Urban Digital Twins and the Valley of Death

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NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

Part 1
AURIN – Fast facts

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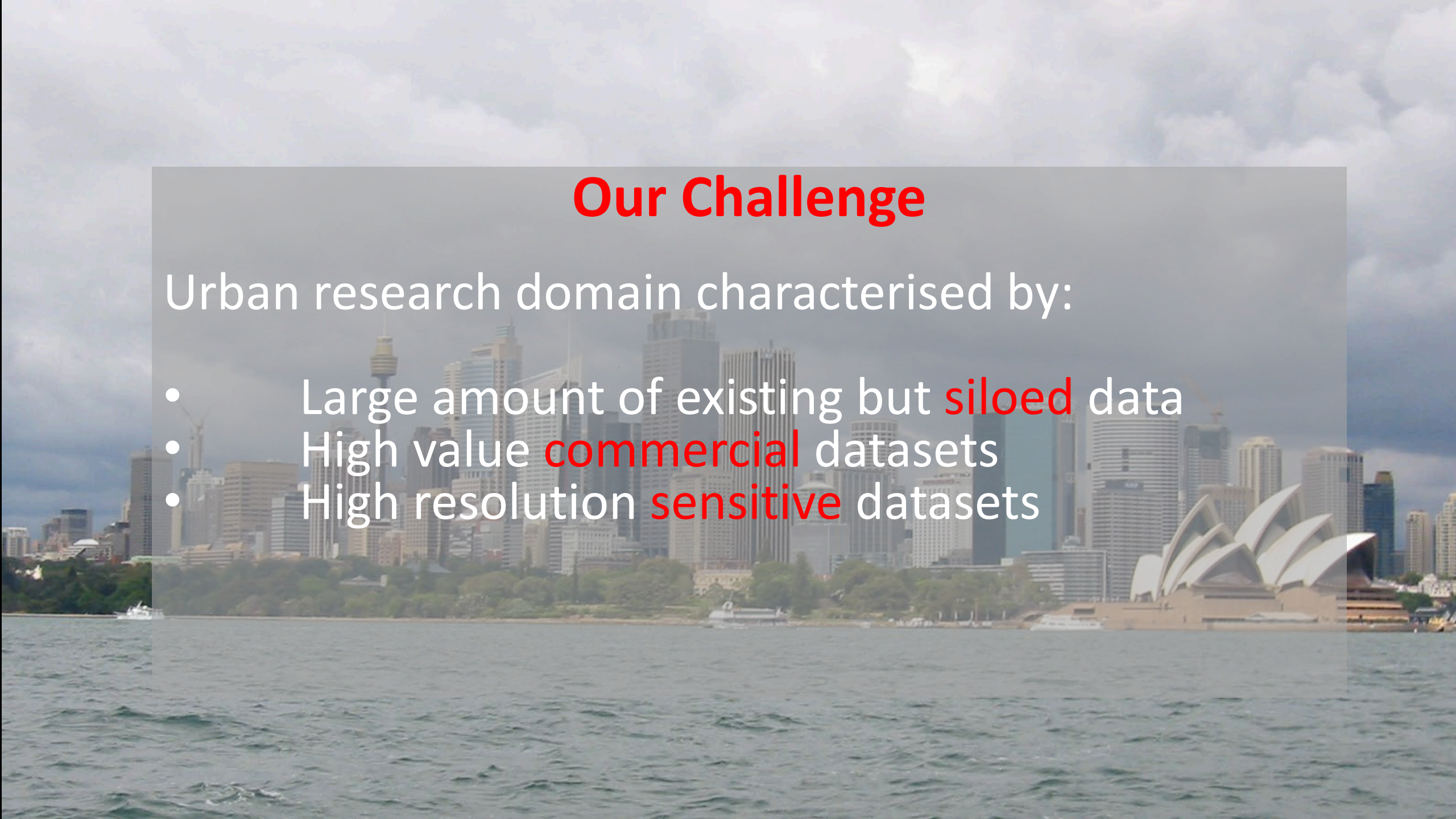
Our Role

Serving the urban research community by:

- Providing hard-to-get data
- Enabling hard-to-do implementation
- Contributing to workforce upskilling



Our Challenge

Urban research domain characterised by:

- Large amount of existing but siloed data
- High value commercial datasets
- High resolution sensitive datasets

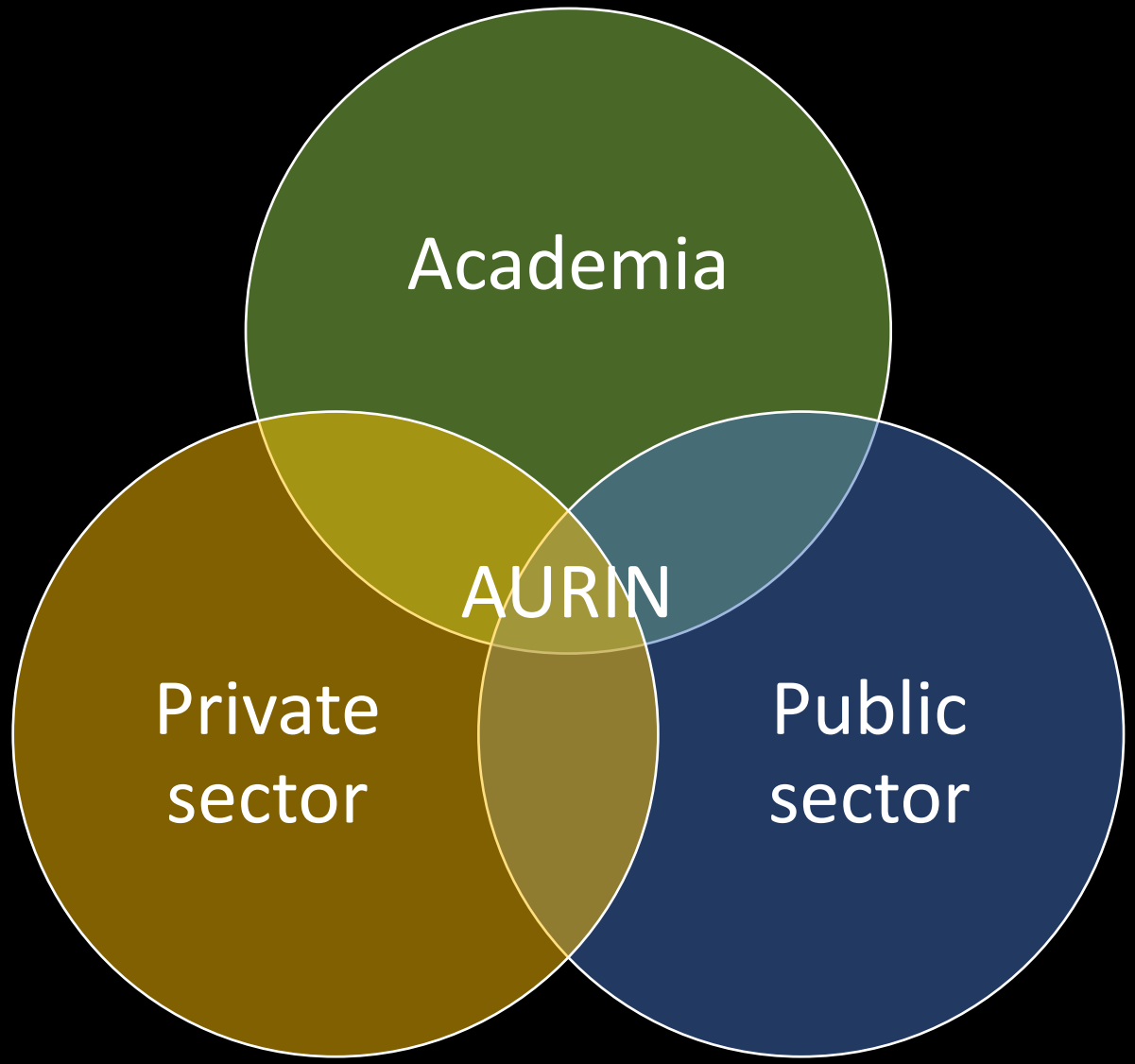
Our Objective

Supporting research that addresses the impact of:

- Climate change
- Energy transition
- Demographic transformation

…on cities, infrastructure & communities

AURIN - Partnerships



aws
NVIDIA
Telstra
'yes' OPTUS
PEXA
Domain
ARUP
nearmap
Geoscape
Endeavour Energy
Australian Government
Geoscience Australia
CSIRO

AURIN - Academic Nodes

Housing Analytics Lab (UNSW Node)

Part 2
Urban Digital Twin…in search of sibling!

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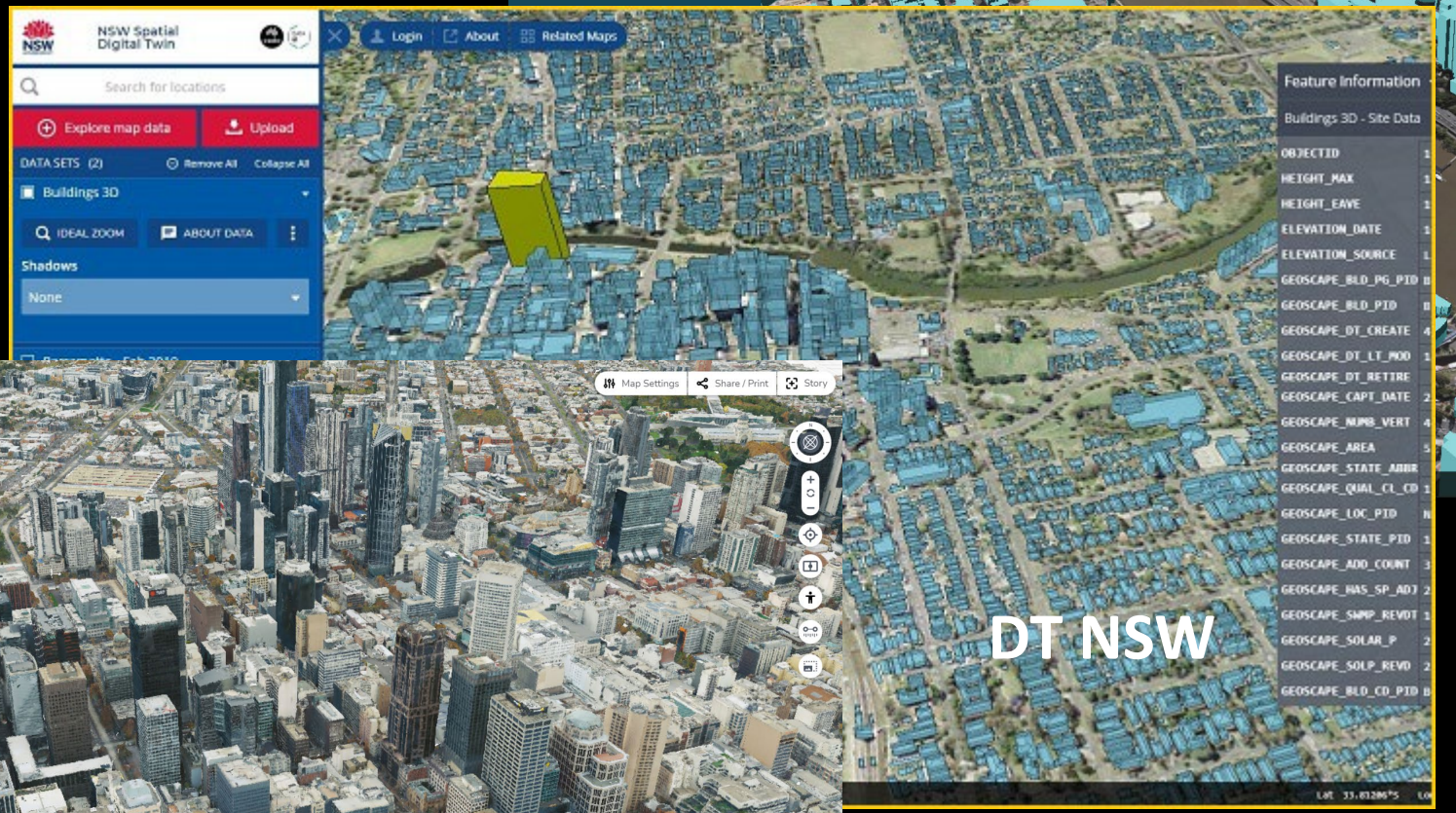
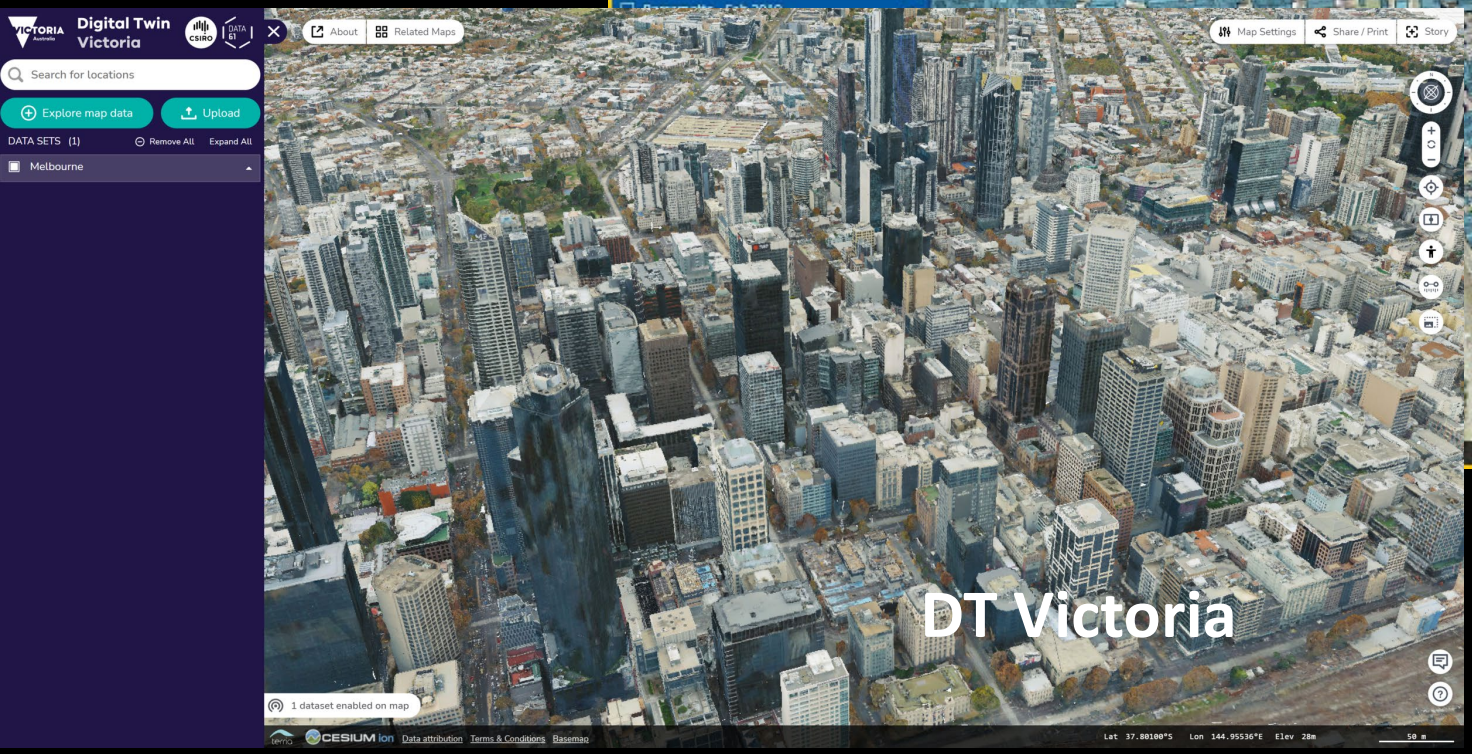
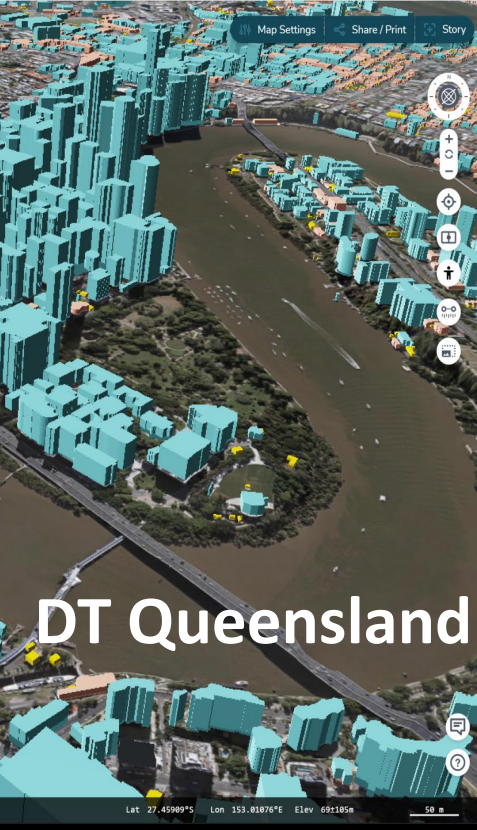
UDTs are everywhere!



DT NSW



DT Victoria



DT Queensland

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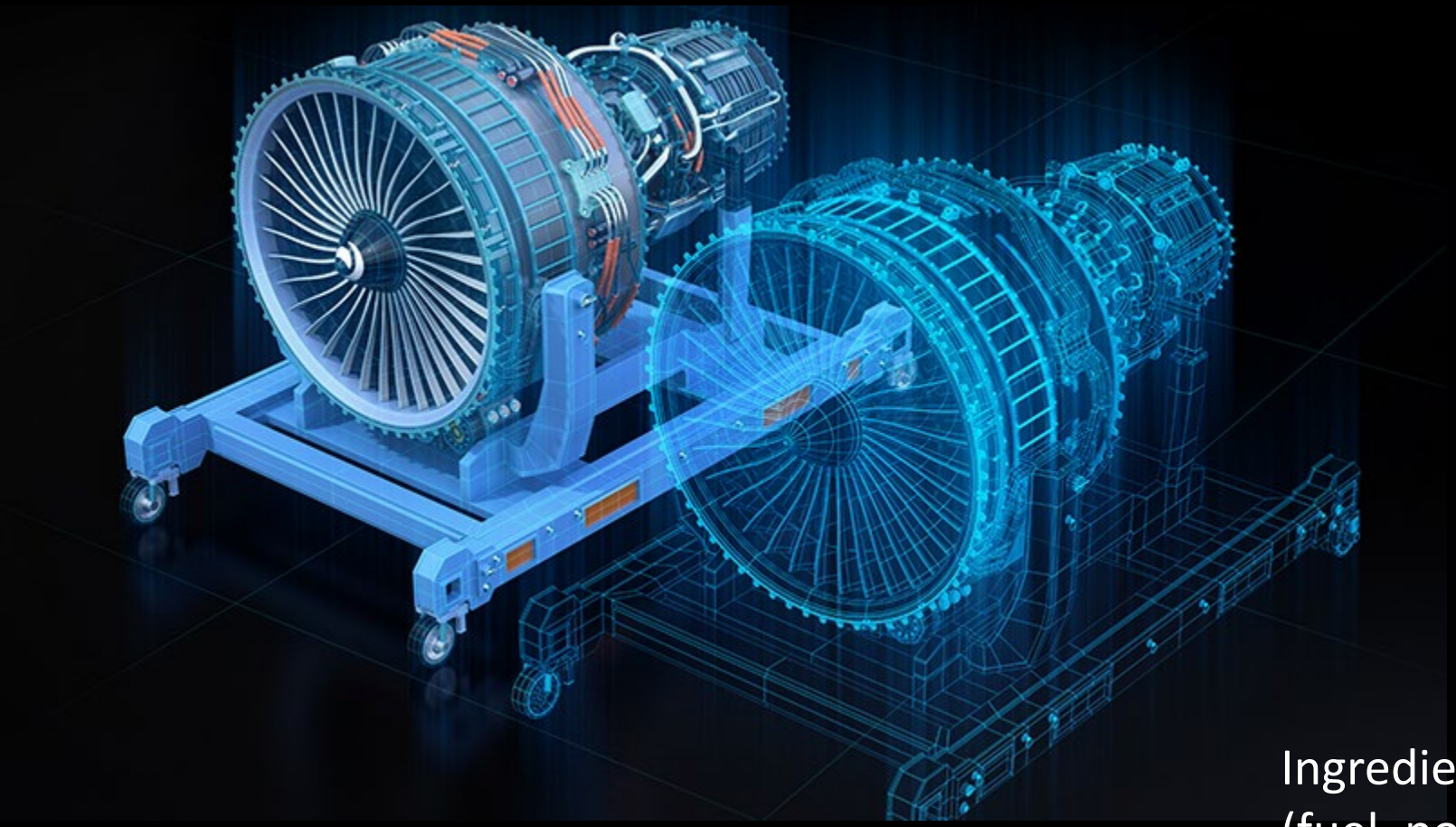
Challenges facing UDTs

- Fuzzy concept derived from industry
- Broad range of technologies (GIS to ABM)
- Weak business cases so far
- High transaction costs (back-end) due to:
  - Poor data accessibility
  - Weak semantic interoperability
  - Limited technological reusability
  - Hypothetical system scalability
- UDTs aim to represent urban ecosystems
- Ecosystems include **flows** & **functions**
- Cities are meant to serve and host **people**

Industrial Digital Twin



- Rolls Royce turbine
- Industrial digital twin (IDT)
- Ultra-realistic representation
- Structural digital copy
- Integrated functional simulation
- Real-time comparison
- Feedback to real system
- Objective #1: performance
- Objective #2: quality control

Ingredients: virtual components, resources (fuel, power), functions and flows

Credit: Shutterstock, 2023

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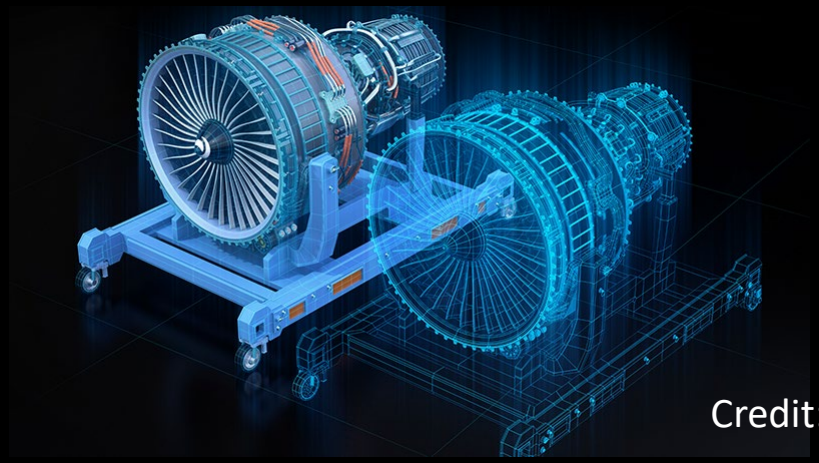
From complex to complicated



Credit: Shutterstock, 2023

Credit: ESRI UK, 2023

Industrial DT

- Physical asset
- Well-identified components
- Closed system
- Laws of physics
- Predictable behaviour
- Reliable monitoring
- Accessible data

Urban DT

- Physical, biological and human assets
- Loosely identified components
- Open system
- Laws of physics, biology and psychology
- Unpredictable behaviour
- Sparse monitoring
- Poor data accessibility

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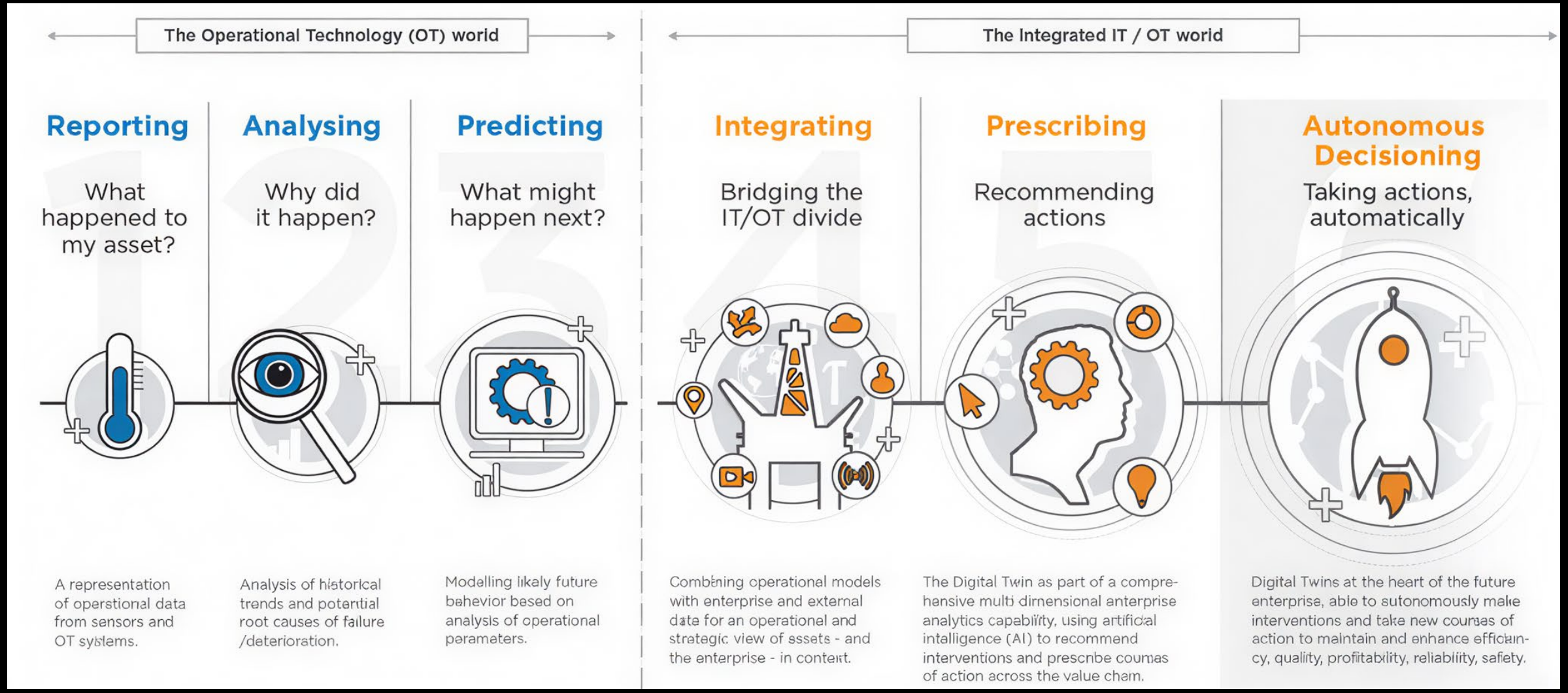
Holistic representation and simulation

(Simcity, Electronic Arts, circa 2000)

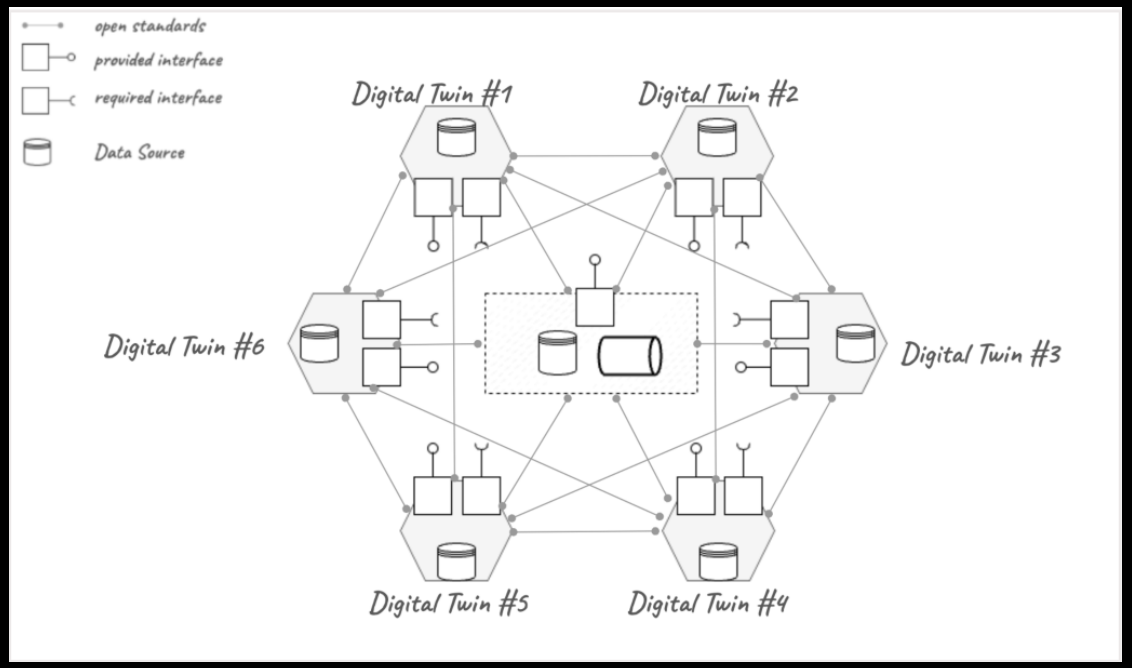
UDTs in action



https://web.archive.org/web/20220316014422/https://www.smart-energy.com/policy-regulation/digital-twins-maturity-continuum-david-socha/

Next generation UDTs

Good old model orchestration!
Multi-agent system principles
Robustness Law (Jon Postel): “Be conservative in what you do, be liberal in what you accept from others.”



(Source: S. Contreras Martin, 2024)

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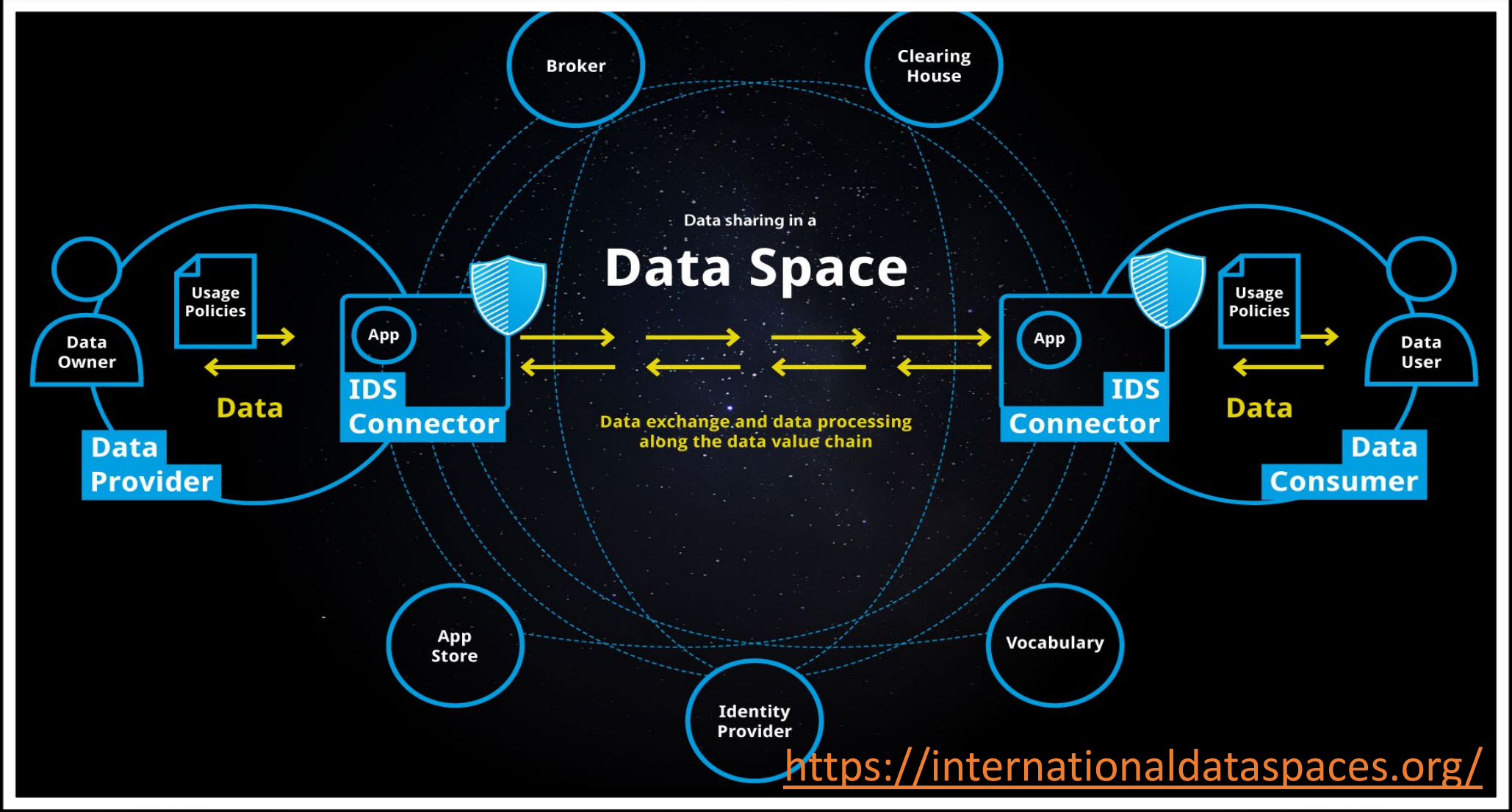
Data Space concept - UDT

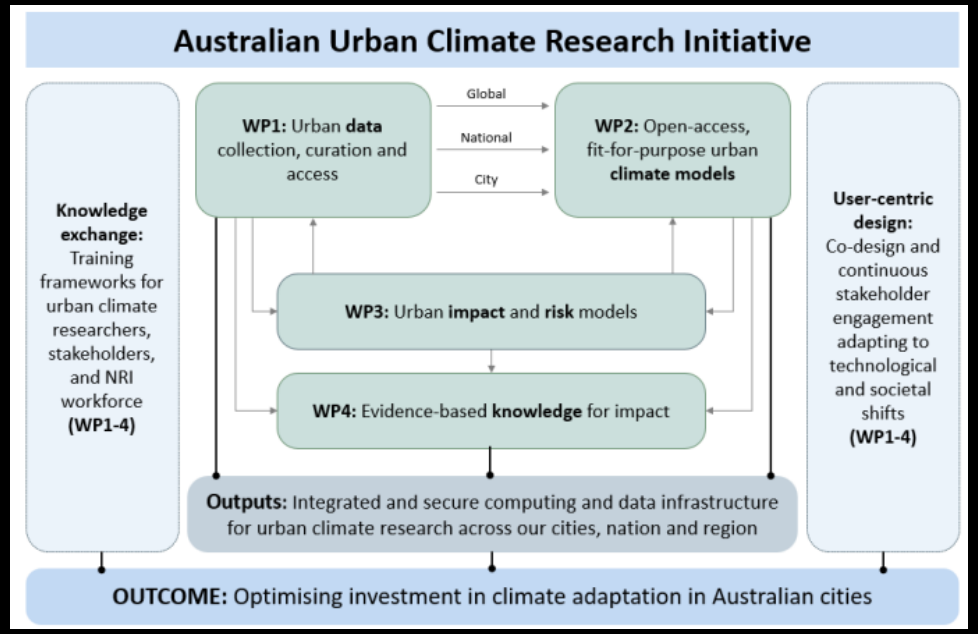


https://internationaldataspaces.org/

AUCRI Initiative (NCRIS funding)

Rationale:
Cities will experience significant warming by the end of the century, impacting over 90% of Australia's population. However, our national tools for climate predictions and projections currently lack accurate representations of urban environments, and the necessary observations and datasets to assess them.

Objective:
Establishing a crucial National Digital Research Infrastructure (NDRI) to inform evidence-based urban policies and interventions aimed at future proofing urban and infrastructure systems against climate change. AUCRI will position Australia as an international scientific leader in the field and optimise our investment in climate adaptation in Australian cities.



Summary

- Unlike Industrial Digital Twins, which operate in closed, well-defined physical systems, UDTs must represent open, complex urban ecosystems shaped by physical, biological, and human dynamics.
- This complexity leads to weak business cases, poor data accessibility, limited interoperability, and high transaction costs—key contributors to UDT project failure beyond initial deployment.
- The UDTs should not be dismissed as unsolvable "wicked problems." Drawing lessons from industrial digital twins, gaming environments such as SimCity, and emerging multi-agent and data-space architectures, a path toward next-generation UDTs that are modular, interoperable, and scalable.
- Robust data infrastructure, strong governance, and cross-sector collaboration can help urban digital twins cross the Valley of Death and deliver enduring societal value.

Our door is always open!

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