

› **TAMING COMPLEXITY**  
Understanding the Urban Operating Environment as a System

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16 December 2021, NATO SAS TECHNICAL COURSE

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## Taming complexity

01. URBAN ENVIRONMENT - A COMPLEX SYSTEM
02. COLLABORATIVE SYSTEMS THINKING
03. APPLICATIONS OF SYSTEMS THINKING
04. CONCLUSIONS



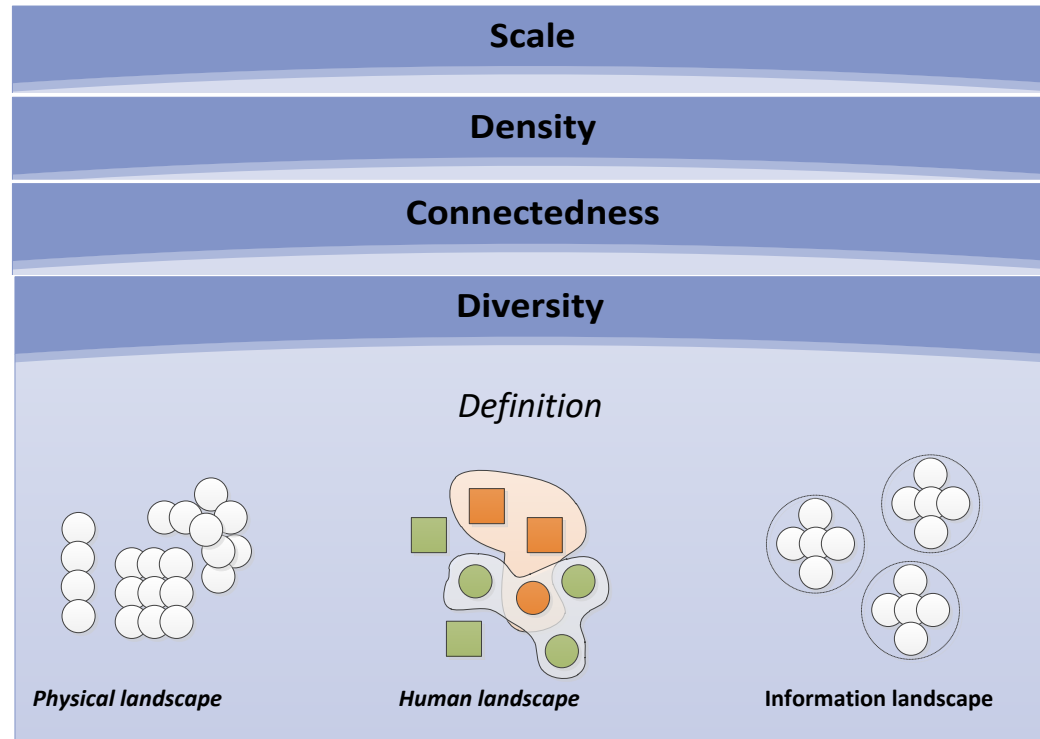
› **01. INTRODUCTION**  
Understanding the Urban Operating Environment as a System



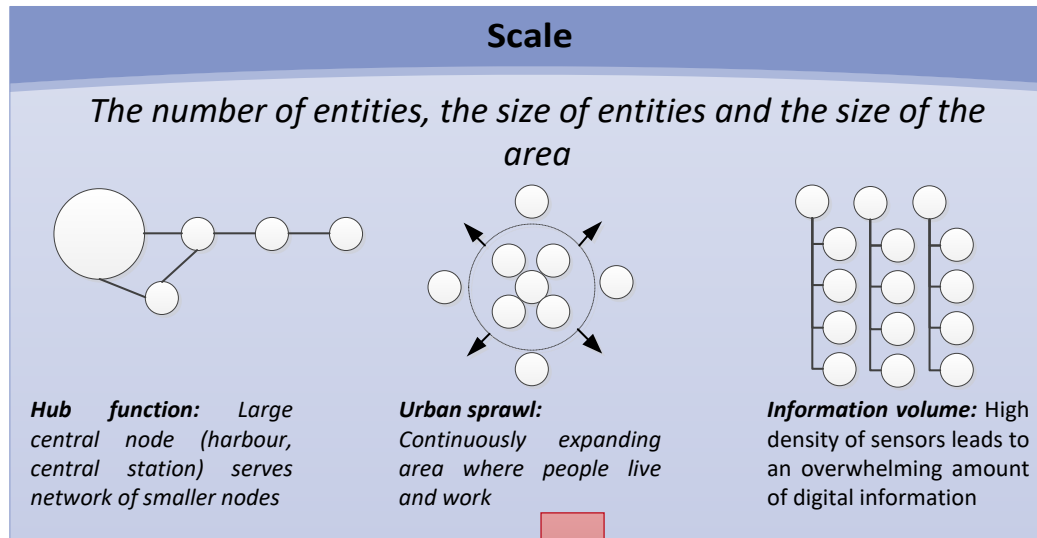
# THE OPERATING ENVIRONMENT IN MULTIPLE DIMENSIONS



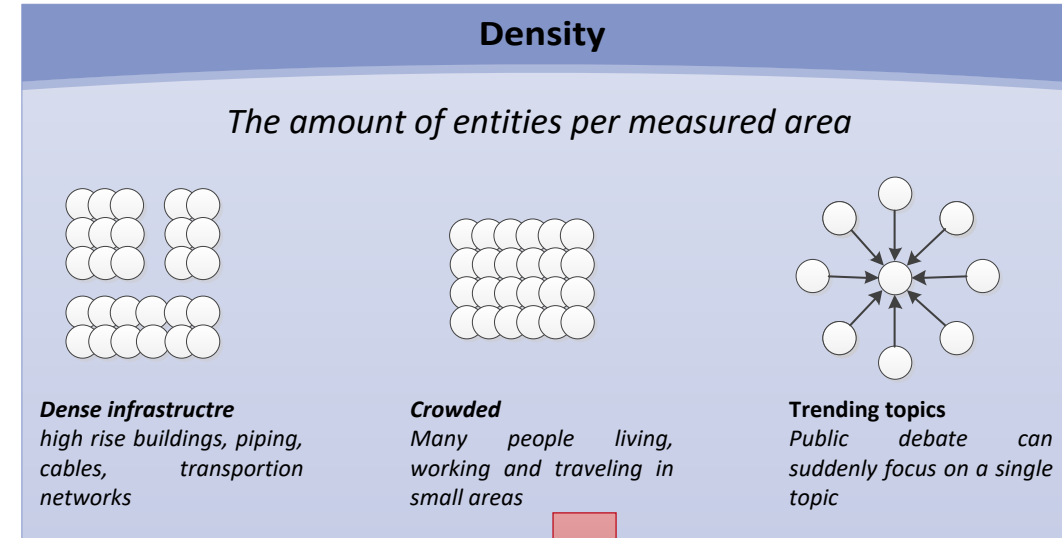
# DOMAINS, PROPERTIES AND CONFIGURATIONS



# PROPERTIES AND CONFIGURATIONS



- *Urban swallow*
- *Impossible to cordon*

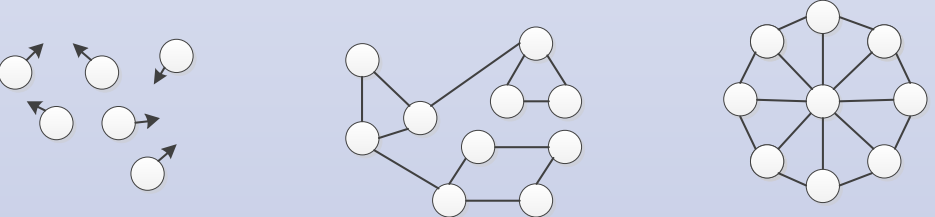


- *Collateral damage*
- *Line of sight*
- *Control of the narrative*

# PROPERTIES AND CONFIGURATIONS

### Connectedness

*The number of connections between entities within the area and outside the area*



**Trade hub:**  
*The littoral connects sea, land and air, creating dense travel patterns*

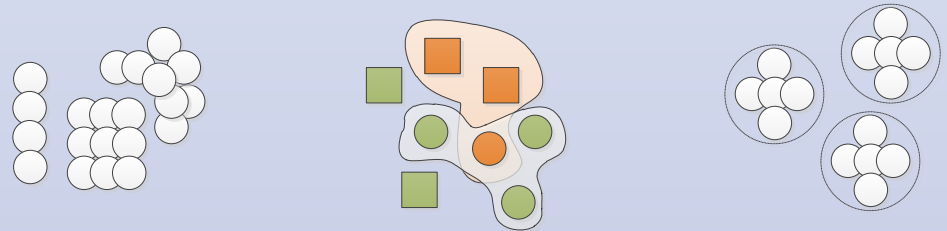
**Social networks:**  
*People connect online and offline in communities of interest*

**Smart cities:**  
*Entities (businesses, people, devices) are connected 24/7*

- Cascading effects
- Limited opportunity for surprise

### Diversity

*The variety of entities within the area*



**Urban jungle:** *Variety of lay-out, building types, functional roles: Slums, suburbia, industrial areas*

**Demographics:**  
*Individuals form groups based on: Ethnicity, culture, age, religion, social status*

**Filter bubbles:**  
*Different groups get information from different sources*

- Adversary recognition problem
- Varying conflict perceptions

An aerial night view of a city harbor. In the foreground, a large, illuminated crane stands on a barge. The harbor is filled with various boats, including several large cargo ships docked at a pier on the right. The city skyline is visible in the background, with numerous high-rise buildings lit up. The water reflects the city lights.

› **02. URBAN ENVIRONMENT**  
Understanding the Urban Operating Environment as a System



Moving beyond descriptions of properties...

...towards an understanding of cities as systems.



# › WHAT IS A SYSTEM?

- › A set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its “function” or “purpose”. (Meadows)
- › .. More than the sum of parts
- › .. A whole – taking something away or adding something might change the behaviour of the system
- › .. the system operates through the flow of information and material

## **STRUCTURE DRIVES BEHAVIOUR**

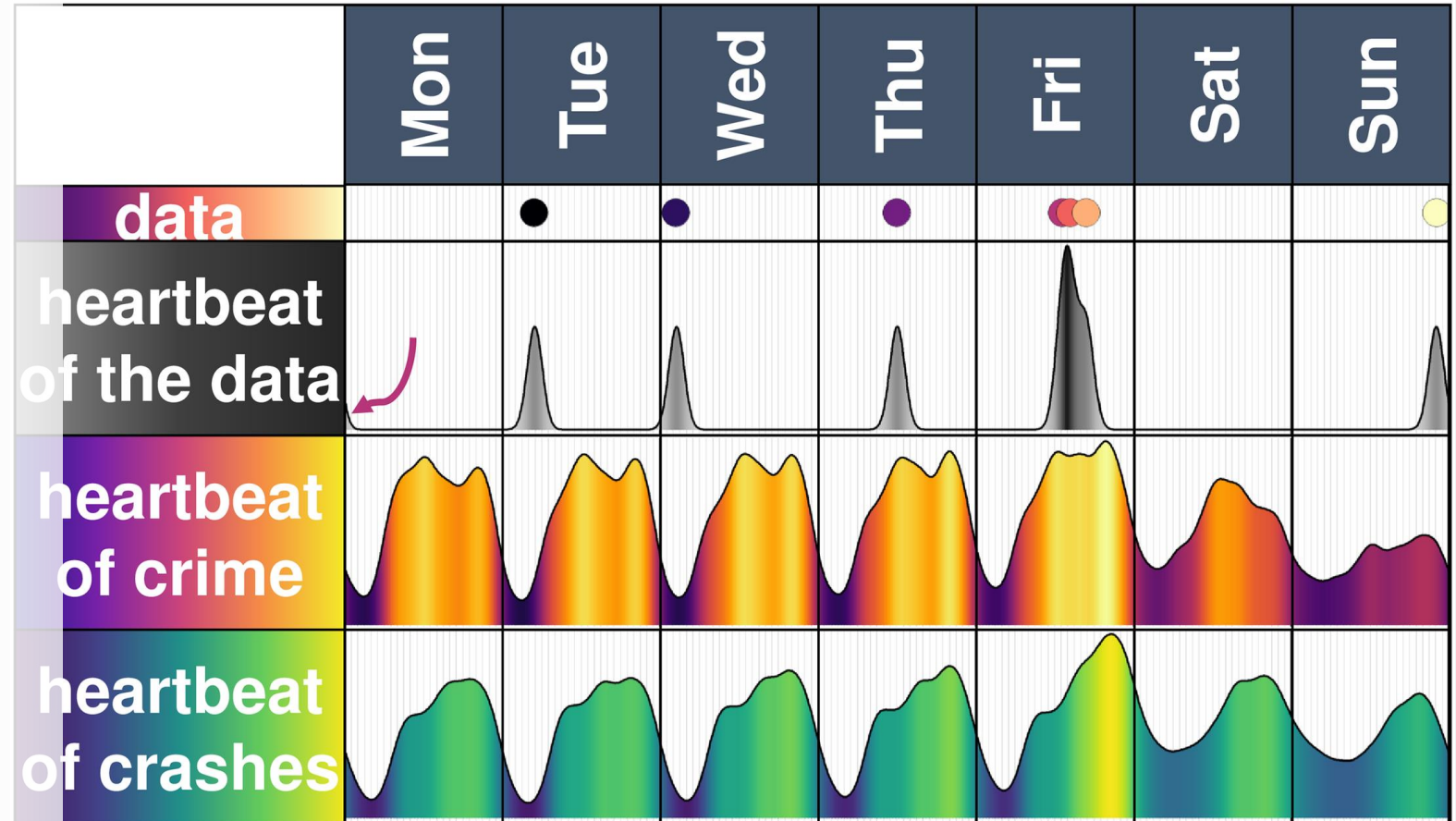


## › CITIES AS SYSTEMS

- › *‘Cities are not build environments. The infrastructure is just there to help. The intent of cities is that people interact’*
  - › Bettencourt
  
- › *‘Cities really function as sets of interactions that flow across networks: some physical and visible but many relational, social, and often invisible’*
  - › Batty, Cheshire

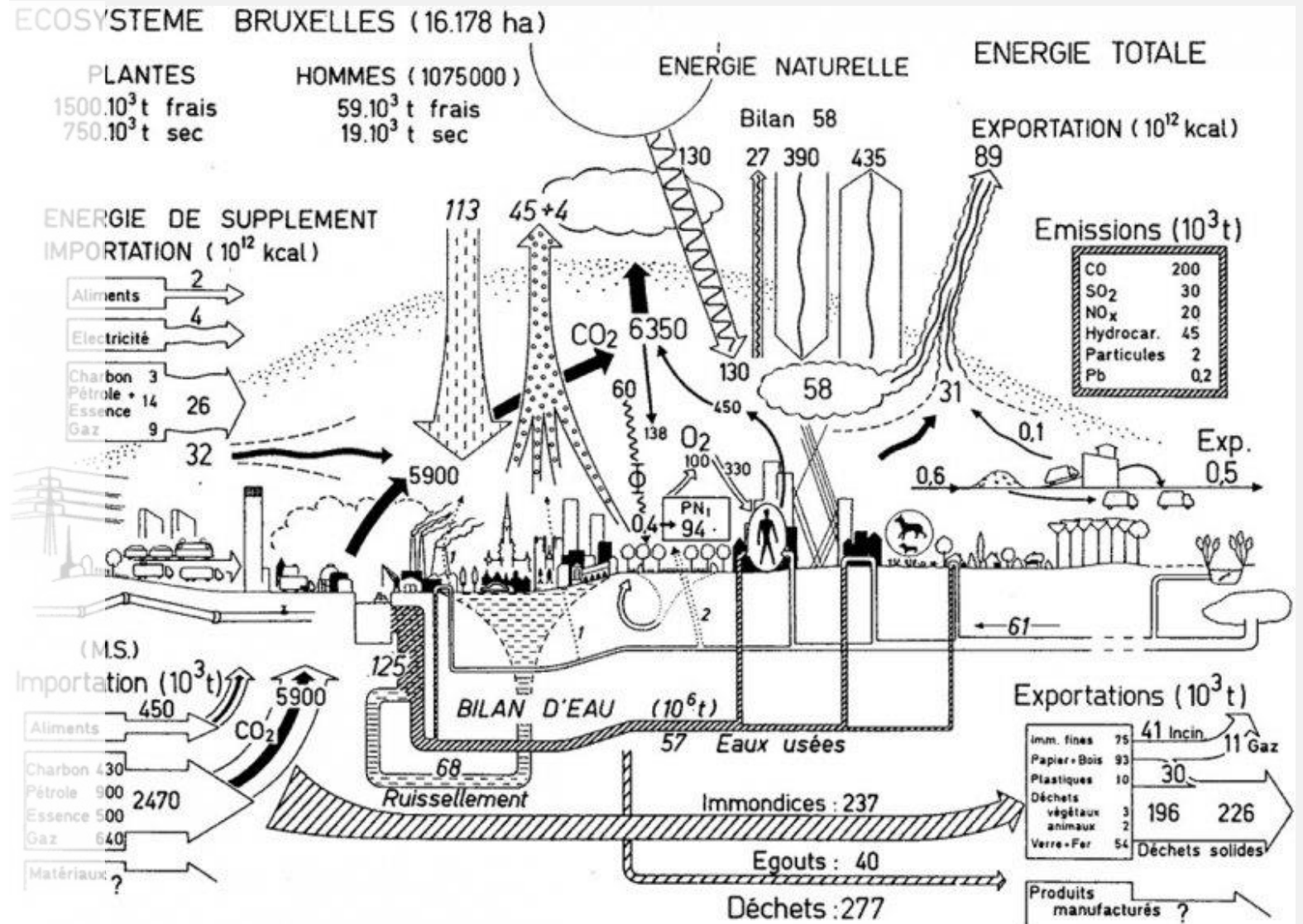


# CITIES HAVE A HEARTBEAT



Prieto Curiel, R., Patino, J. E., Duque, J. C., & O'Clery, N. (2021). The heartbeat of the city. *PloS one*, 16(2), e0246714.

# CITIES HAVE A METABOLISM

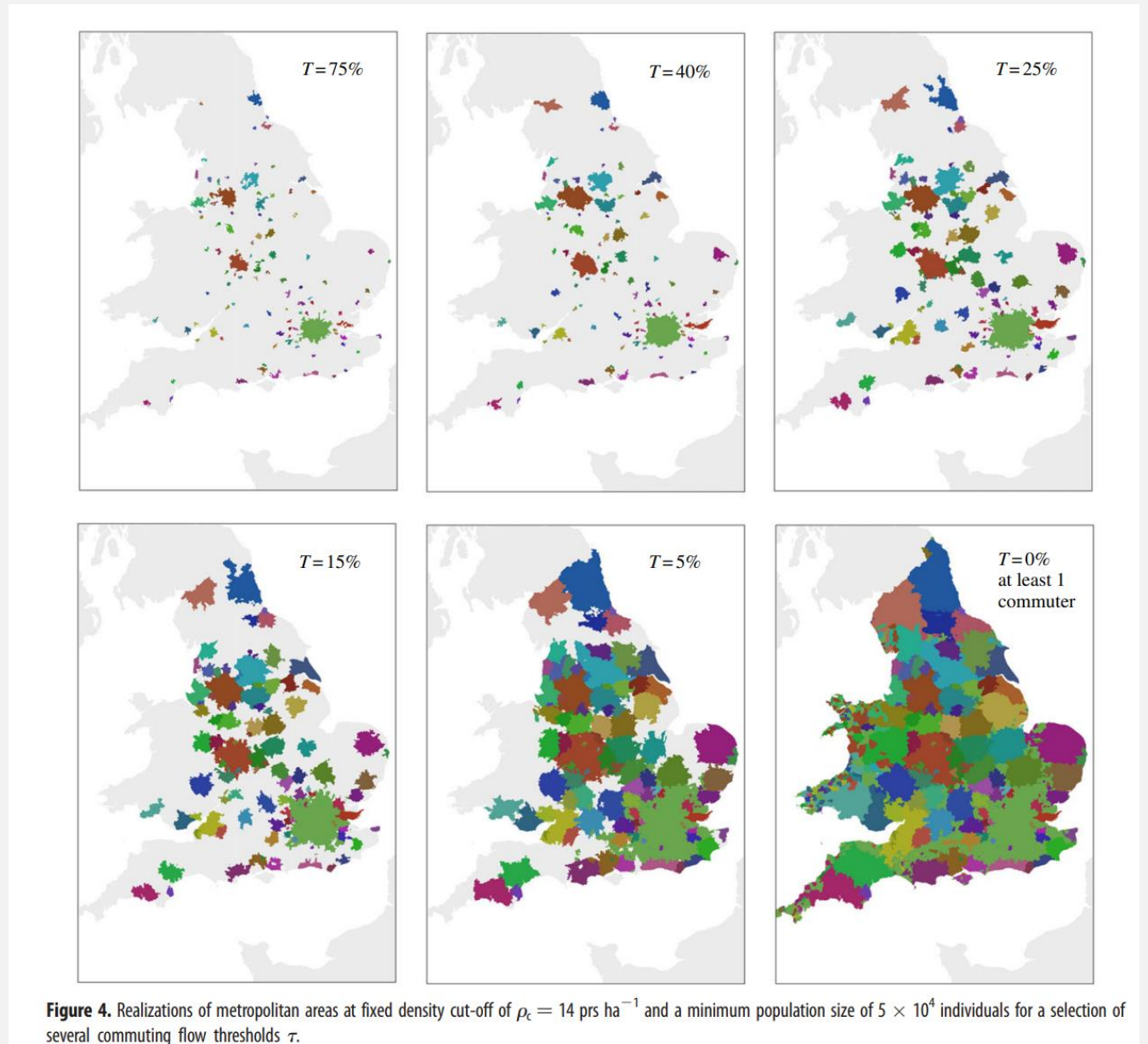


Duvigneaud, P., Denayeyer-De Smet, S., 1977. L'Ecosystème Urbain, in L'Ecosystème Urbain Bruxellois, in Productivité en Belgique. In: Duvigneaud, P., Kestemont, P. (Eds.), Travaux de la Section Belge du Programme Biologique International, Bruxelles, pp. 581e597.

# DO CITIES HAVE BOUNDARIES?

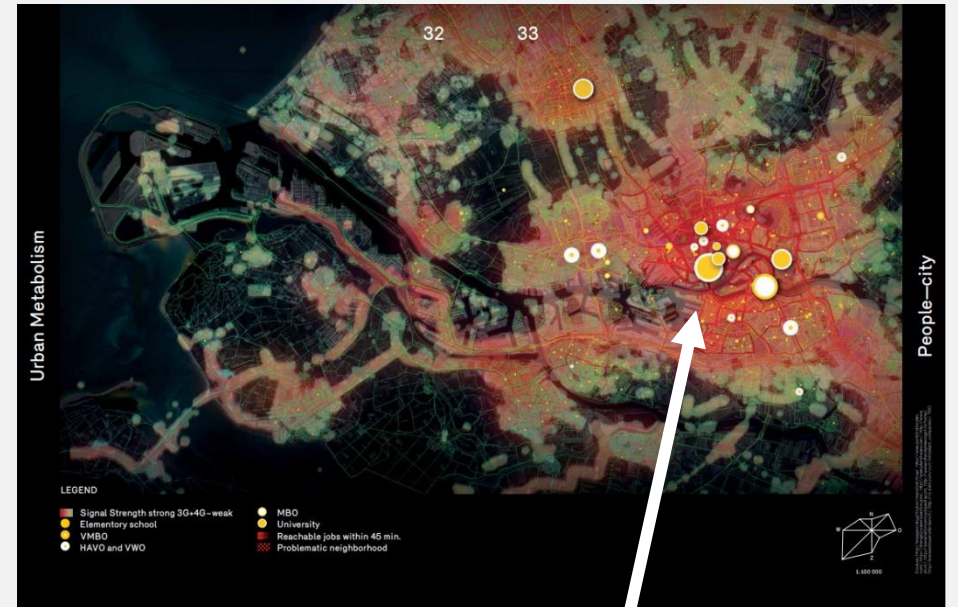
› 'To understand place, we must understand flows, and to understand flows we must understand networks'

- Batty



Arcaute E, Hatna E, Ferguson P, Youn H, Johansson A, Batty M. 2015  
Constructing cities, deconstructing scaling laws. J. R. Soc. Interface 12:  
20140745. <http://dx.doi.org/10.1098/rsif.2014.0745>

# CITIES ARE SYSTEMS WITHIN SYSTEMS



Tillie, N. M. J. D., Klijn, O., Frijters, E., Borsboom, J., Looije, M., & Sijmons, D. F. (2014). *Urban Metabolism, sustainable development in Rotterdam*.

# › DYNAMIC COMPLEXITY

## Properties of dynamic complexity

- › Dynamic
- › Tightly coupled
- › Governed by feedback
- › Nonlinear
- › History-dependent
- › Self-organizing
- › Adaptive

## Implications for decision-making

- › Counterintuitive
- › Policy resistant
- › Characterised by trade-offs

# SO NOW WHAT?

Sterman, J. D. (2001). System dynamics modeling: tools for learning in a complex world. California management review, 43(4), 8-25.

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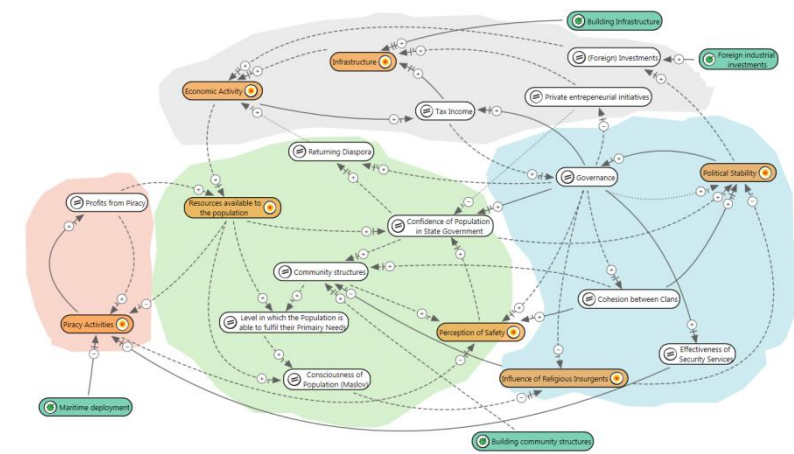
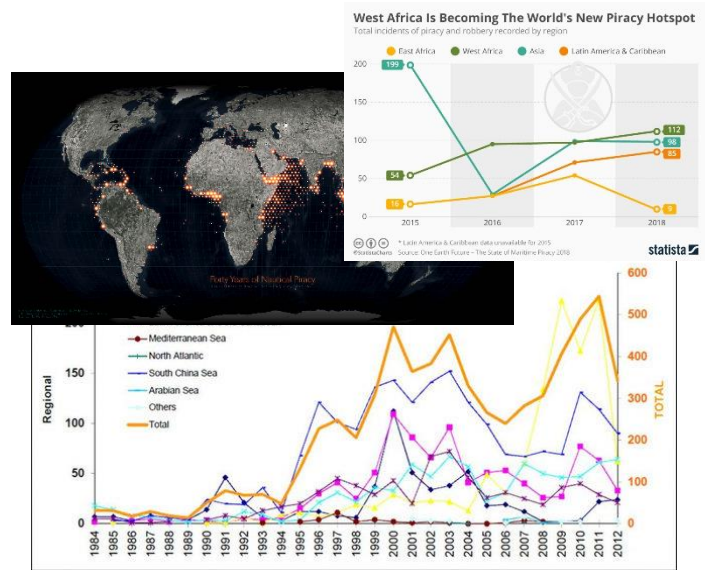


› **03. COLLABORATIVE SYSTEM THINKING**  
Understanding the Urban Operating Environment as a System

# ANALYZING COMPLEX SYSTEMS

Somali pirates seize oil tanker in first major hijack since 2012

Somali pirates hijack second boat in a month 'to use as mothership'



Policy      Reactive      Responsive      Constructive

Image sources: [www.statista.com](http://www.statista.com); [www.visualcapitalist.com](http://www.visualcapitalist.com); [www.independent.co.uk](http://www.independent.co.uk); Nguyen, C. M., & Le, T. Q. (2019). Impact of piracy on maritime transport and technical solutions for prevention. *International Journal of Civil Engineering and Technology*, 10(01), 958.



Don't model the system, model the problem



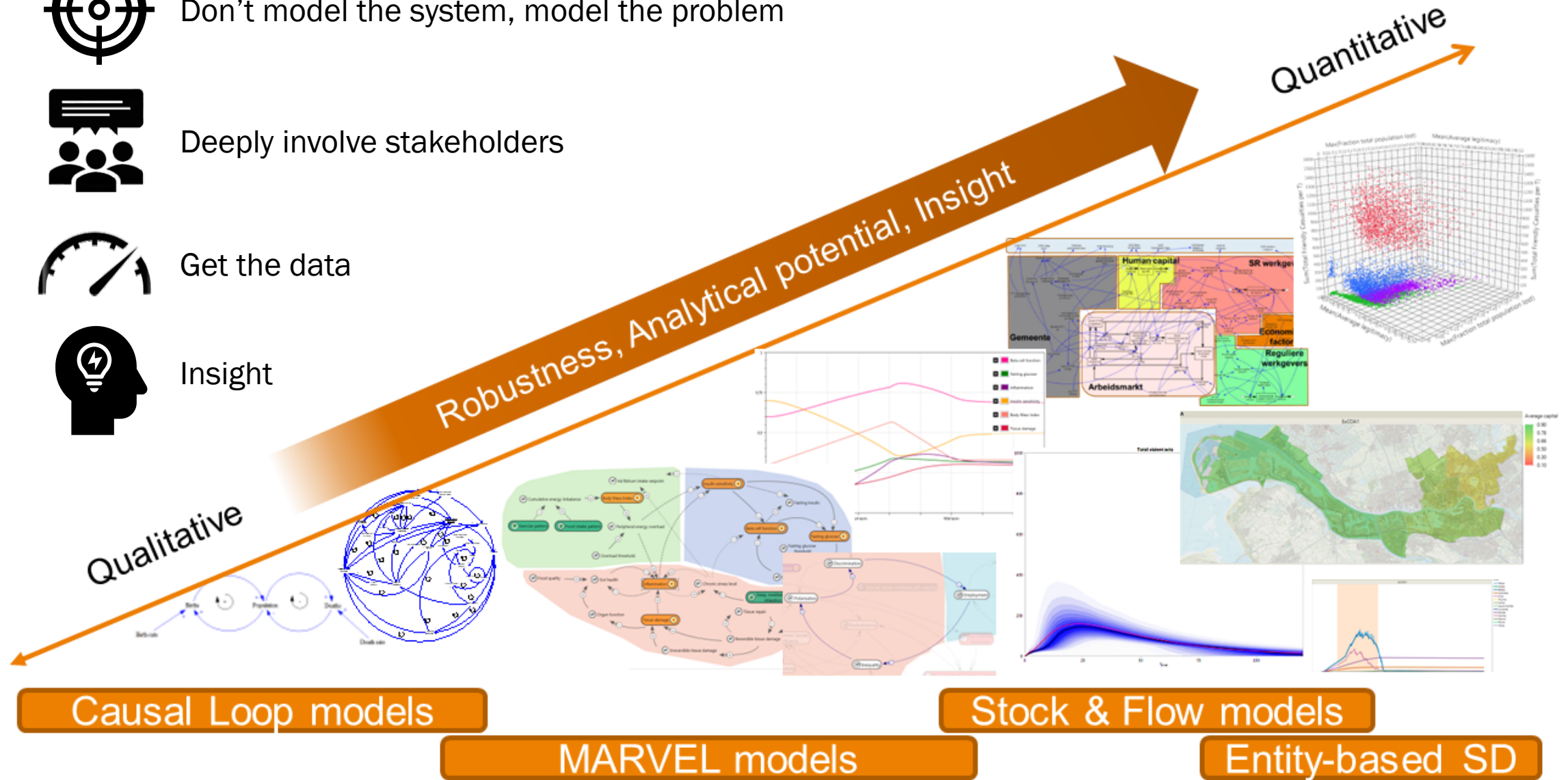
Deeply involve stakeholders



Get the data



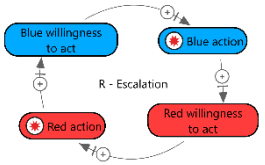
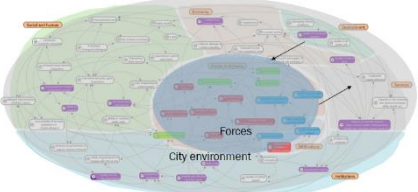
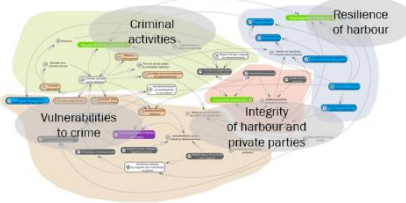
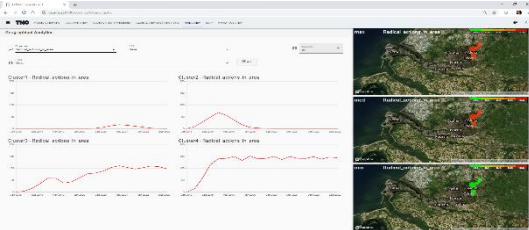
Insight



› **04. APPLICATIONS OF SYSTEM THINKING**  
Understanding the Urban Operating Environment as a System

# APPLICATIONS OF SYSTEM THINKING

## Overview of examples

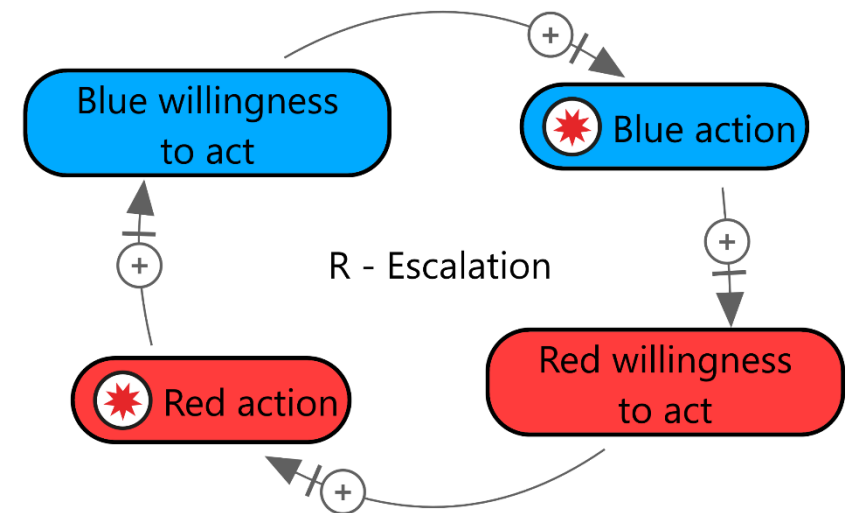
	Example	System thinking added value
	Archetypes of actor behaviour in conflict	Recognise and understand recurring patterns of behaviour
	City-as-a-system analysis of urban operations	Planning or wargame support to understand effects on urban environment
	Crime in sea harbours	Collaborative problem structuring to design new policies
	Planning support in land operations	Analysis of alternative futures of insurgency development for policy development

# › SIMPLE TOOLS: SYSTEM ARCHETYPES



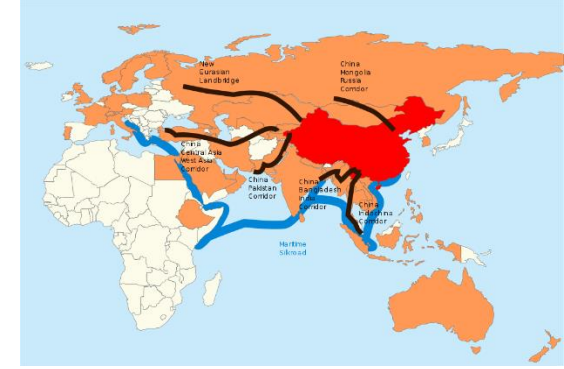
## Archetypes of actor behaviour

- › The behaviour of actors in conflict is **not unique**, it follows repetitive patterns
- › An archetype is an **elegant and simple explanation** of a pattern of behaviour and its underlying structure
- › Archetypes provide a **template for quick analysis** of observed behaviour and reflection on proposed actions
- › Decisionmakers can use archetypes to take a systemic perspective on **the interaction between actors** in conflict and **develop effective courses of actions**



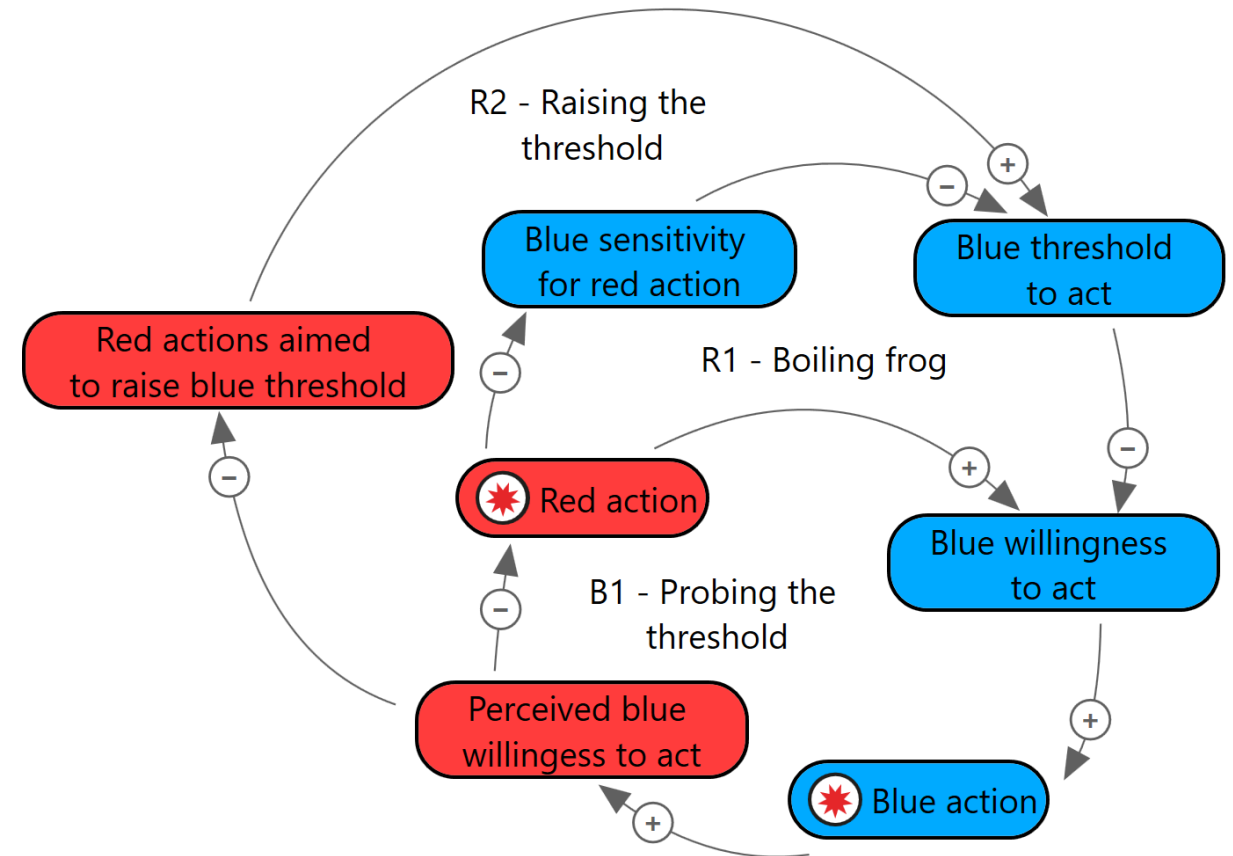
# AN ARCHETYPE OF CONFLICT BEHAVIOUR

## Raising the threshold, boiling the frog



China's Belt and Road Initiative – precarious balance of investment and security

- › China probed the threshold of what Western countries deem acceptable levels of foreign investment (B1)
- › Some countries got accustomed to increased Chinese FDI, the frog was boiled (R1)
- › The perceived threshold of allowable Chinese FDI in Western countries was raised (R2)
- › Some Western countries have expressed concern about Chinese investments in critical infrastructure. China has thus recently crossed a threshold



Keijser, B., Veldhuis, G.A., & van Scheepstal, P. 2020. Towards a Dynamic Theory of Hybrid Conflict: An Exploration with System Archetypes. NATO OR&A

# CITY-AS-A-SYSTEM MODELLING OF URBAN ENVIRONMENT

## Creating oversight of effects on the city environment

- › Support to urban wargame or urban operations
- › Key uses of the model:
  - › Understanding the situation
  - › Analysis of the problem situation
  - › Finding levers for interventions
  - › Support to wargame adjudicators



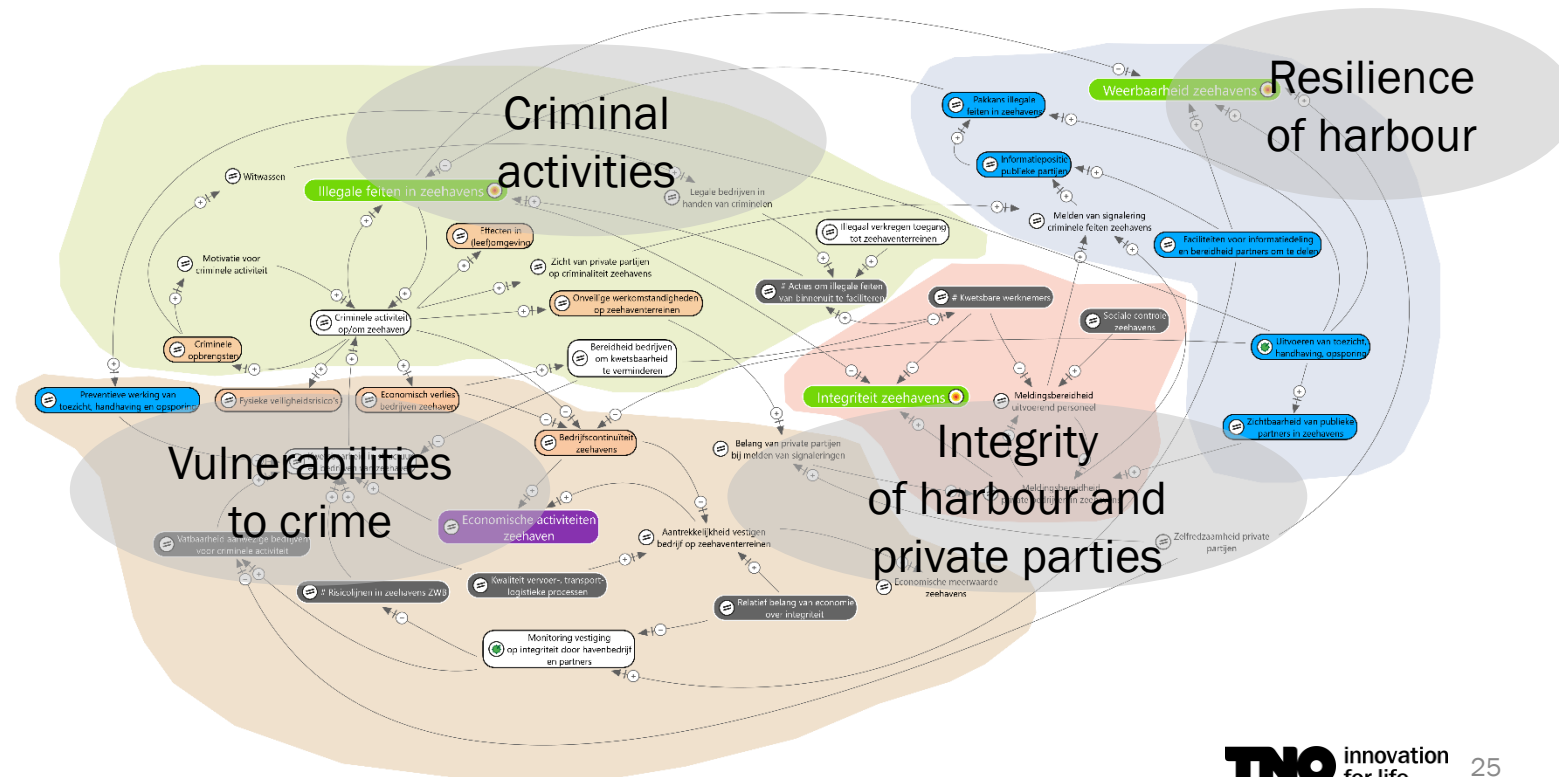


# COLLABORATIVE PROBLEM STRUCTURING

## Crime in sea harbours

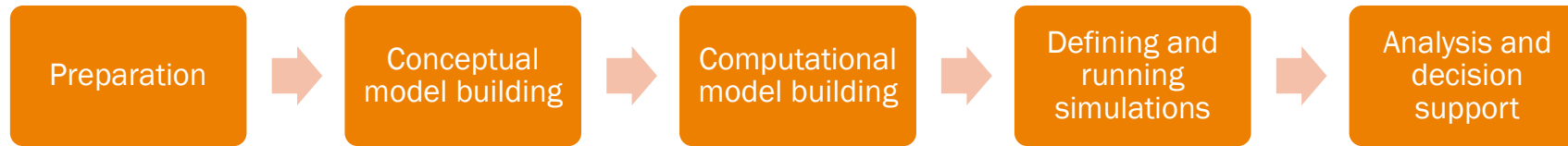


- › Collaborative model building sessions with many stakeholders related to crime
- › Key uses of the model:
  - › Support to public-private collaborative problem structuring
  - › Support to policy programme design



# PLANNING SUPPORT IN LAND OPERATIONS

## Analysis of alternative futures of insurgency development

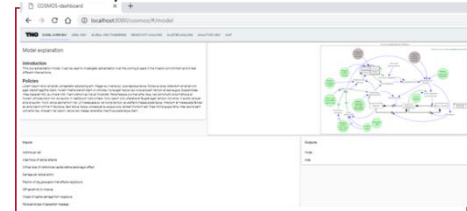


› Analysis of simulations from system dynamics model of insurgency

› Key uses of the model:

- › Understand problem drivers under uncertainty
- › Compare effects of courses of action on development of insurgency

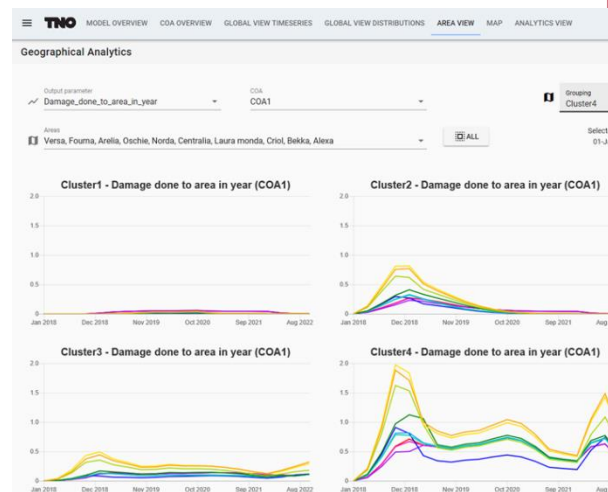
M&S expert  
Specialist staff member



Analyst  
e.g. Environment or plans cell staff



End user  
e.g. Commander or section chief



	Strength	Weakness	Opportunity/threat
Aggressive policy	Effective limitation of radical separatists and actions	Extra polarization, no inequality reduction, no extra resilience	Uncertain balance between reducing actions & increasing polarization
Mixed FOM & reduce visibility policy	Lower separatist support through less persuasion	Reduction in resilience is delayed, but not avoided	Underlying problems linger, rebound can occur
Social influence policy	Effective limitation of polarization, damage to resilience is limited	Radical separatist, if present, are only slowly removed	Radical separatists can linger, rebound can occur
No policy	When no policy is directed at the insurgency, radicalization escalates, radical actions are frequent and inequality and polarization increase and persist. In some cases resilience capital is effective in limiting escalation.		

› **05. CONCLUSIONS**  
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# › SUMMARY



Urban environments are complex systems



Systems thinking as an analytical perspective



Modelling methods to create insight



# › SUMMARY

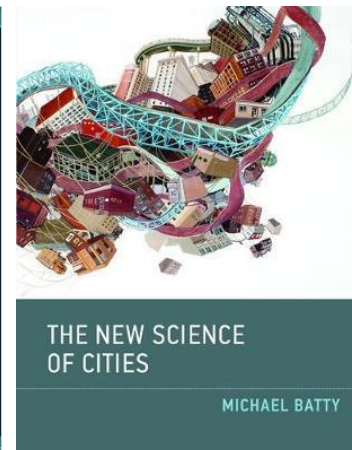
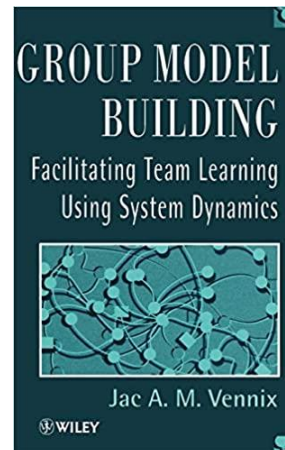
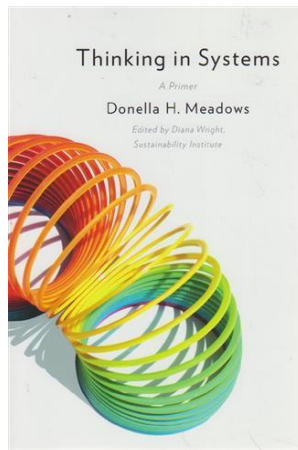


## Thinking in Systems

“We can’t impose our will on a system. We can listen to what the system tells us and discover how its properties and our values can work together to bring forth something much better than could ever be produced by our will alone.”

– Donella H. Meadows

### Suggested readings



NATO OTAN

S&T  
organization

**Towards a Dynamic Theory of Hybrid Conflict:  
An Exploration with System Archetypes**

Bas Keijser      Guido Veldhuis      Peter van Scheepstal  
TNO Defence, Safety & Security  
THE NETHERLANDS

Bas.Keijser@TNO.nl      Guido.Veldhuis@TNO.nl      Peter.vanScheepstal@TNO.nl

Applications

**Concept development for  
comprehensive operations support  
with modeling and simulation**

Journal of Defense Modeling and Simulation: Applications, Methodology, Technology  
2020, Vol. 17(1) 99–116  
© The Author(s) 2018  
DOI: 10.1177/15485129188114407  
journals.sagepub.com/home/dms

JDSM  
SAGE

Guido A Veldhuis, Nico M de Reus and Bas MJ Keijser

Collaborative problem structuring using  
MARVEL

Guido Arjan Veldhuis, Peter van  
Scheepstal, Etiënne Rouwette & Tom  
Logtens

EURO Journal on Decision Processes  
ISSN 2193-9438  
EURO J Decis Process  
DOI 10.1007/s40070-015-0045-1

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