

MABS 2024

From drug epidemics to urban futures...
A life with agents!

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AURIN



What?

- Accessing and sharing data on urban and infrastructure systems

How?

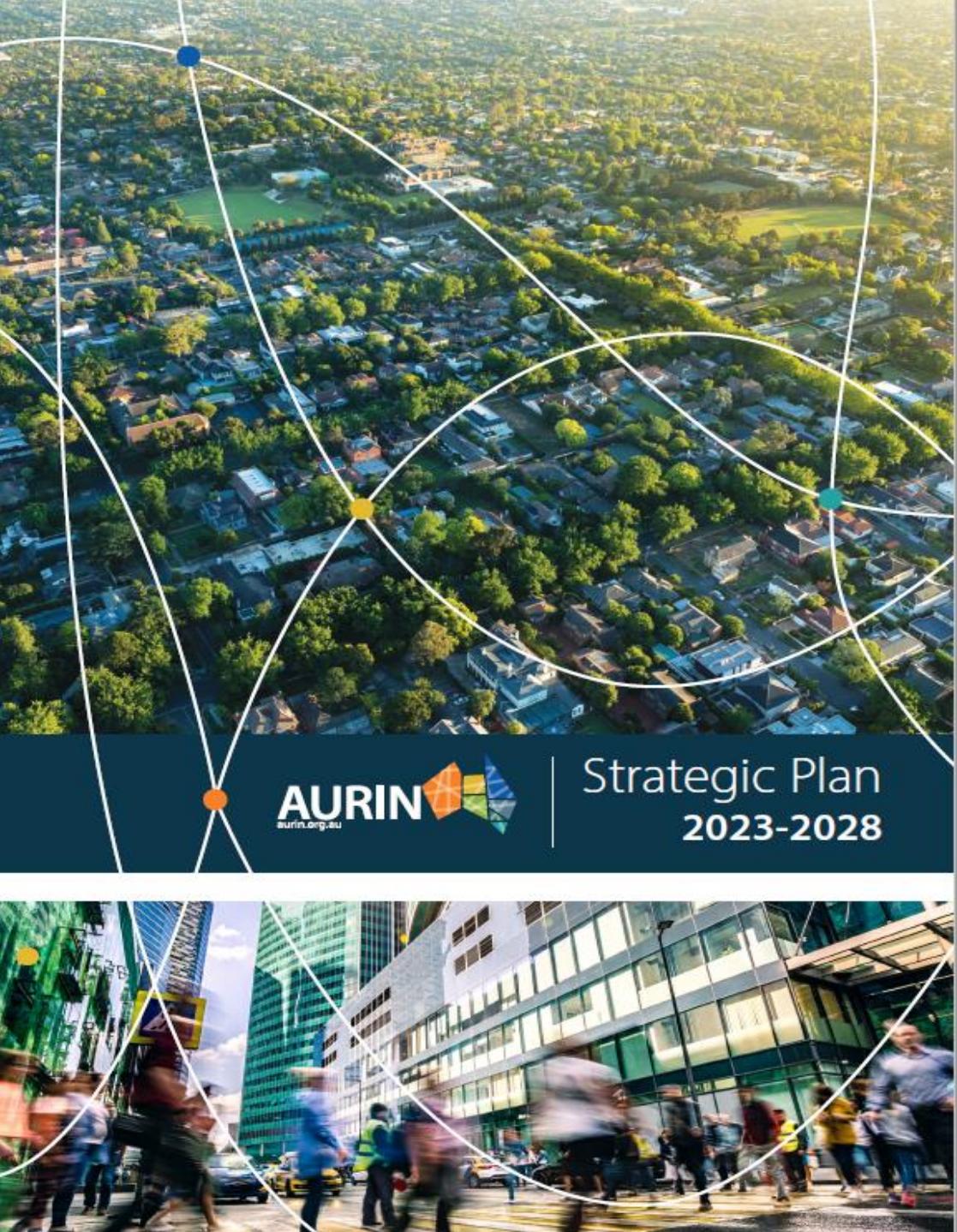
- Hard-to-Get Data
- Hard-to-Do Things
- Avoid duplication
- Foster collaboration

WHY?

Addressing impact of...

- Climate change
- Energy transitions
- Demographic change

...on cities, infrastructure systems and regional communities



A journey with agents

- 2001 – Catchescape: socio-technical model of an agricultural catchment in Northern Thailand
- 2003 – Atollscape: socio-technical model of freshwater management on Tarawa atoll
- 2005 – Atollgame: computer-assisted RPG of freshwater management on Tarawa atoll
- 2007 – SimDrug: socio-technical model of street-based illicit drug markets
- 2009 – SimAmph: socio-behavioural model of amphetamine use and dependence
- 2011 – SimReef: socio-technical model of the Meso-American reef in Yucatan
- 2012 – Reefgame: computer-assisted RPG of coral reef management in the Philippines

A journey with agents

2013 – SimUse: socio-behavioural model of polydrug use in Australia

2013 – AronzoWinSim: spatial ABM of Alpine tourism's adaptation to climate change

2015 – Transmob: socio-technical model of transport and residential mobility in Sydney

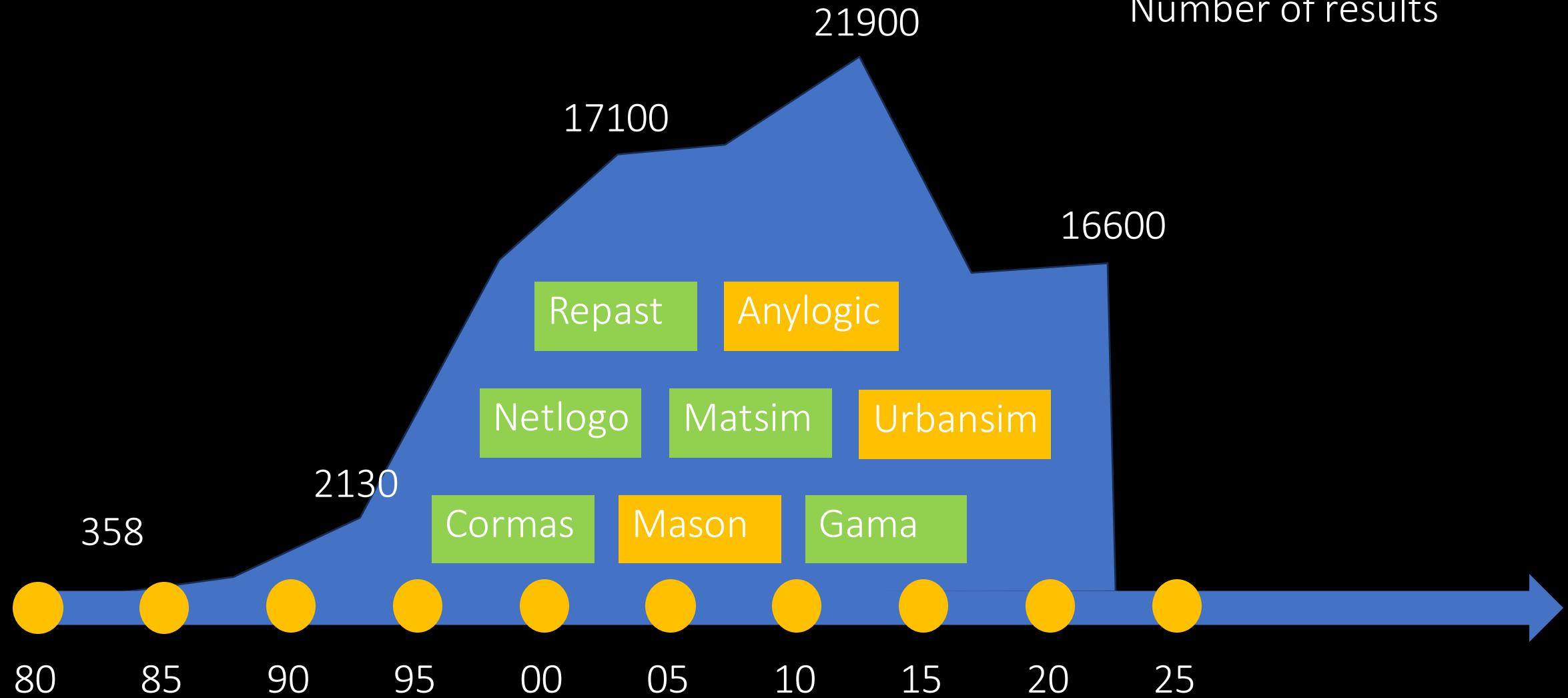
2017 – ABM for urban planning, current limitations and future trends

2021 – FloodAware: a near-real-time urban flood forecasting model

2024 – What's next????

A journey with agents

Google Scholar search:
'agent-based modelling'
Number of results



The power of agents



Power#1 – Geospatial dynamics



Power#2 – Hybrid modelling paradigms



Power#3 – Social behaviour and interactions

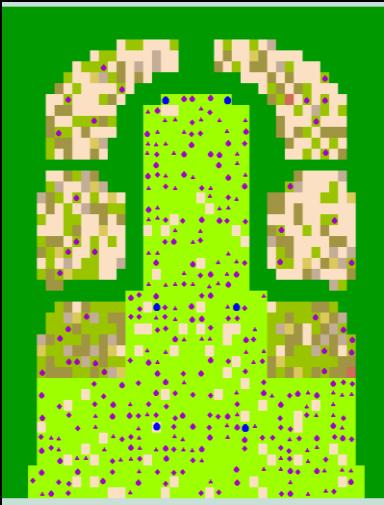


Power#4 – Participation and validation



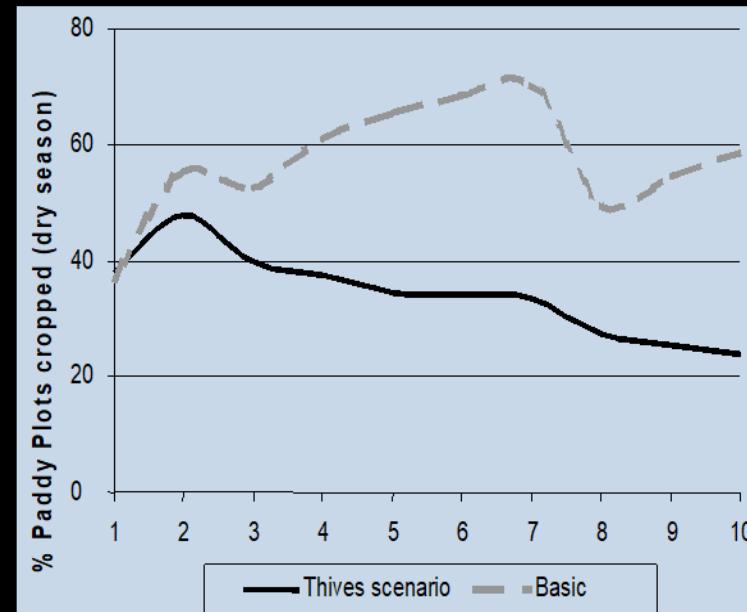
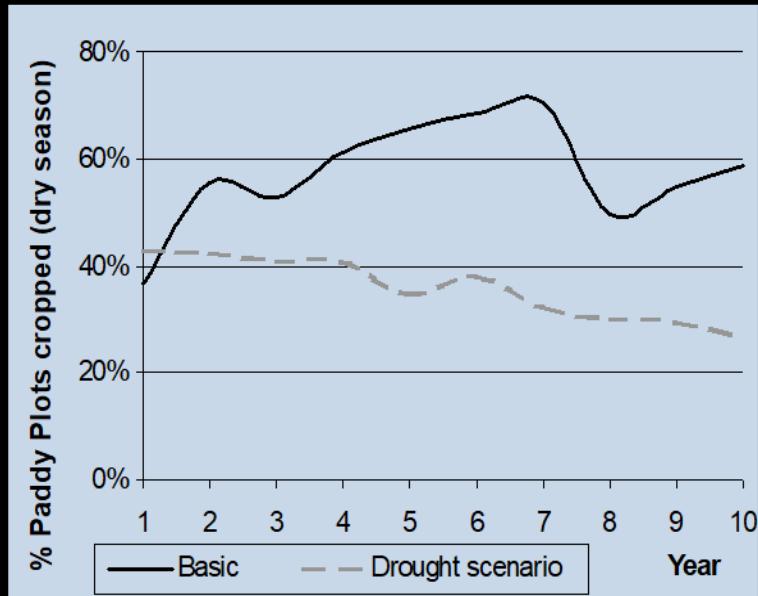
What is the ‘next big thing’ for ABM?

Geospatial dynamics - Catchscape



From GIS to Choremie

Spatially distributed socio-technical system



- Social learning process
- Emerging new behavioural patterns
- Non linearity of response linked to weir manager's strategies
- 30% thieves in the system as disruptive as worse climate scenario !

Source: Becu et al., Ecological Modelling (2003)

Geospatial dynamics - FloodAware



Spatially distributed socio-technical system

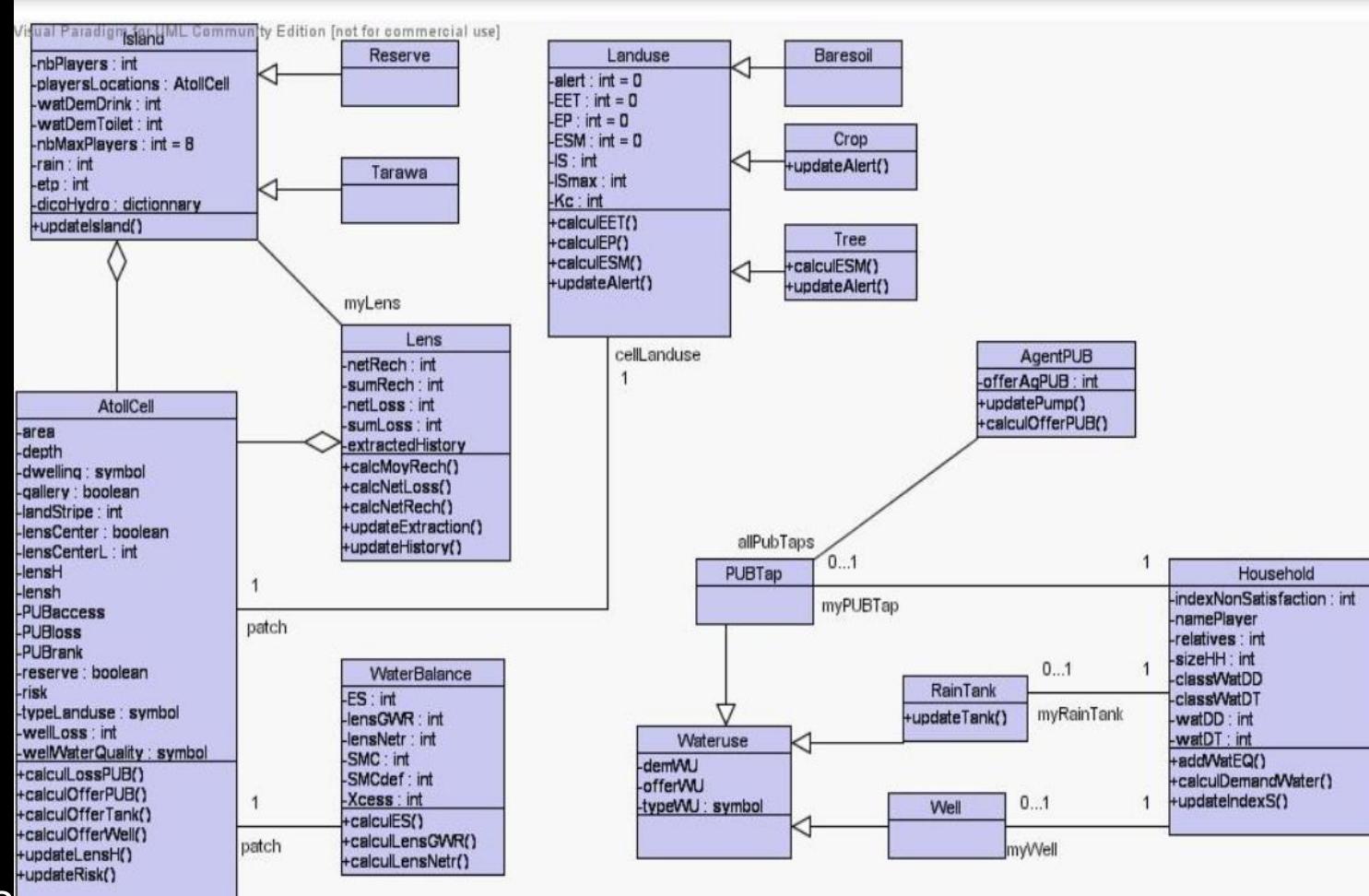


Source: Barthelemy et al., Handbook of Smart Cities (2020)

Hybrid modelling paradigms- Atollscape

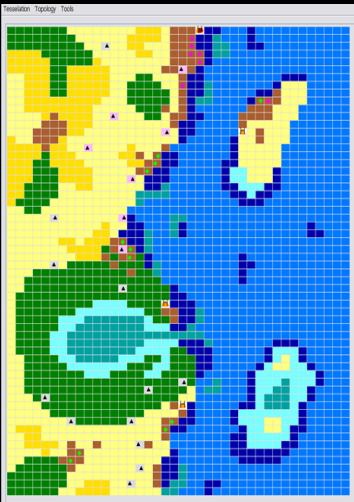


Semi-empirical 2D hydrogeological model

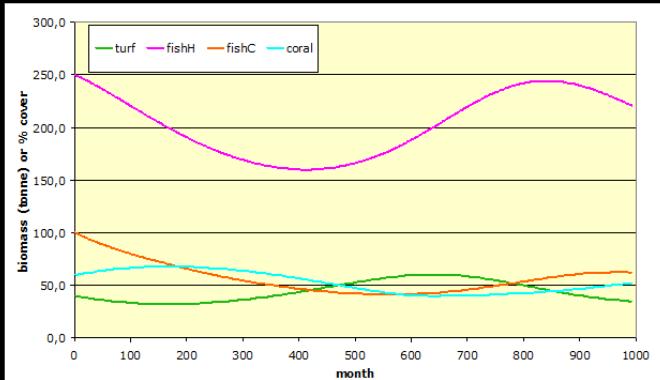


Source: Perez et al., MODSIM Proc. (2003),

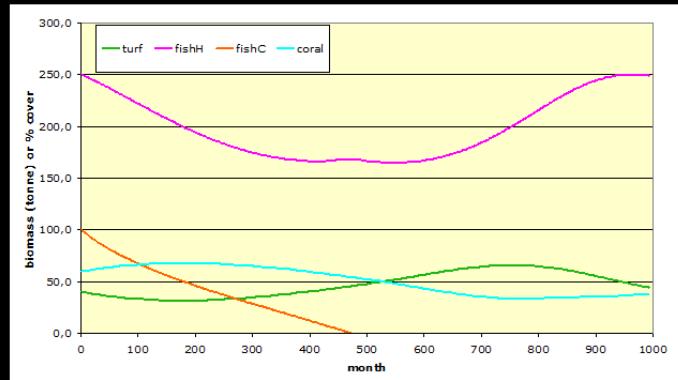
Hybrid modelling paradigms- SimReef



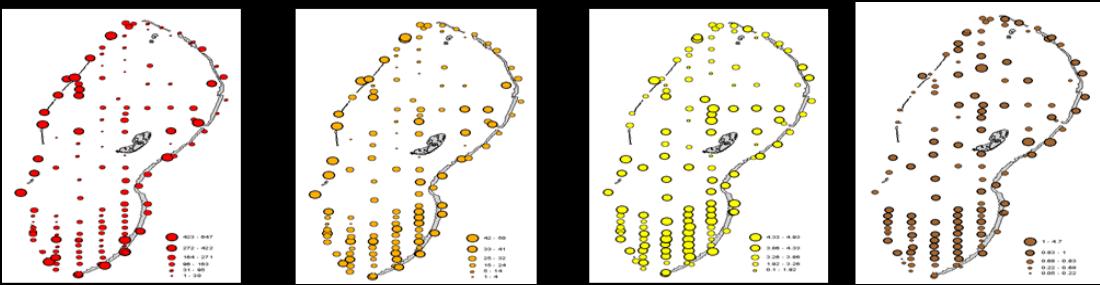
Differential equation-based benthos model



Fishing Pressure (FP): 0 t/month



Fishing Pressure (FP): 0.2 t/month



Equations:

$$\Delta\text{coral} = 17.10^{-3} * (\text{coral} + \text{recruit}) + 8.10^{-3} * (\text{coral}^2 / (\text{coral} + \text{turf})) - 22.10^{-3} * \text{coral}$$

$$\Delta\text{turf} = 1.10^{-2} * \text{turf} - 5.10^{-5} * (\text{turf} * \text{fishH})$$

$$\Delta\text{fishH} = 2.10^{-3} * (\text{fishH} + \text{recruit}) + 1.10^{-4} * (\text{fishH} * \text{turf}) - 6.10^{-3} * \text{fishH} - 1.10^{-5} * (\text{fishH} * \text{fishC})$$

$$\Delta\text{fishC} = 1.10^{-3} * (\text{fishC} + \text{recruit}) + 45.10^{-6} * (\text{fishH} * \text{fishC}) - 5.10^{-3} * \text{fishC} - 1.10^{-4} * \text{fishC}^2$$

$$\text{Fishing: } \Delta\text{fishC} - (\text{FP} - (\text{FP}^2 / \text{fishC})) \quad \& \quad \Delta\text{fishH} - (\text{FP}^2 / \text{fishC})$$

Source: Melbourne-Thomas et al., Ecology & Society (2011)

Hybrid modelling paradigms- Transmob

Transport & residential mobility model (scale 1:1)

110,000 Agents (1:1)

85,000 Private Motorized Vehicles

50,000 Households (17 categories)

60 Travel Zones

32 Bus Routes

8 Transport Modes

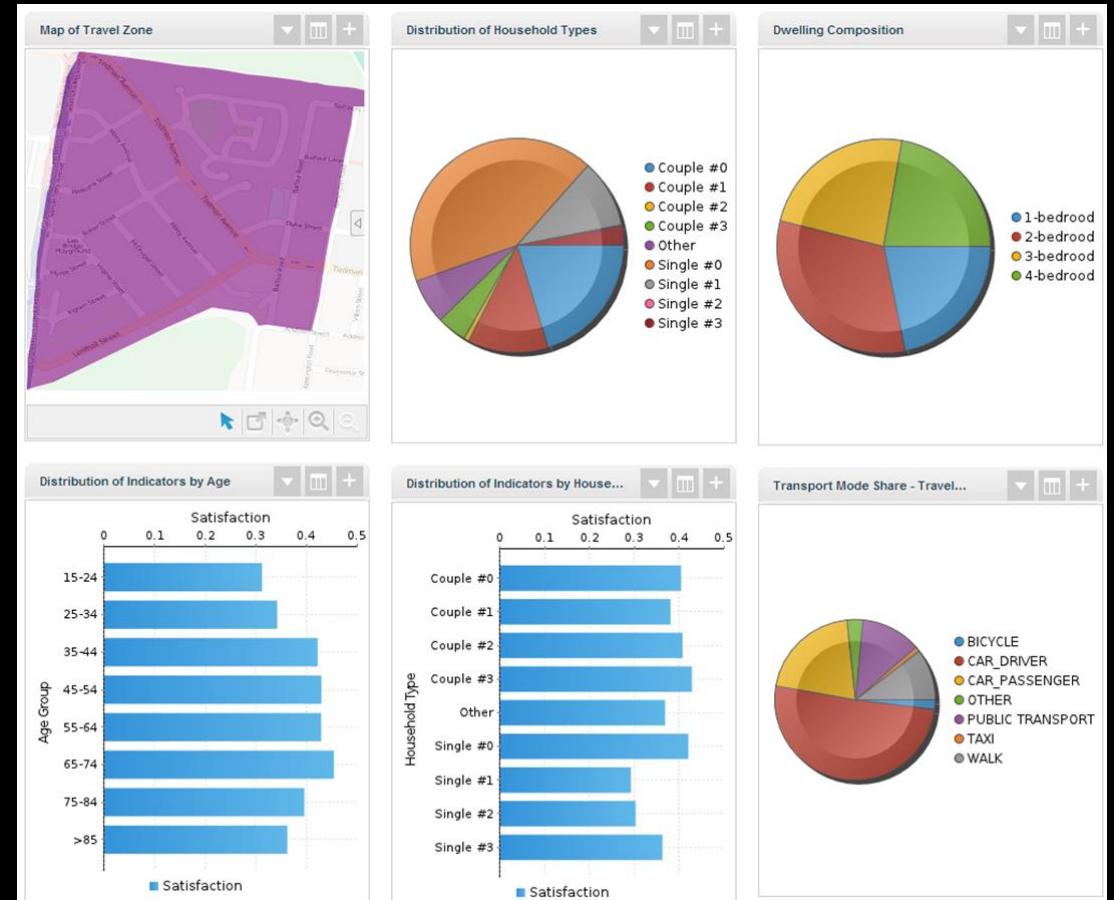
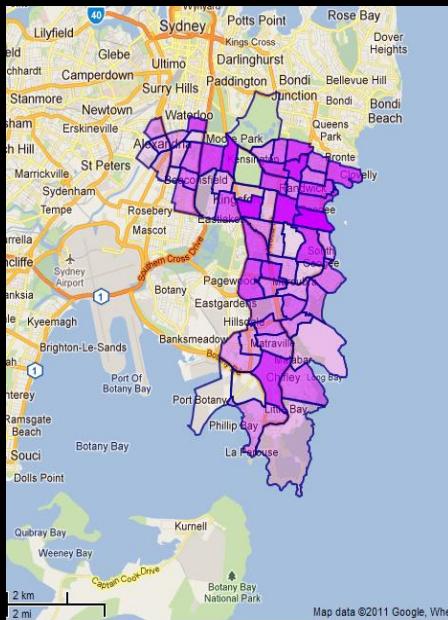
6 Transport Purposes

4 Dwelling Categories

Period: 2006-2026

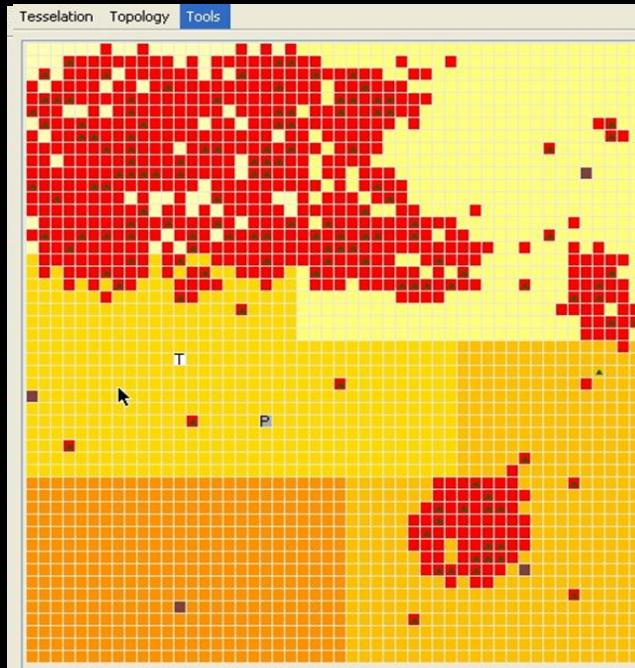
Calibration: Census 2006

Validation: Census 2011



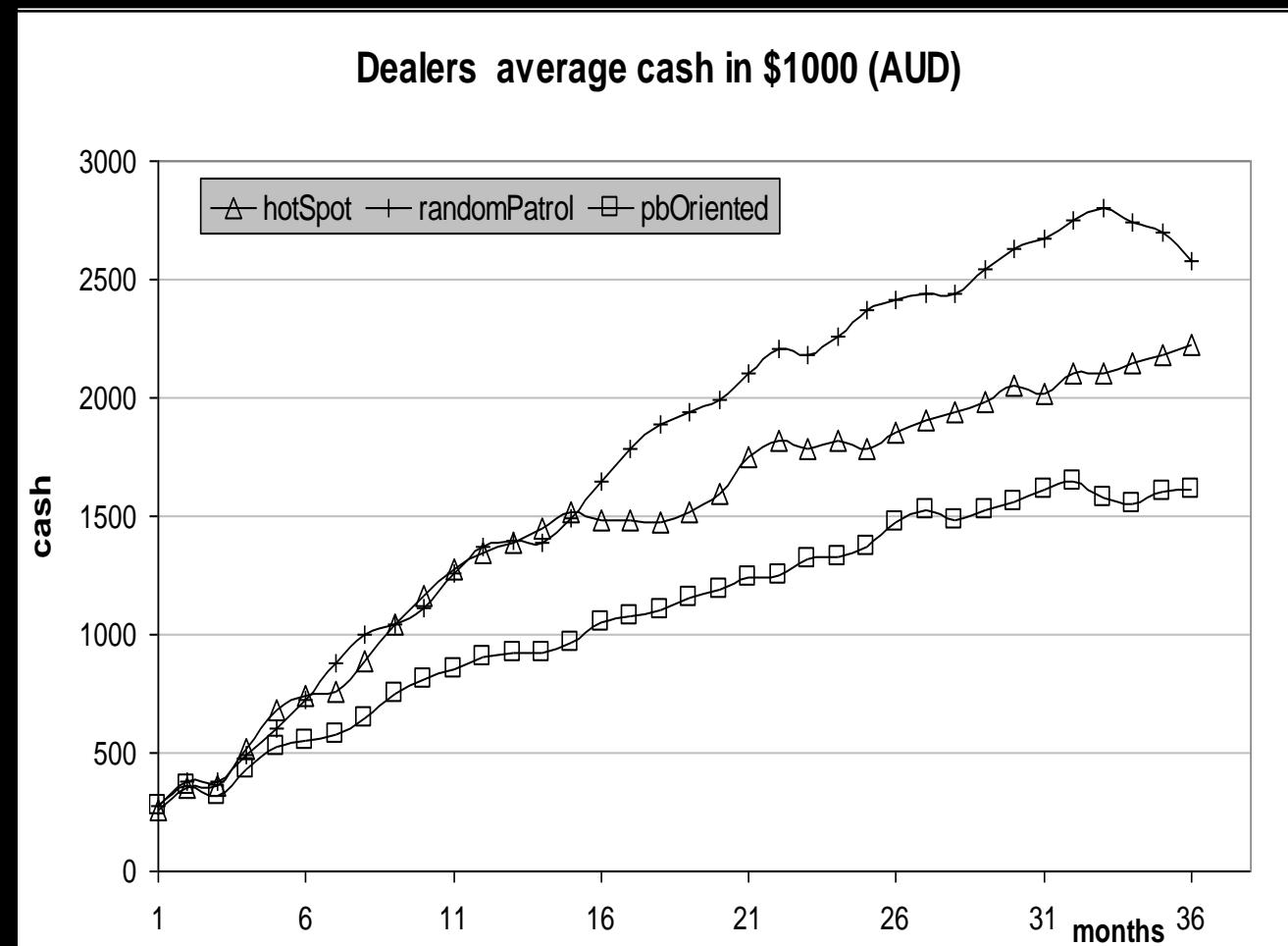
Source: Huynh et al., Systems (2015)

Social behaviour and interactions - SimDrug



Scenario#3 - Problem-oriented policing

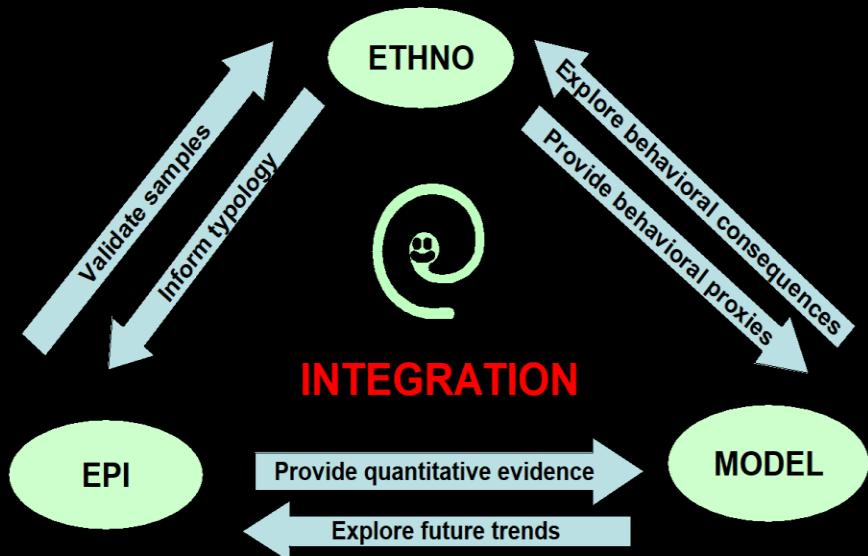
Abstract and rule-based interaction model



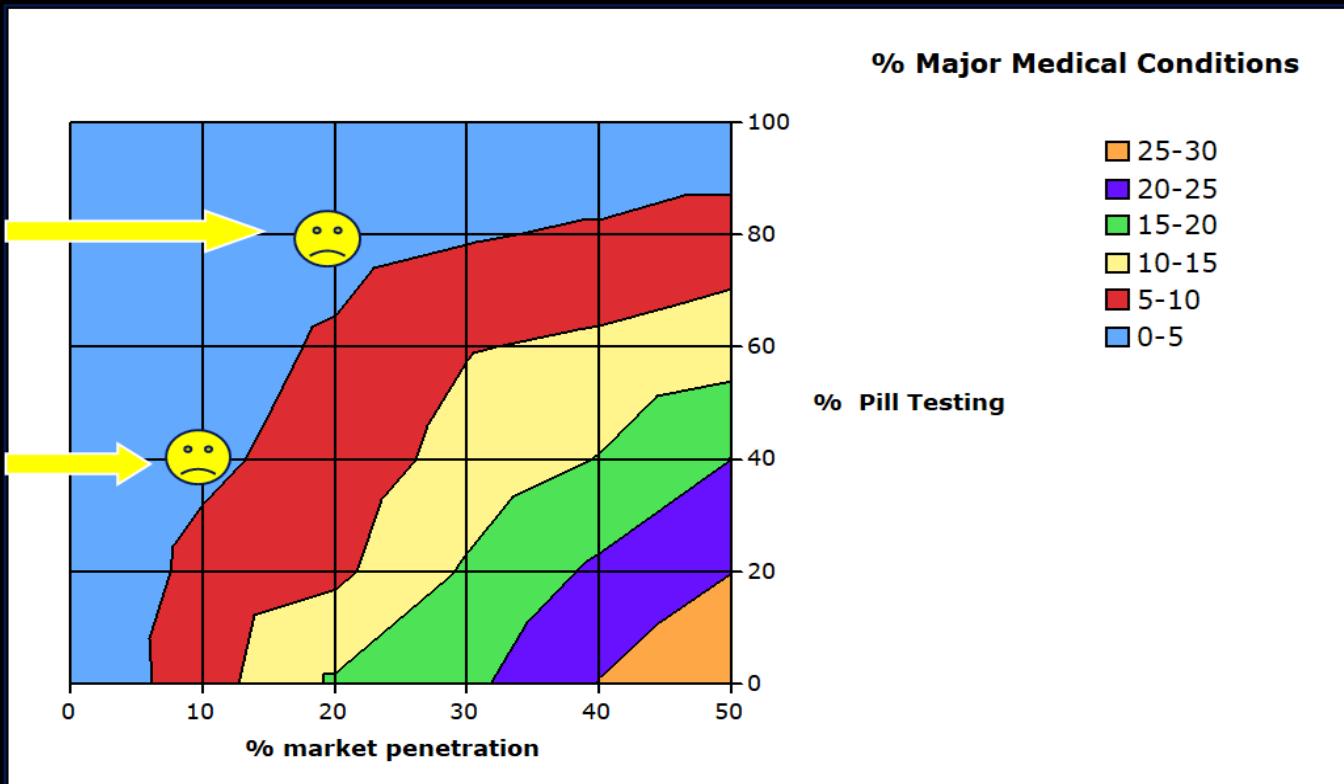
Source: Dray et al., Jour. Exp. Criminology (2008)

Social behaviour and interactions - SimAmph

Polydrug use and dependence trajectories



Generative social modelling

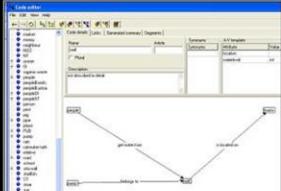
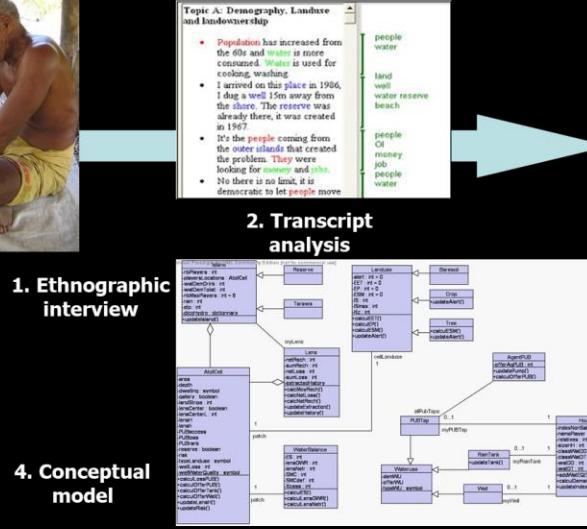


Comments:

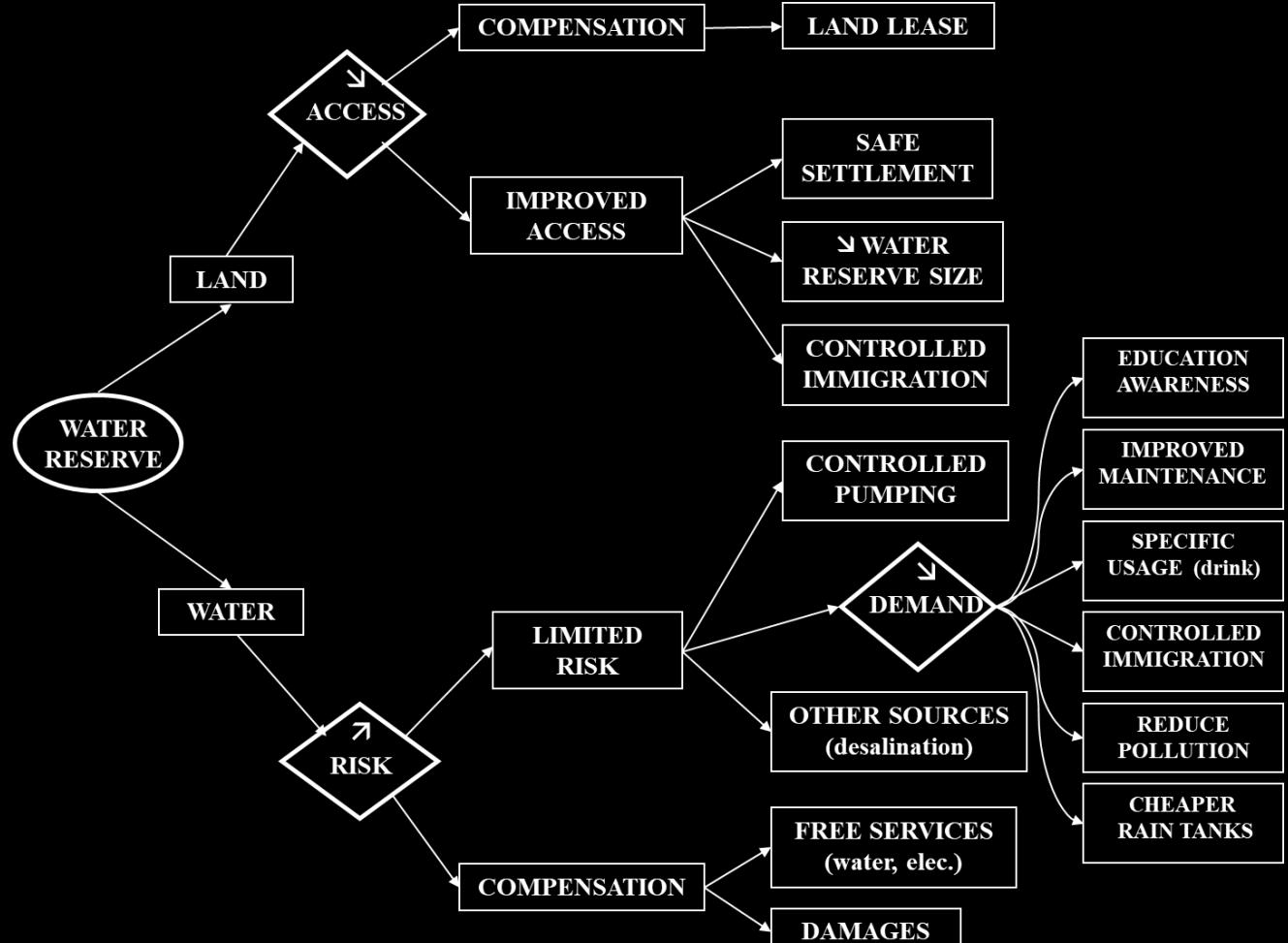
A harm reduction program aiming at keeping the prevalence of major medical conditions among users at usual levels (< 5%), should provide access to pill testing facilities to, at least, 40% of users when the market penetration is only of 10%. This percentage jumps to 80% when the market penetration reaches 20%. Beyond that point, nearly the entire population of users needs to have access to pill testing.

Source: Dray et al., Addiction (2009)

Participation and validation - Atollgame



RPG with incremental constraints



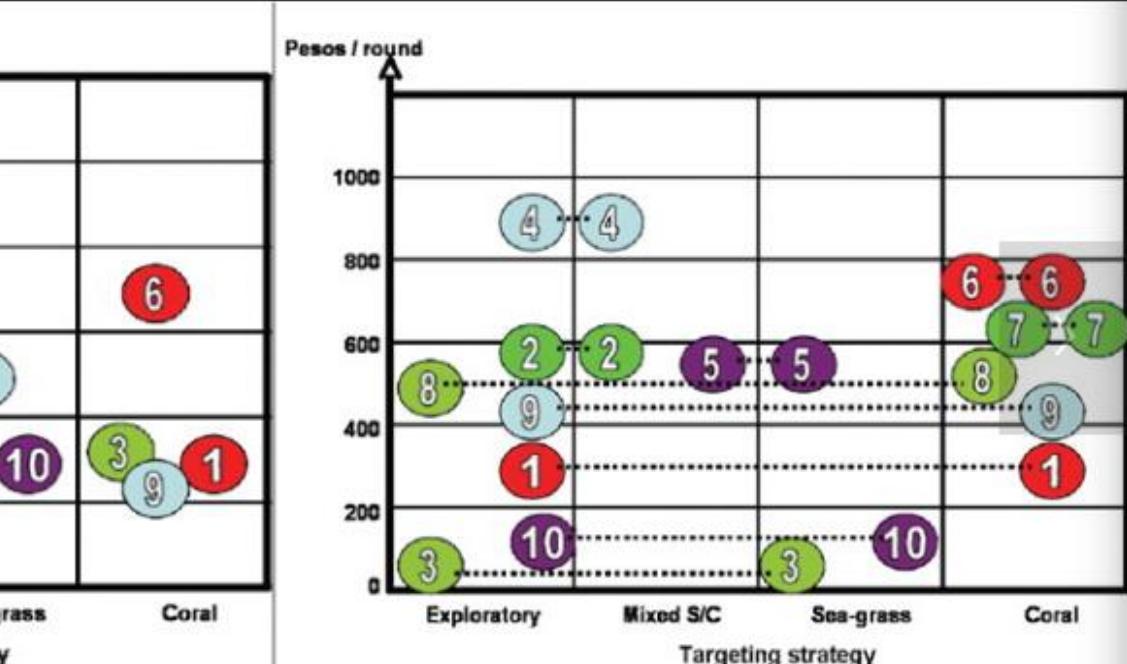
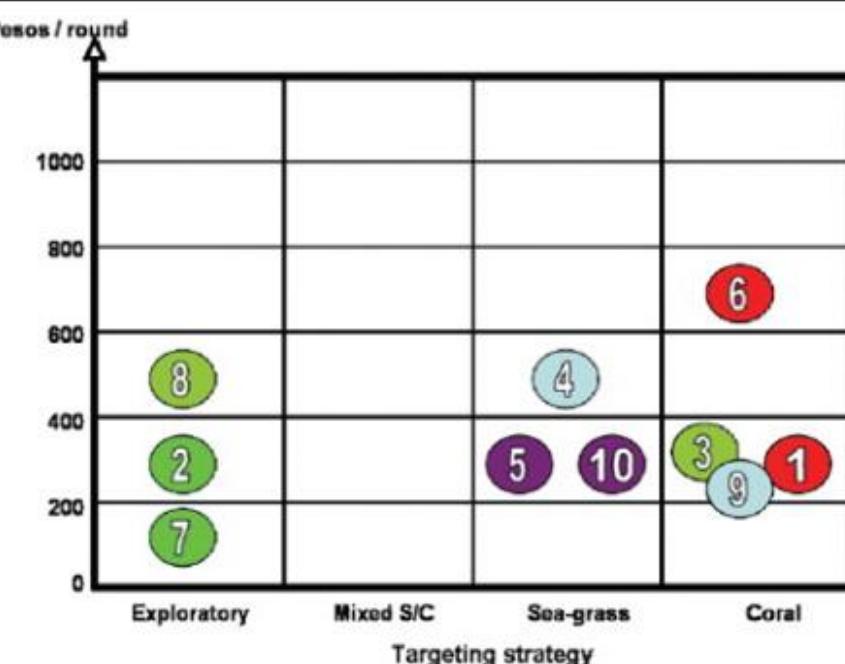
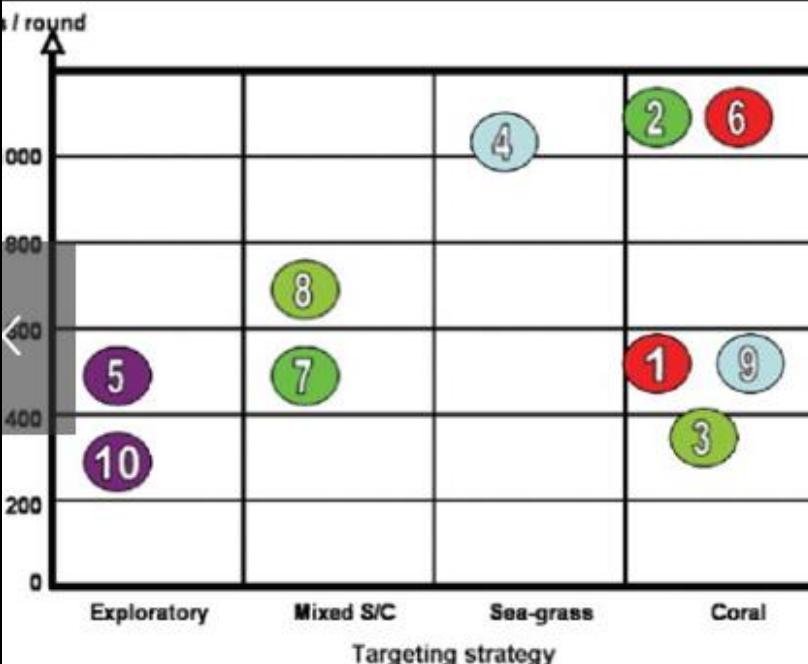
Knowledge engineering process

Source: Dray et al., JASSS (2006)

Participation and validation - Reefgame



Exploring livelihood strategies with RPG



RPG with local fishing communities

91 man 92 taxi 93 rice 94 mig 95 buil 96 97 98 aqu 99 100

Source: Cleland et al., Simulation & Gaming (2012)

Why does all this matter?



Power#1 – Geospatial dynamics



Power#2 – Hybrid modelling paradigms



Power#3 – Social behaviour and interactions

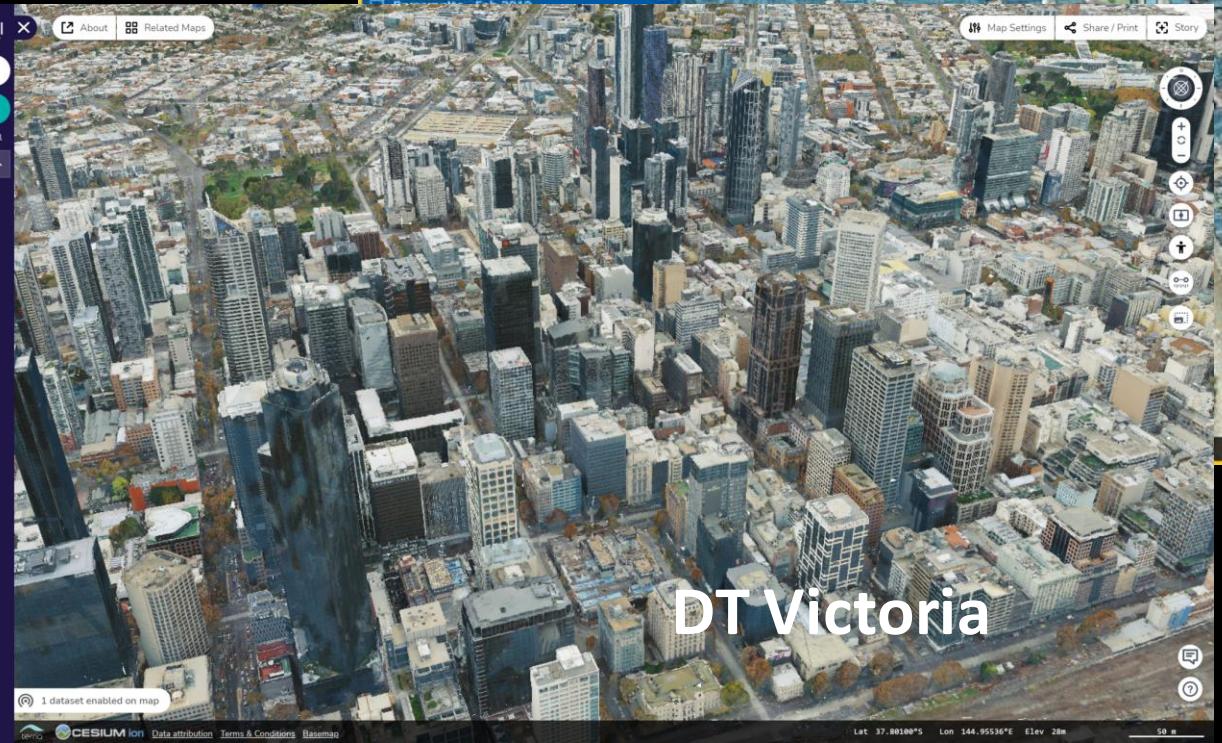


Power#4 – Participation and validation



MABS concepts and methods needed to enhance Urban Digital Twins!

UDTs are everywhere!



NSW Spatial Digital Twin

Search for locations

+ Explore map data Upload

DATA SETS (2) Remove All Collapse All

Buildings 3D

IDEAL ZOOM ABOUT DATA

Shadows None

Feature Information

- Buildings 3D - Site Data
- OBJECTID
- HEIGHT_MAX
- HEIGHT_EAVE
- ELEVATION_DATE
- ELEVATION_SOURCE
- GEOCAPE_BLD_PG_PTD
- GEOCAPE_BLD_PTD
- GEOCAPE_BT_CREATE
- GEOCAPE_BT_LT_M00
- GEOCAPE_BT_BETRTE
- GEOCAPE_CAPT_DATE
- GEOCAPE_NUMB_VERT
- GEOCAPE_AREA
- GEOCAPE_STATE_ABRE
- GEOCAPE_QUAL_CL_CD
- GEOCAPE_LOC_PTD
- GEOCAPE_STATE_PTD
- GEOCAPE_ADD_COUNT
- GEOCAPE_HAS_SP_ABZ
- GEOCAPE_SWMP_REVDT
- GEOCAPE_SOLAR_P
- GEOCAPE_SOLP_REVDT
- GEOCAPE_BLD_CD_PTD

Lat 33.87204°S Lon 151.20000°E Elev 691.05m 50 m

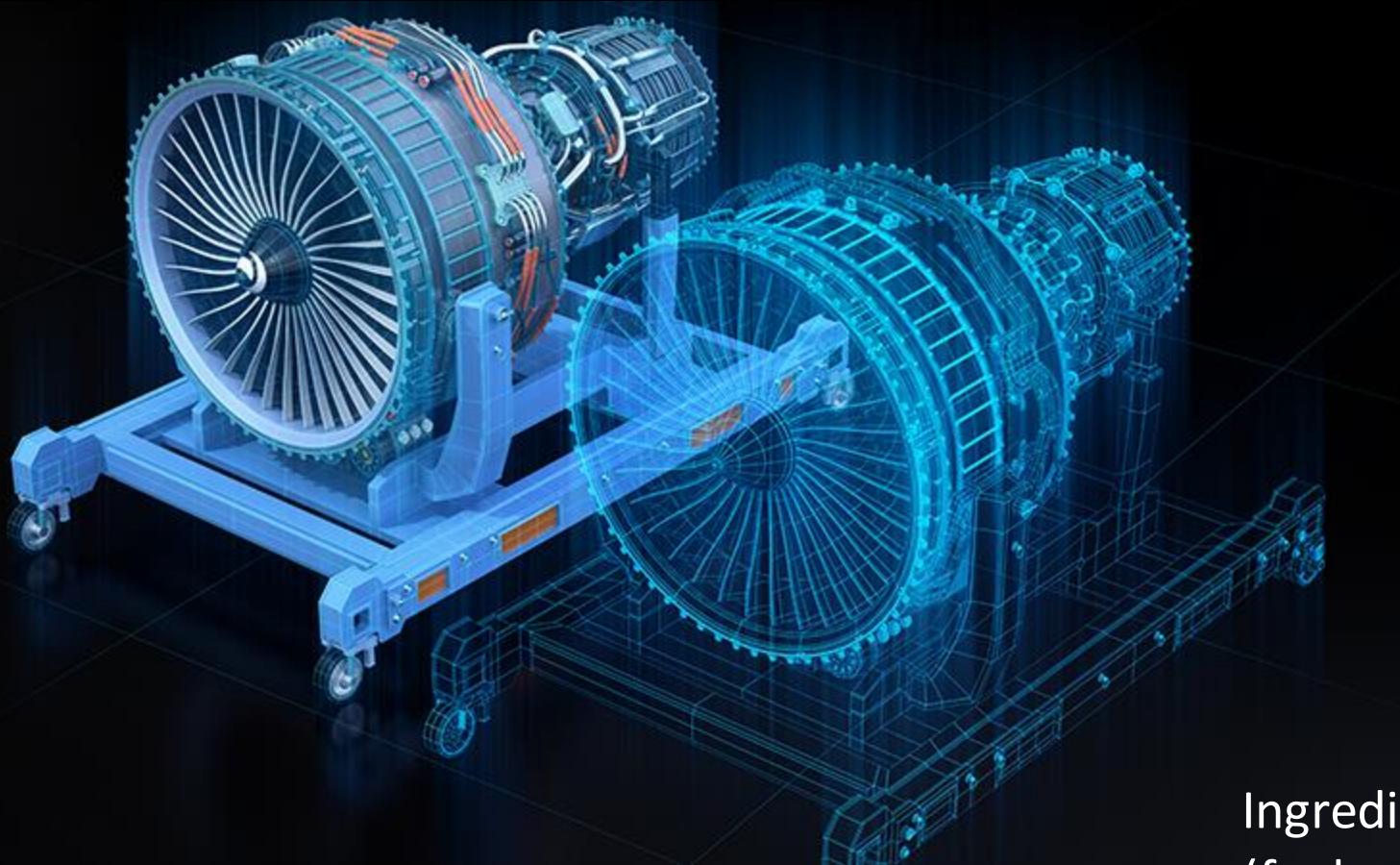


Challenges facing UDTs

- 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

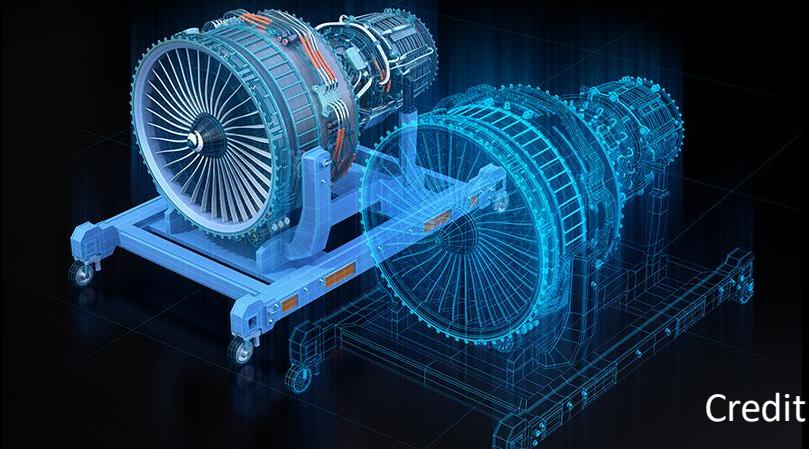


- Rolls Royce turbine
- Industrial digital twin (IDT)
- Ultra-realistic representation
- Structural digital copy
- Integrated functional simulation
- Real-time comparison
- Feedback to real system
- Objective #1: performance
- Objective #2: quality control

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

Credit: Shutterstock, 2023

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

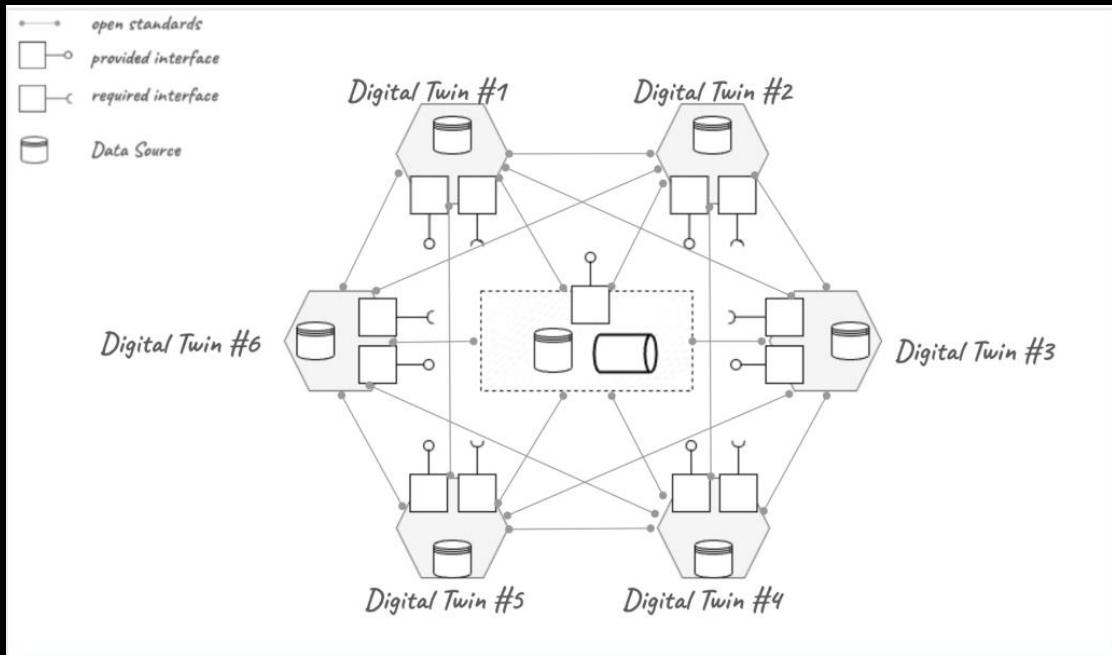
Urban DT

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

Next generation UDTs

Robustness Law (Jon Postel)

“Be conservative in what you do, be liberal in what you accept from others.”



(Source: S. Contreras Martin, 2024)



Power#1 – Geospatial dynamics

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Power#4 – Participation and validation

Bring people back, get ABM in!



(Simcity, Electronic Arts, circa 2000)

Thank you!

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