001	A02EXT	12514 ALKARA 2B LOCK 2 ENTRY
01593-001	A02EXT	12019 ALKARA 2A DAYROOM 1 ENTRY

e	Part Number	Description
sual	HT PROIR202KIT	Infra-Red Hearing Augmentation system
sual	AMP-X300	Power Amplifier, 200W, 100V
sual	C2N-IO	Control Port Expansion Module
sual	CGEIB-IP	KNX/IP-Gateway
sual	RMC4	4-Series™ Control System
sual	TSW-760-W-S	7 in. Touch Screen, White Smooth
sual	AMP-X300	Power Amplifier, 200W, 100V
sual	HD-RX-101-C-E	DM Lite – HDMI® over CATx Receiver, Surface Moun
sual	HD-TX-101-C-E	DM Lite – HDMI® over CATx Transmitter, Surface Mc
sual	RMC4	4-Series™ Control System
sual	TSW-760-W-S	7 in. Touch Screen, White Smooth
sual	EB-L1070UNL	Data Projector - 7000ANSI - Laser - HDBaseT

30+ VBIS categories

available for multi-disciplines and various facility types.

5000+ VBIS codes

available for asset classification mapping to the Revit elements.

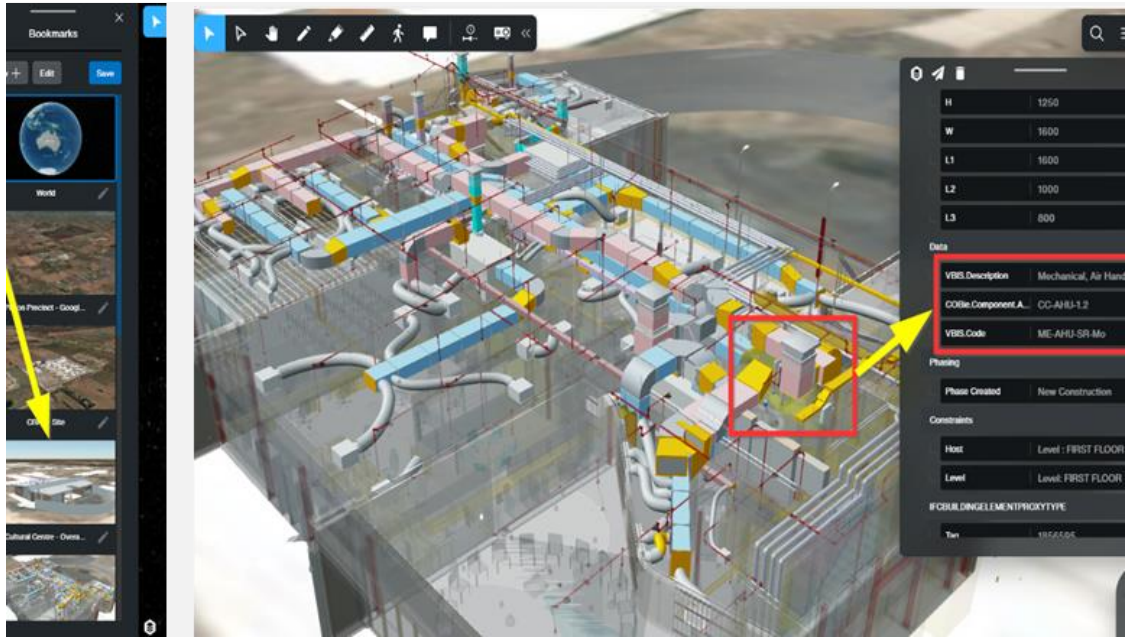
500+ part/model numbers

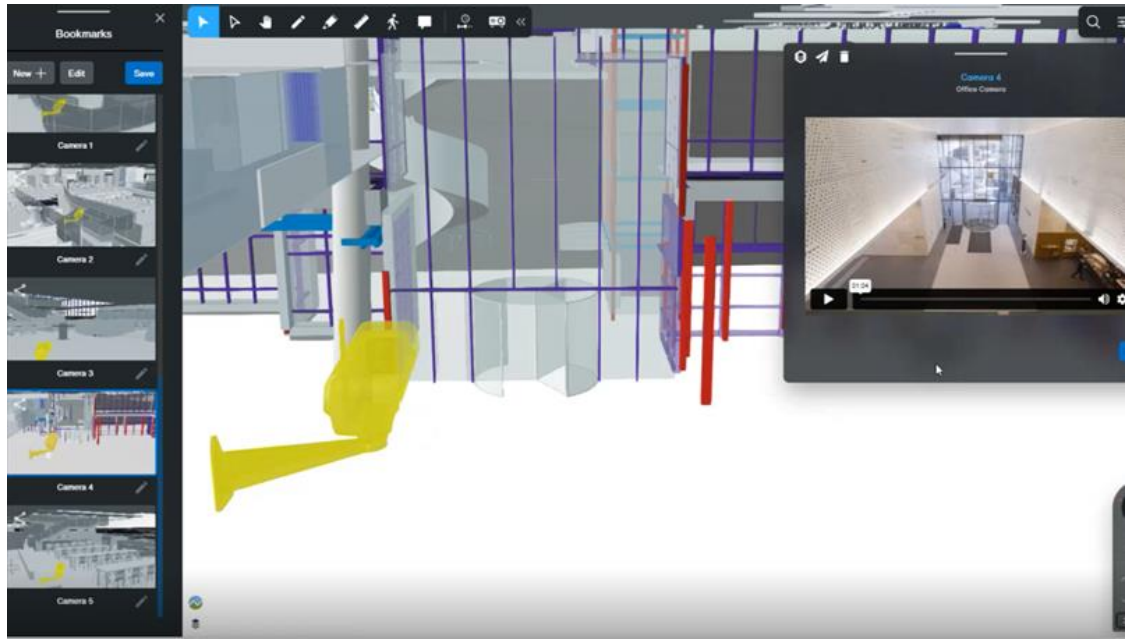
found for linking product information from the project asset register.

Preparing BIM models for seamless integration with next-gen Digital Twin platforms

ARUP

Handover and data migration to the client's Common Data Environment





Asset Digital Twin

enabled by rectified BIM models and external asset database.

Live Digital Twin

An IoT integration example of CCTV camera live streams.

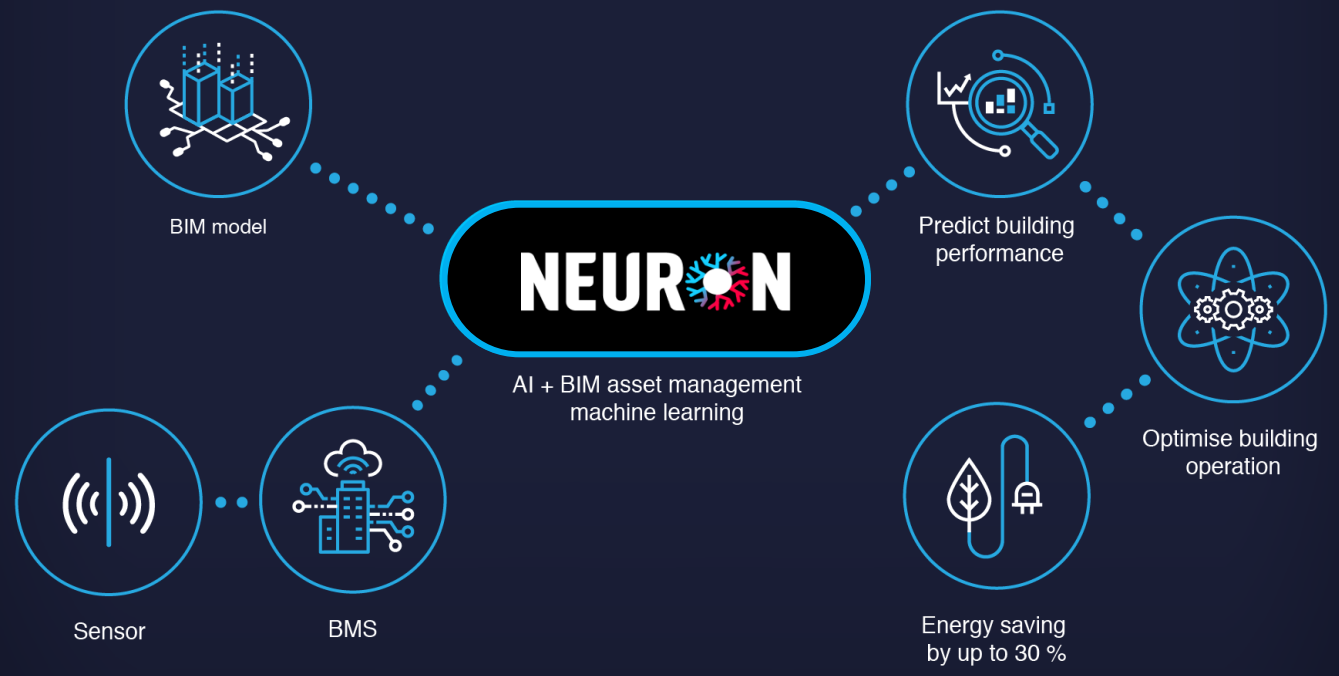
Building Management Systems

AI & Machine Learning

1. What if a building had a brain...

AI & Machine Learning

1. What if a building had a brain...



AI & Machine Learning

1. What if a building had a brain...

Automated asset inspections powered by machine learning

ARUP

Brief overview of Loupe 360

General architecture in Loupe 360

Survey, Specification and Build:

UAV (Drones), UGV (e.g. robot dog)

Mobile: maintenance vehicle integrated / bespoke loco mounted

Fixed: Integrated onto fixed infrastructure e.g. maintenance rails

AI and Machine Learning

Defects detection (e.g. water & tree root ingress, spalling, cracking) and obstruction

Change detection (e.g. temporal progression and defect growth)

Inventorying: (e.g. FLS signage, MEP equipment cataloguing)

User Interface

Collaborative decision-making cloud platform

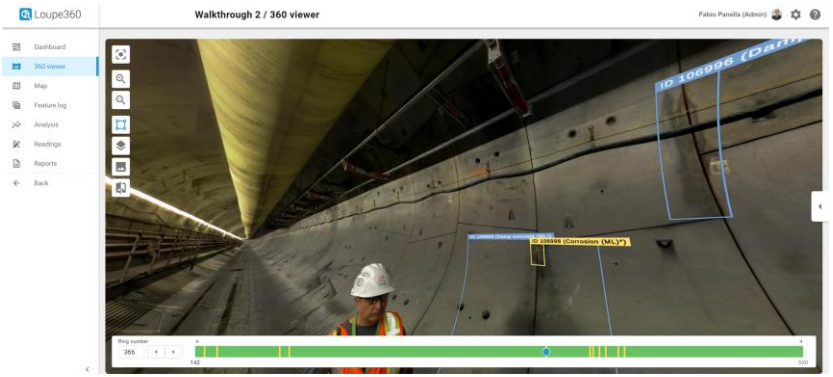
Intuitive virtual walk throughs and ML indicators

User defined analytics, risk scoring and automated reporting

Use cases

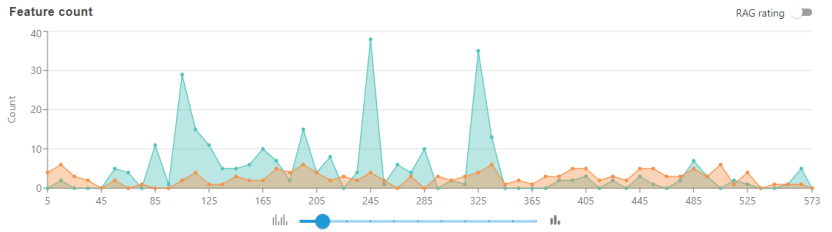
Asset defect detection

- Impartial assessment of asset condition.
- The initial inspection serves as the baseline for future change detection analysis.



Asset management prioritisation

- Change detection.
- Strategic inspection and maintenance planning.
- Data driven expenditure optimisation.



Asset protection

- Identifying different types of defects and inferring their root causes allows preventative, protective works to happen beyond the asset itself.

Automated inspection

Machine Learning (ML) powered tool for asset management

Automated Inspection → **Automatic Defect Detection** → Immersive Visualisation

Hi-res 360-degree camera data capturing

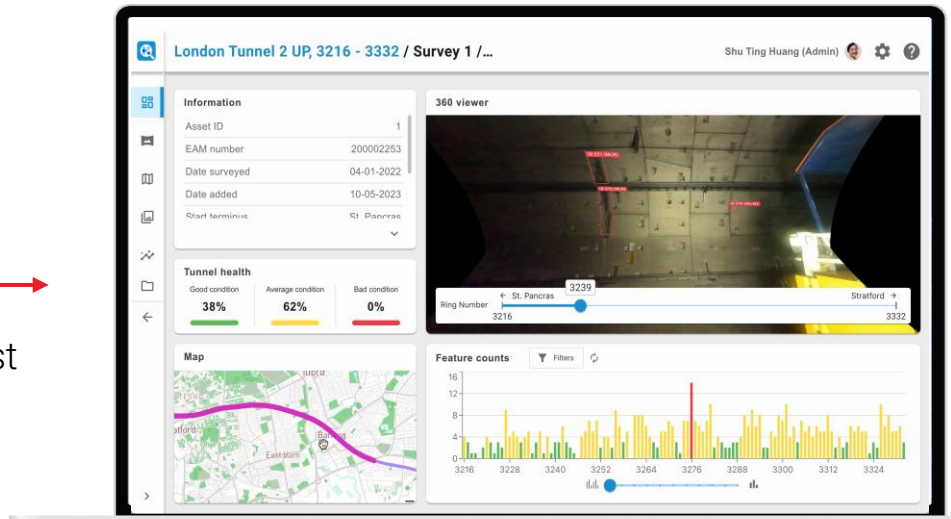
ML-powered predictive analytics for

repeatable & objective outcomes

>70% reduction of time

>50% reduction site staff

Up to 40% O&M cost saving



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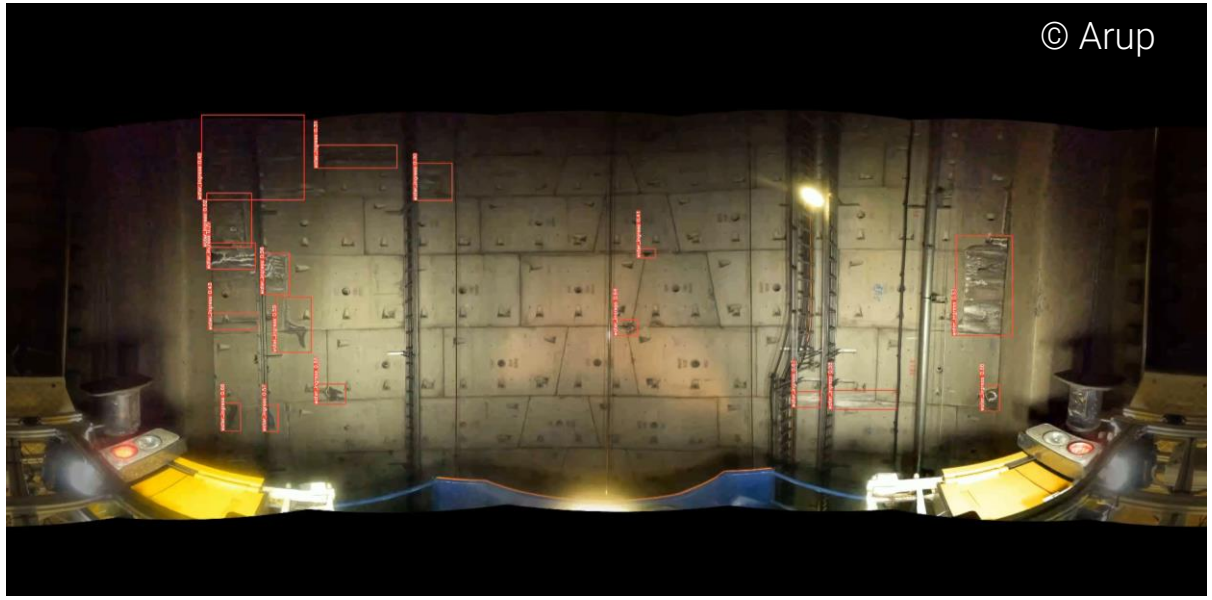
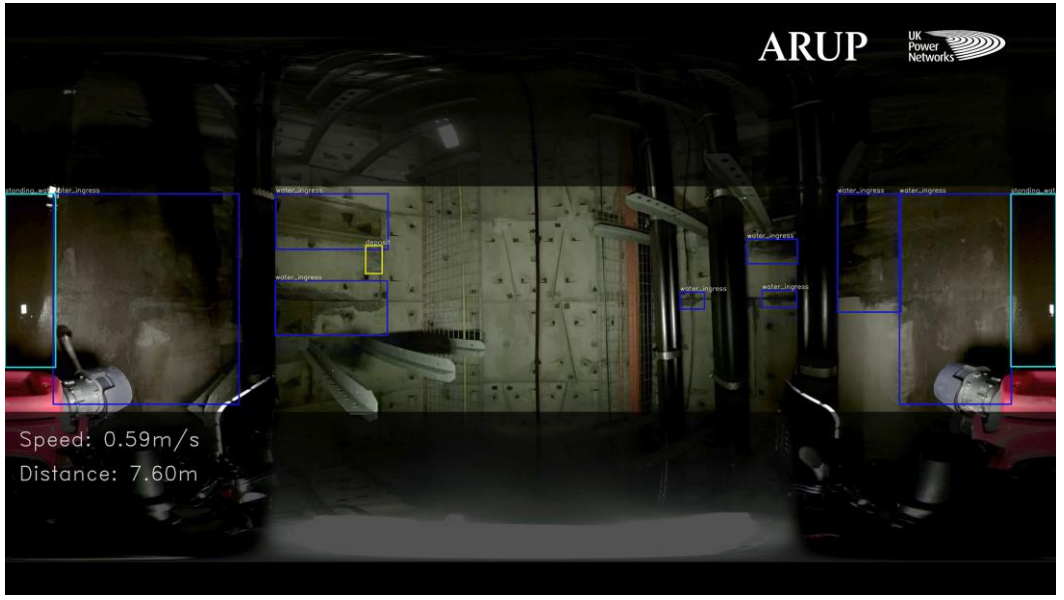
Machine Learning-powered condition assessment

Automated Inspection → **Automatic Defect Detection** → Immersive Visualisation



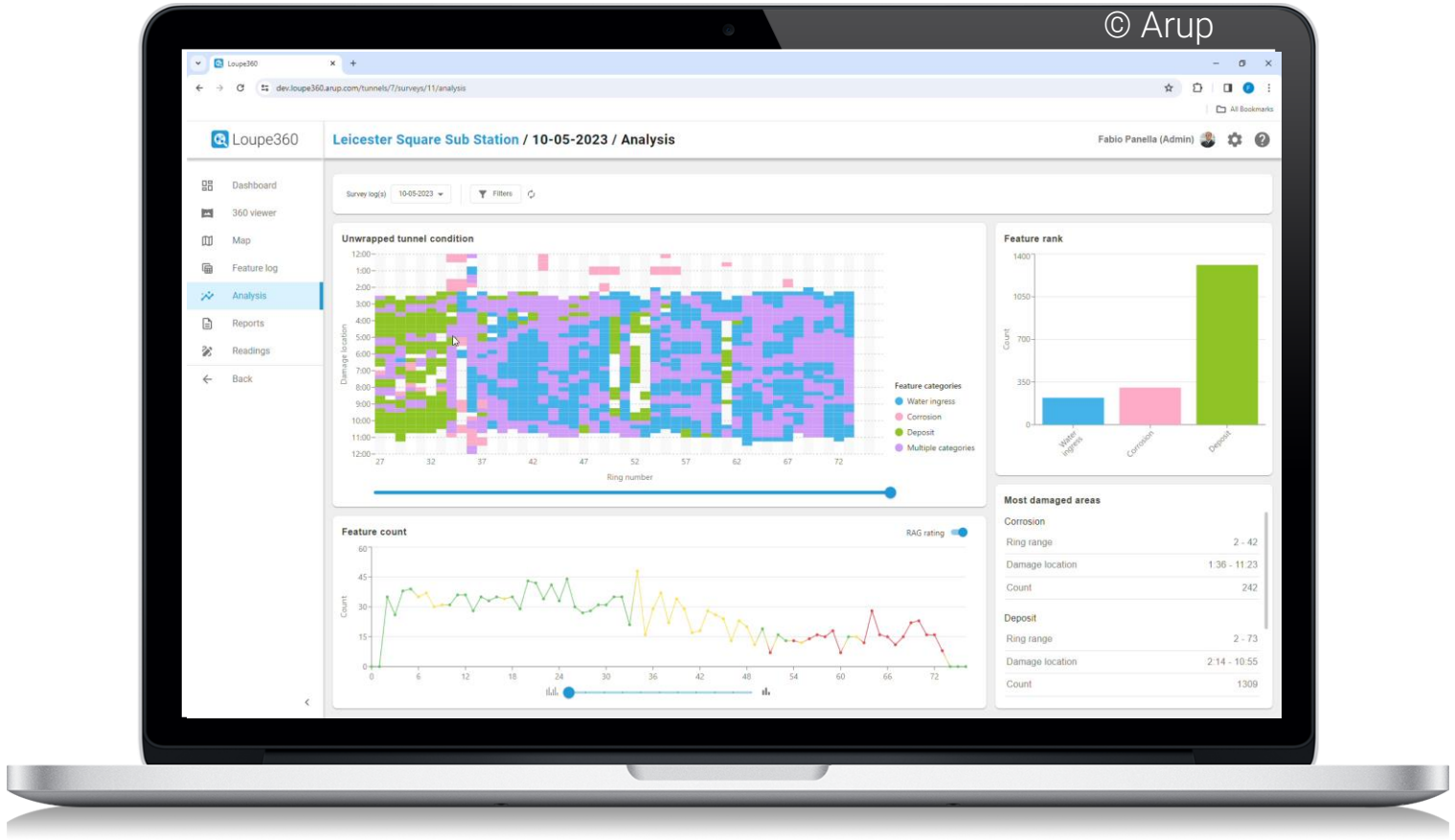


Network Rail High Speed Ltd. hs1 high speed one

UK Power Networks Delivering your electricity

Intuitive dashboarding for asset management

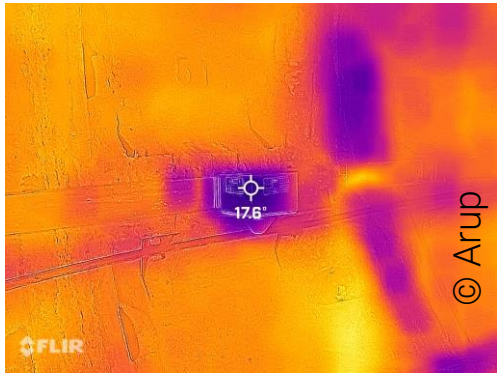
Automated Inspection → Automatic Defect Detection → **Immersive Visualisation**

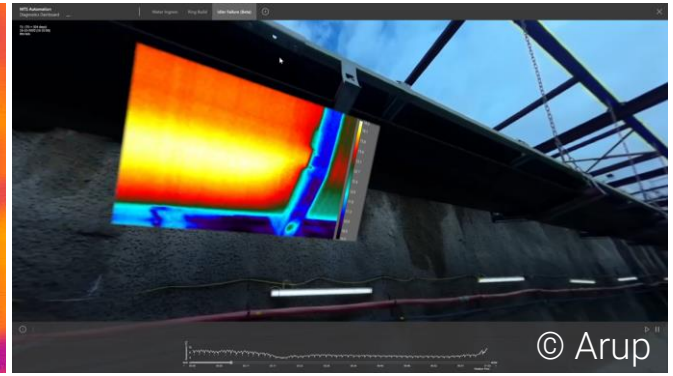


The data is visualised in a web-based dashboard. Easy to interpret visuals accurately describe the asset conditions.

Automated reporting is also available to match the client's standards.

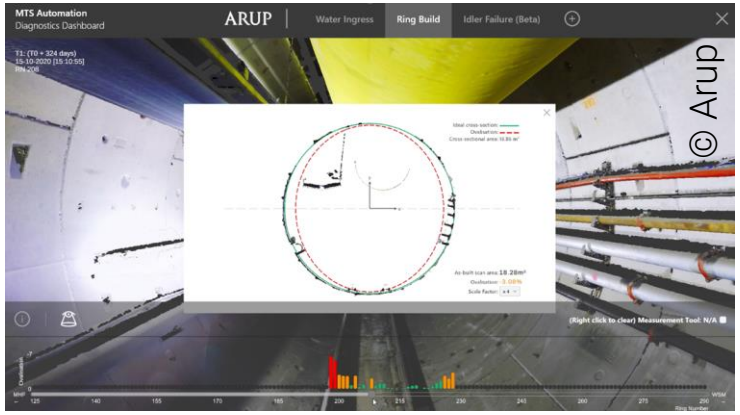
Beyond defect detection



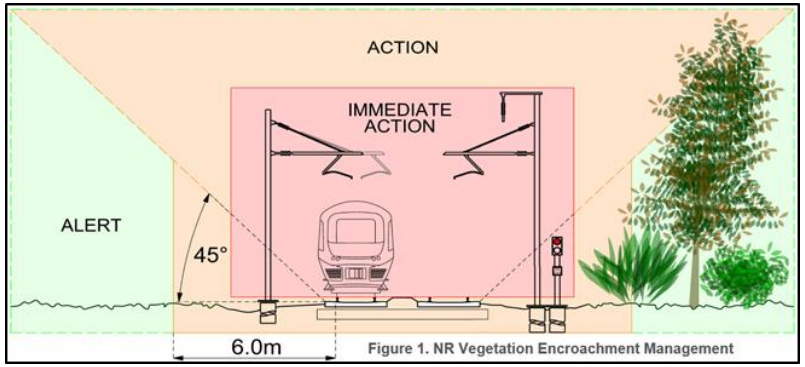


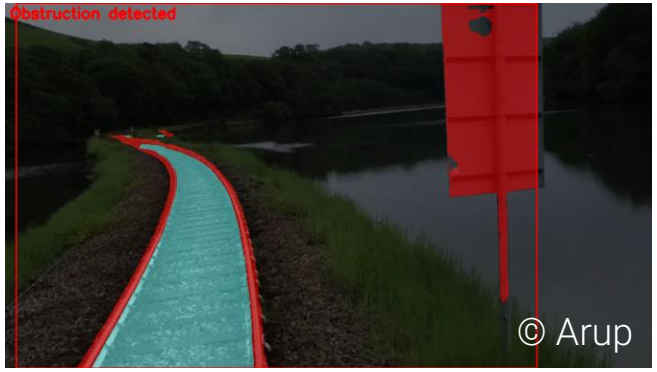
Detection of defects beyond the visual spectrum from thermal imagery (e.g., early signs of dampness in concrete, equipment overheating, cable health assessment).

AI-powered automated inventorying



Geometric conformity of cross sections considering relevant standards and tolerances





Detection of obstructions from revenue vehicles built-in dash cameras. It can be deployed for operation and maintenance of rail infrastructure (e.g., vegetation maintenance)

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