



*ARC Centre of Excellence  
in Policing and Security*

# Matching Modelling Techniques to Policy Problems

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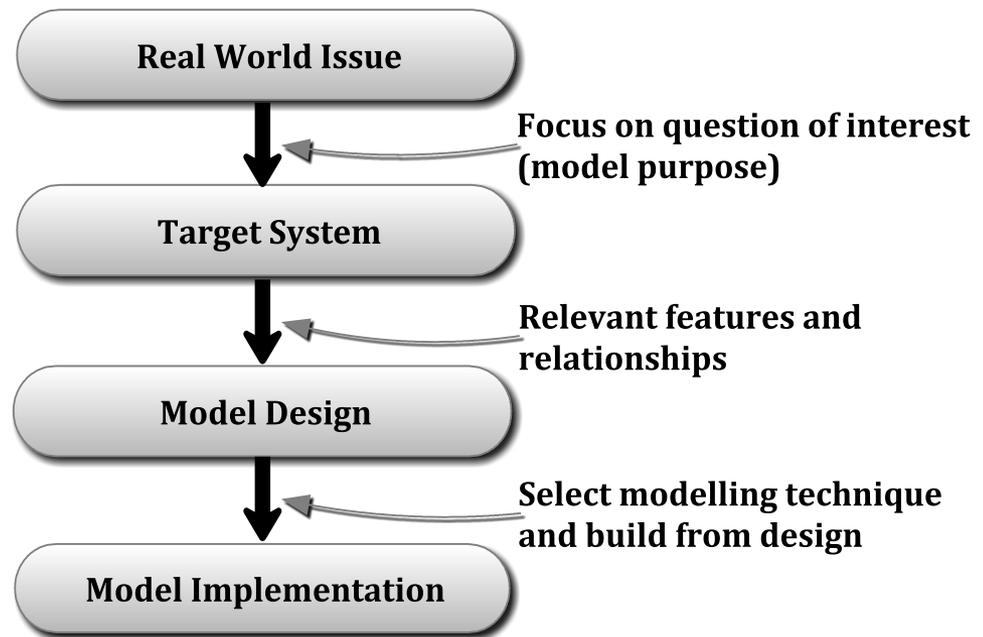


# What is the presentation about

- Short answer: a forthcoming book
  - Title: ??? (Fit for purpose?)
- Audience: research leaders and policy developers in complex real world issues
- Content:
  - What can models do?
  - Choosing a model (and modeller)
  - Effective involvement in modelling process
  - Case studies (19)
    - From environment, public health, policing and security literature

# What is a model?

- Abstraction
  - Simple, focus
  - Easier to understand
- Of target system
  - Enough detail to extrapolate from model to system
- Language
  - External to modeller
  - Diagrams, equations, game rules, simulations



# Selecting a modelling technique

- Three sets of constraints:
  - Functionality: How is the model output to be used in the broader project (eg forecasting, communication, decision making)?
  - Accuracy: want to match assumptions of technique with characteristics of target system
  - Feasibility: Practical considerations such as time, cost, expertise, data availability
- Trade-offs within and between groups

# Example – water management plan

- Middle Rio Grande Water Plan 2000-2050
  - <http://www.waterassembly.org/waterplan.htm>
- Rio Grande main water supply for several communities
  - Increased population, hence demand
  - Legal constraint: minimum river outflow
- Environmental considerations (eg bosque)
- Model to assist planning

# Case study references

- Middle Rio Grande Water Assembly (2004). *Middle Rio Grande Regional Water Plan 2000-2050*. <<http://www.waterassembly.org/waterplan.htm>>.
- Passell H, VC Tidwell, SH Conrad, RP Thomas & J Roach (2003). *Cooperative Water Resources Modeling in the Middle Rio Grande Basin*. Albuquerque, NM: Sandia National Laboratories.
- Passell H, VC Tidwell, D Thomas & SH Conrad. (2004). *Cooperative modeling: Community-based water resources management for the Rio Grande*. Paper presented at Identifying Technologies to Improve Regional Water Stewardship: North – Middle Rio Grande Corridor  
<[http://www.unm.edu/~cstp/water\\_reports.html](http://www.unm.edu/~cstp/water_reports.html)>
- Cockerill K, V Tidwell & H Passell (2004). 'Assessing Public Perceptions of Computer-Based Models', *Environmental Management*, 34(5) 609.
- Cockerill K, H Passell & VC Tidwell (2006). 'Cooperative modeling: Building bridges between science and the public', *Journal of the American Water Resources Association*, 42(2) 457-471.

# Model requirements

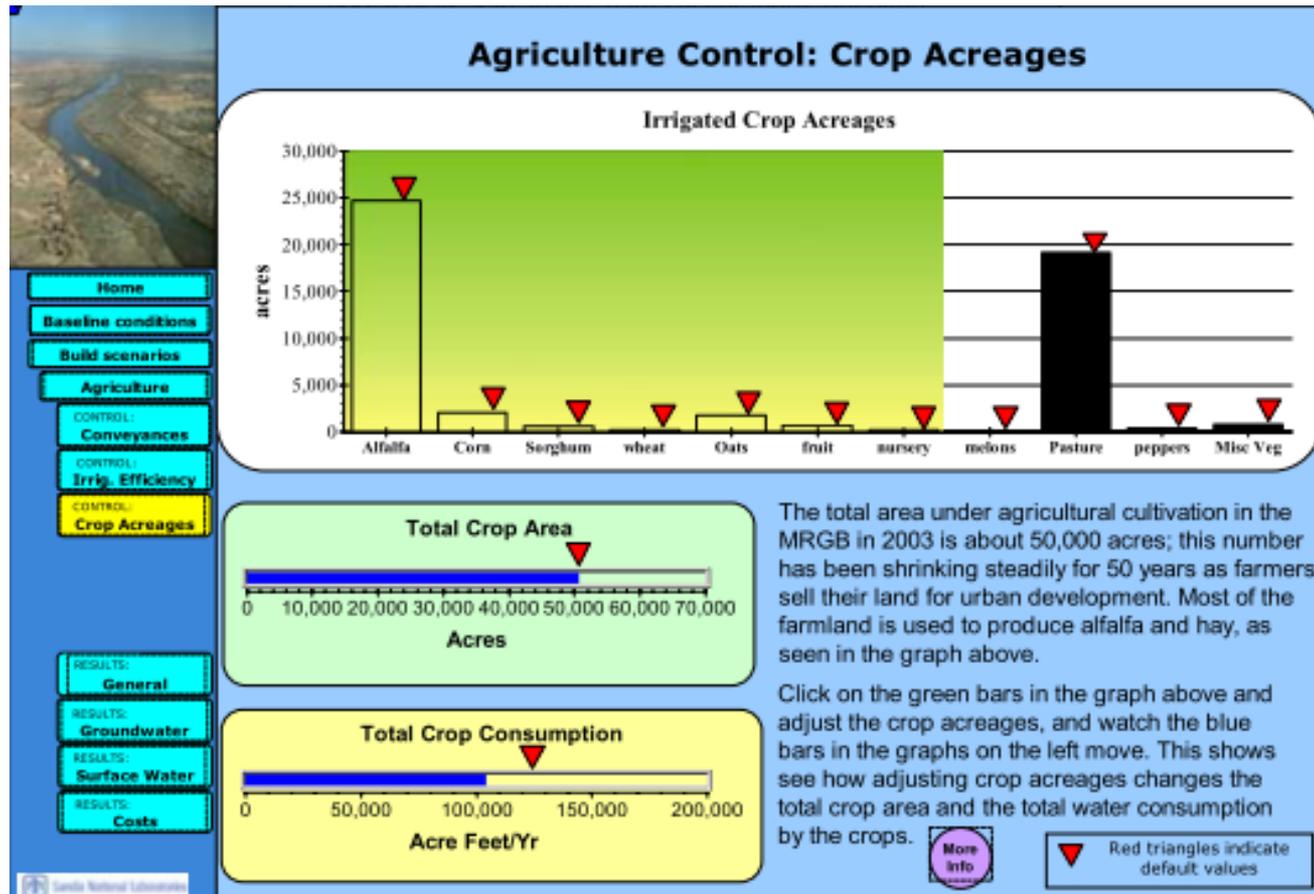
## Functionality

- Include broad knowledge:
  - scientific (eg water cycle)
  - community (eg preferences)
- Develop consensus on options
  - Accessible option setup and results
- Compare effect of different options

## Accuracy

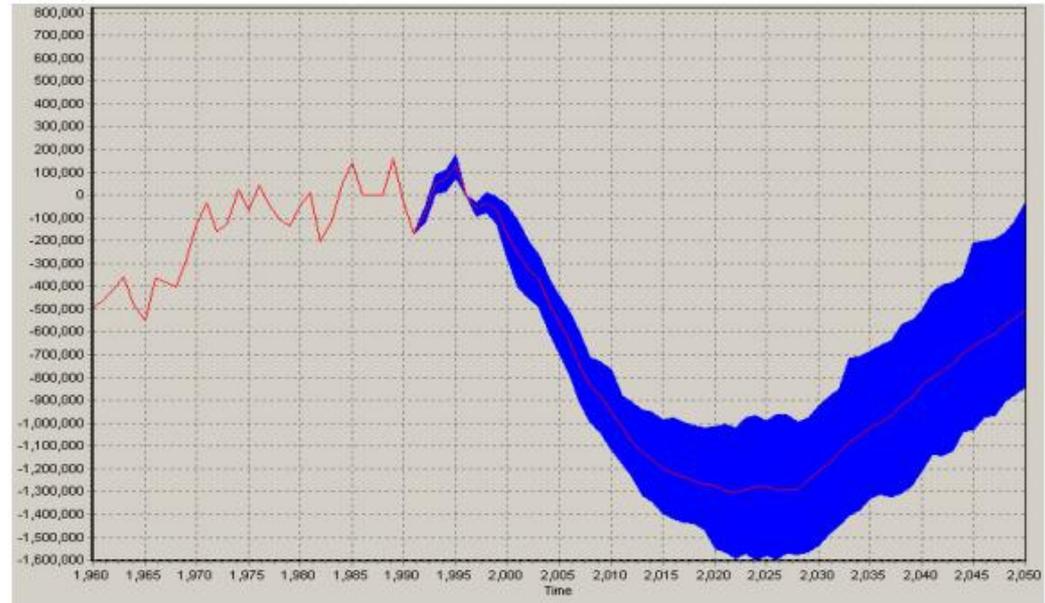
- Key output: water volume
- Dynamic:
  - inflows / outflows
  - analyse by year
- Quantitative: relationships as equations appropriate
- Aggregate: water is water

# Case study – model input screen shot



# Case study – model output

- Change in groundwater over time
- Many runs of same option
  - Option is the recommended set of changes



# Summary of approach

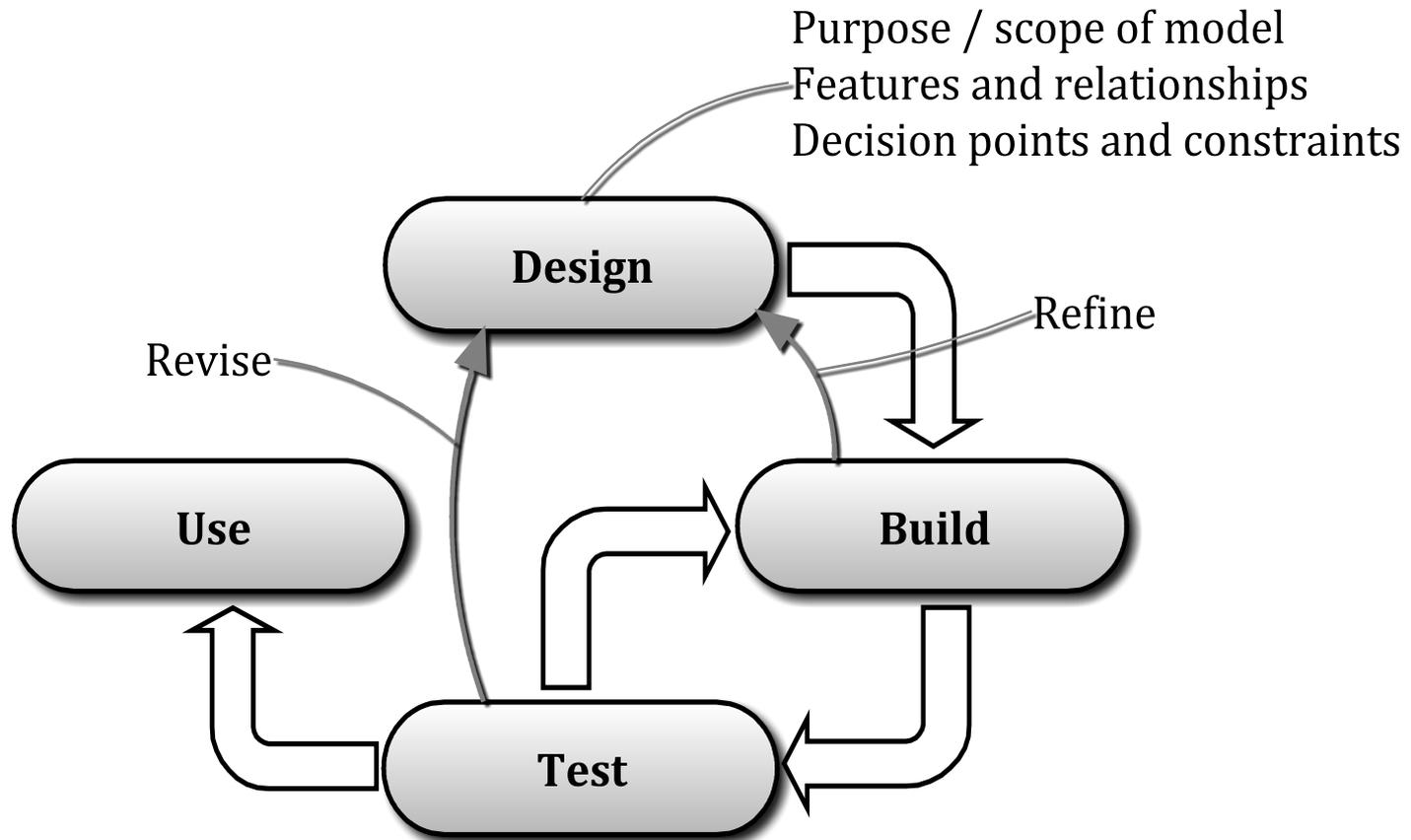
## Functionality

- Model (with modelling process) can provide different insights than surveys, RCT etc
- Common requirements of model for many complex real world issues
- Different techniques can deliver different but overlapping requirements
- Use case studies to inspire

## Accuracy

- Systems to be modelled have specific characteristics
- Modelling techniques have specific assumptions
- Theoretical matching through a taxonomy
- 19 case studies cover 13 methods

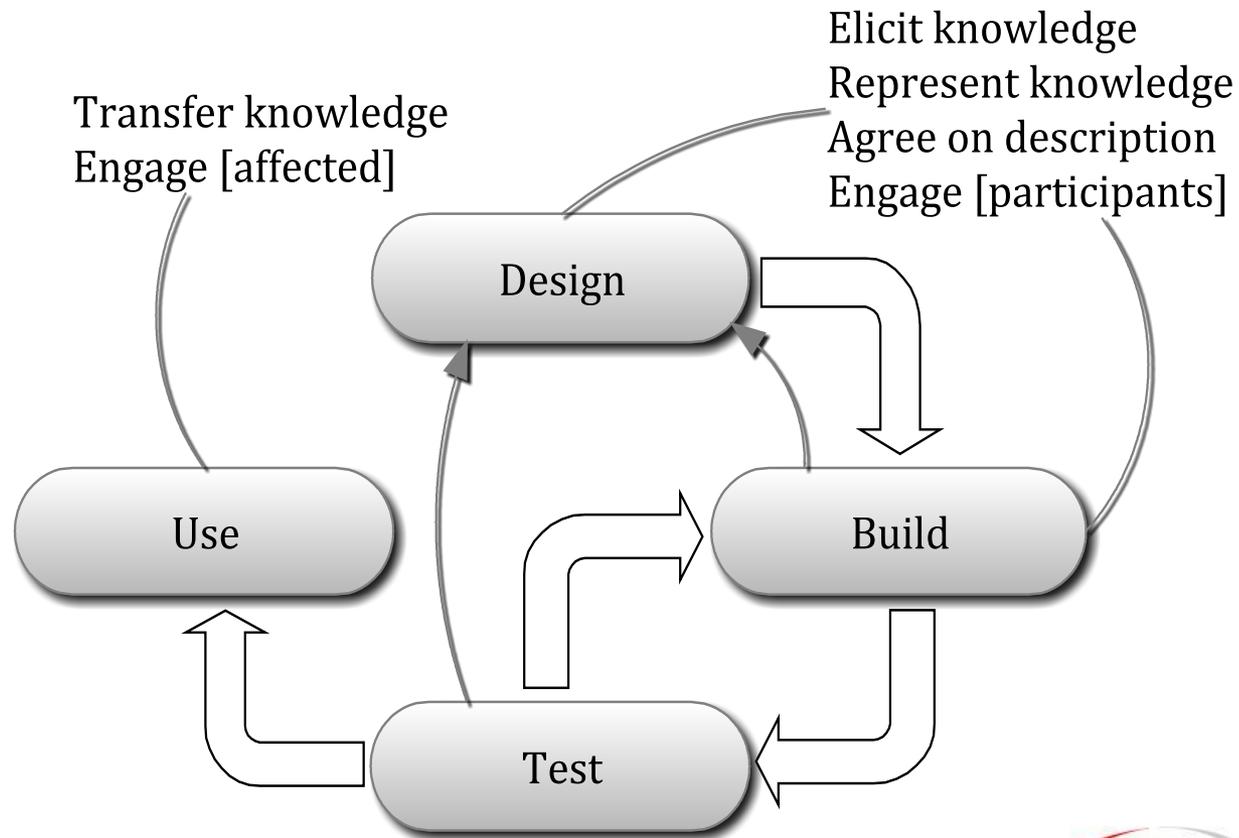
# Reinforced by modelling process



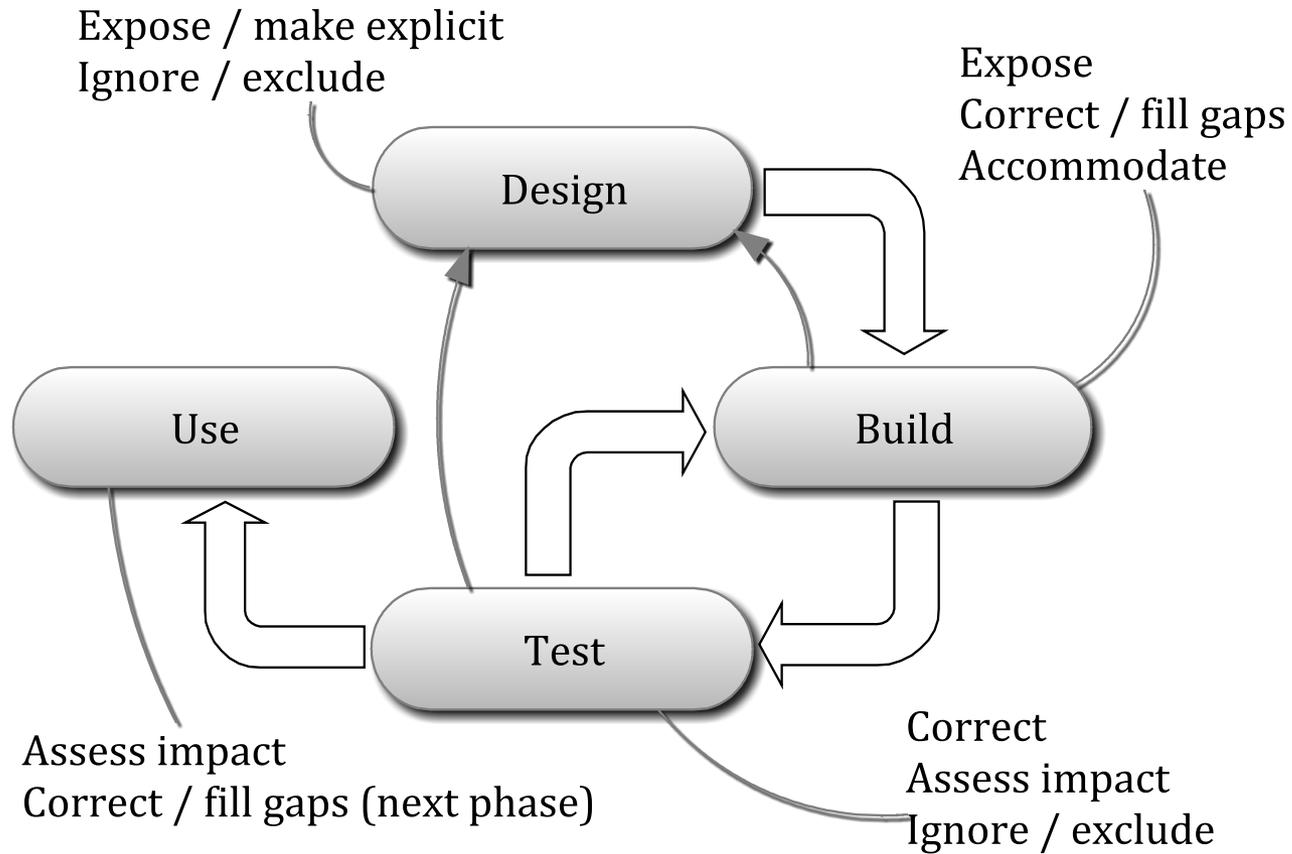
# Functionality: Role in project

- Knowledge synthesis
  - Types: Situational (facts, perspectives), Preferences (values)
  - Sources: Discipline expertise, Interest groups, Community
- Manage unknowns
  - Types: Absence, inconsistency, inaccuracy, (inherent) uncertainty, irrelevance
- Support policy and practice
  - Broader inputs: participation, knowledge, unknowns

# Knowledge synthesis - tasks

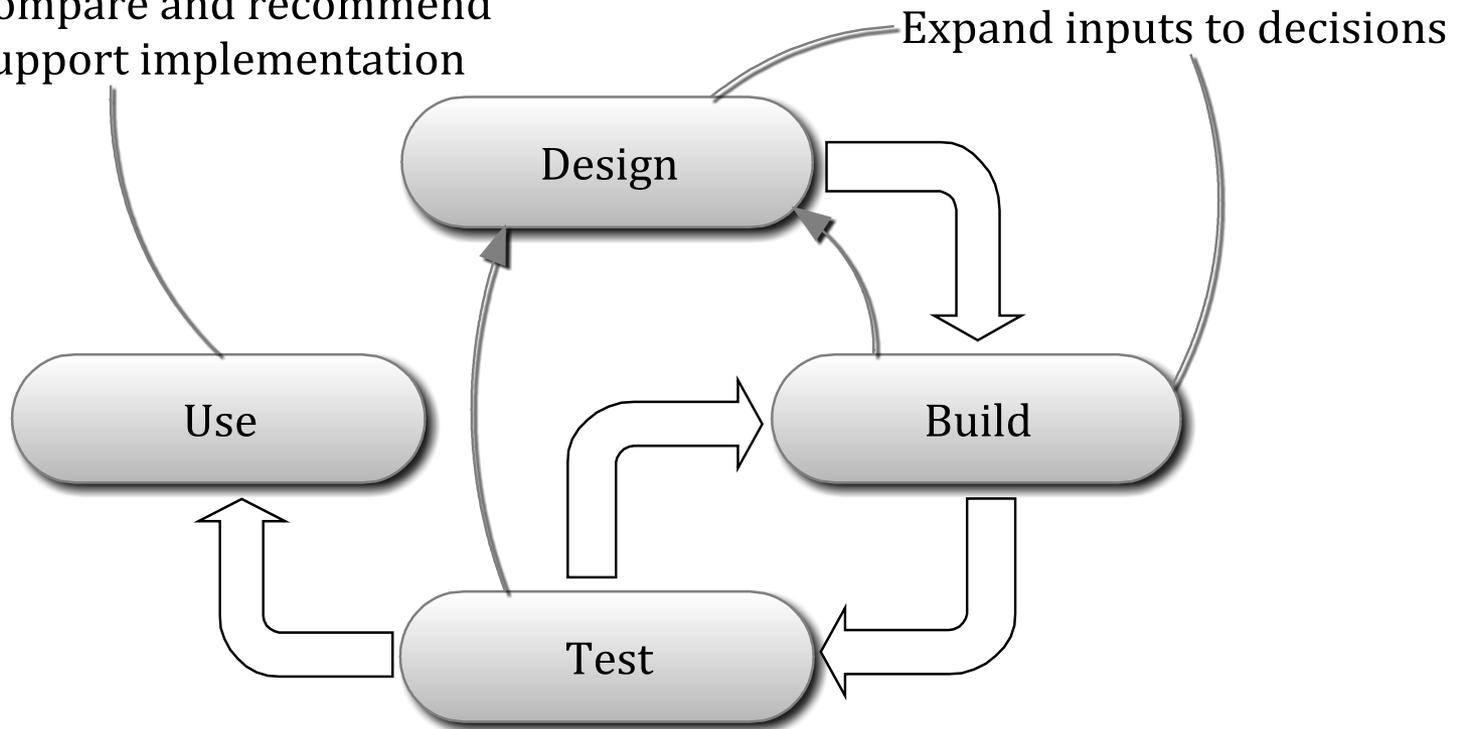


# Manage unknowns - tasks



# Policy and practice support - tasks

Prioritise additional inputs  
Compare and recommend  
Support implementation



# Accuracy: Matching characteristics

- Abstraction
  - Right question
  - Identify relevant features / relationships
- Can key entities and relationships be validly quantified?
- Static vs dynamic
- Interaction?
  - Between individuals or groups in model
  - Between entities and environment
- Cohort vs individual
- Spatial representation
- NOTE: hybrid and systems of models

# Taxonomy – Top layer

|         | Qualitative   | Quantitative Only   |
|---------|---|---|
| Static  | Static Relationship Diagrams<br>Soft Systems Methodology<br>Scenario Analysis<br>Bayesian Networks<br>Social Network Analysis | Decision Trees<br>Bayesian Networks   |
| Dynamic | Causal Loop Diagrams<br>Flowcharting<br>Social Network Analysis   | Markov State Transition<br>Dynamic Microsimulation<br>Statistical Model<br>System Dynamics<br>Cellular Automata<br>Agent Based Modelling<br>Discrete Event Simulation |

# Taxonomy – Dynamic or Quantitative

|                | Cohort   | Individual   |
|----------------|--|--|
| No Interaction | Markov State Transition<br>Statistical Model   | Markov State Transition  |
| Interaction    | Causal Loop Diagrams<br>Dynamic Microsimulation<br>System Dynamics<br>Statistical Models | Flowcharting<br>Social Network Analysis<br>Cellular Automata<br>Agent Based Modelling<br>Discrete Event Simulation |

# Taxonomy – Spatial representation

| Technique                 | Spatial Representation   |
|---------------------------|--|
| Flowcharting              | Limited: Questions about status of neighbours at decision nodes  |
| Social Network Analysis   | Edges exist between neighbouring entities  |
| Cellular Automata         | Explicit correspondence between grid position and represented location, movement not permitted             |
| Agent Based Modelling     | Explicit correspondence between grid position and represented location, movement permitted                 |
| Discrete Event Simulation | Limited: State change from one location to another, but may be presented as movement in animated interface |

# Book details - practical

- Authors:
  - Jennifer Badham and Gabriele Bammer
  - Integration and Implementation Sciences  
([www.i2s.edu.au](http://www.i2s.edu.au))
  - NCEPH / ANU
- When?
- Intend to publish free online with low cost print on demand option

# Acknowledgements - CEPS

- The Australian Research Council (ARC) Centre of Excellence in Policing and Security (CEPS) established in 2007 with the following aims:
  - To be a **national centre of excellence in research**, working across four universities: Griffith University, The Australian National University, The University of Queensland and Charles Sturt University.
  - To **boost policing and security research** capacity in Australia amid the growing complexity and internationalisation of transnational crime in the post 9/11 environment.
  - To shape **policy and practice reform** to strengthen the security and wellbeing of Australia.

