



**34<sup>th</sup>** Annual **INCOSE**  
international symposium

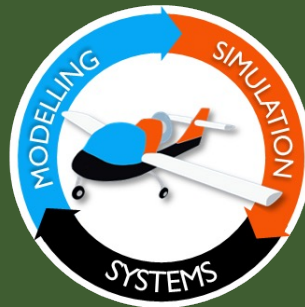
hybrid event

Dublin, Ireland  
July 2 - 6, 2024



*Systems Engineering for Smart-Cities*

# Smart Cities from architecture to application



Jawahar Bhalla (JB)

<https://www.linkedin.com/in/JawaharBhalla/>

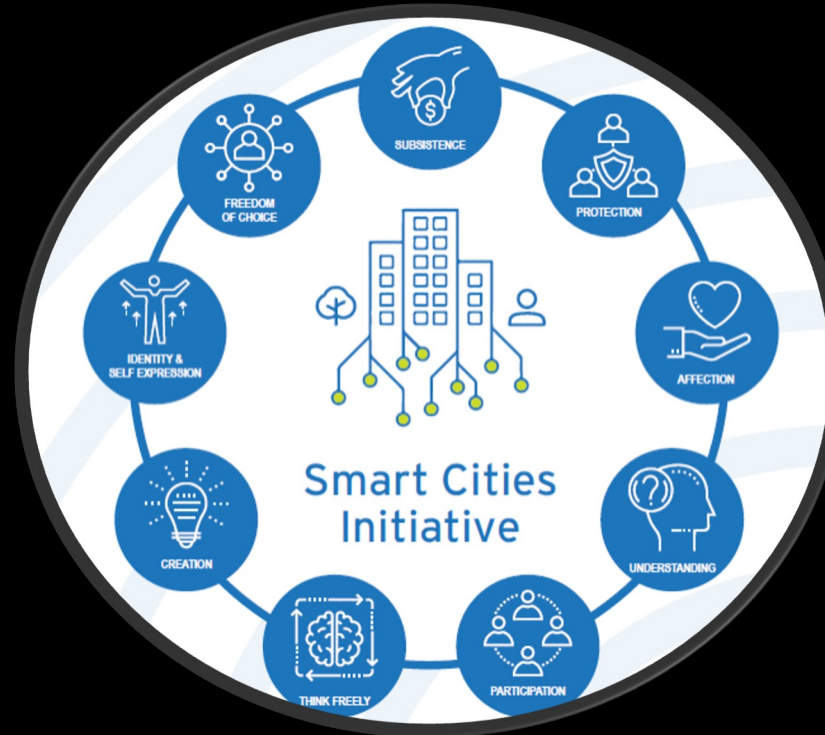


JULY 2 - 6, 2024

# Smart Cities



**Smart cities** represent a transformative approach to urban living, utilizing advanced technologies and data analytics to enhance the effectiveness, efficiency, sustainability and overall quality of urban environments.



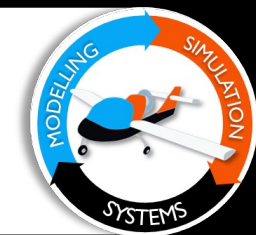
Perhaps the greatest challenge for **systems engineers** will be delivering holistic solutions that stay true to the smart cities vision of improving the quality of life in this disruptive, complex and ever-evolving socio-technical context.

*Disclaimer – the concepts expressed in this presentation are personal opinions and insights that continue to evolve based on theoretical and experiential learning and should not be taken as suggesting the truth nor be associated with any organisation that I have been part of or affiliated with.*



JULY 2 - 6, 2024

# Key Performance Indicators...



Traditional Measures  
Used in the Engineering  
of Systems to measure  
stakeholder value

MOE  
Measures of Effectiveness

MOP  
Measures of Performance

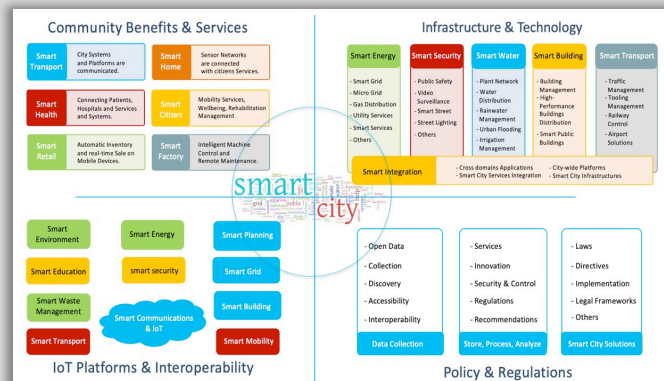
MOS  
Measures of Suitability

CTP  
Critical Technical Parameters

TPM  
Technical Performance Measures

For example, refer  
Section 2.3.4.7 of the SE  
Handbook  
(Measurement Process)

## National Institute of Standards and Technology (NIST) Holistic KPI (H-KPI) Framework



The H-KPI Framework enables  
developing measuring methods and  
tools that allow for **integration**,  
**adaptability**, and **extensibility** at  
**three interacting levels**

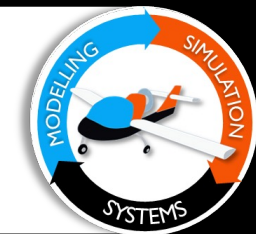
NIST Special Publication 1900-206 "Smart Cities and Communities: A Key Performance Indicators Framework"





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# Key Performance Indicators...



## Traditional Measures

## National Institute of Standards and

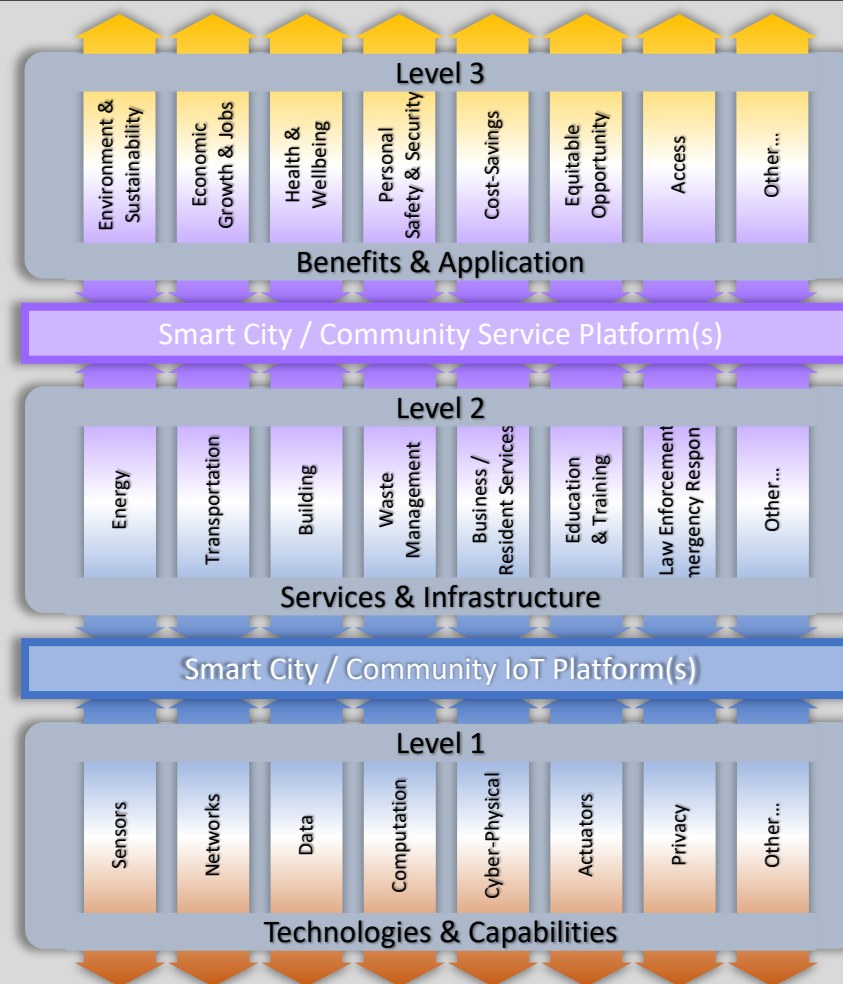
“The H-KPI approach is intended to provide a reliable methodology for assessing *technology and associated community benefits* in smart cities” – across three core objectives :

1. **Integration** –integrating measures across sectors  
infrast  
charac
2. **Applicability** – usable across the diverse smart city and community sector;
3. **Extensibility** – supporting reuse and repurposing of infrastructure, services and datasets and ongoing integration with evolving digital innovation.

## Emergent outcomes

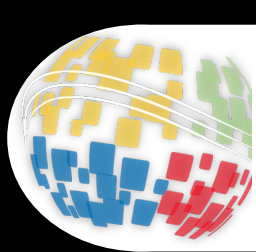
Handbook  
(Measurement Process)

adaptability, and extensibility at  
three interacting levels

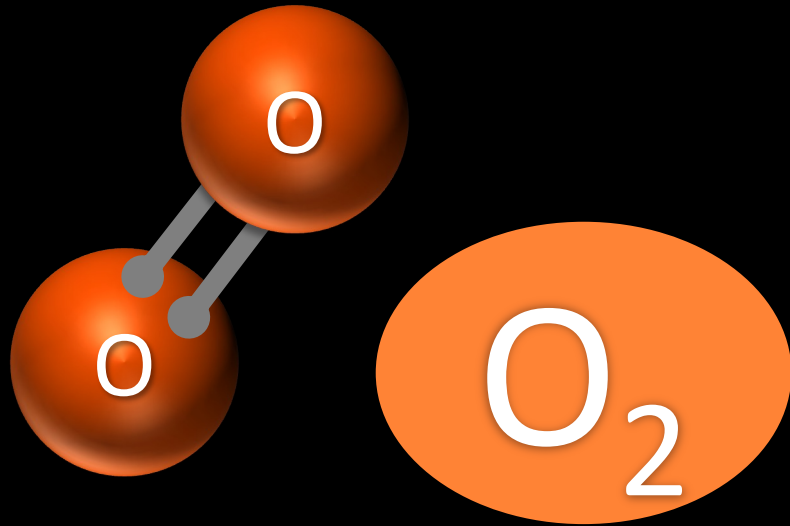
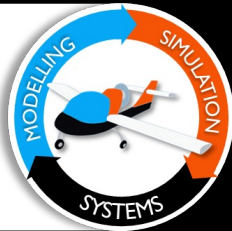


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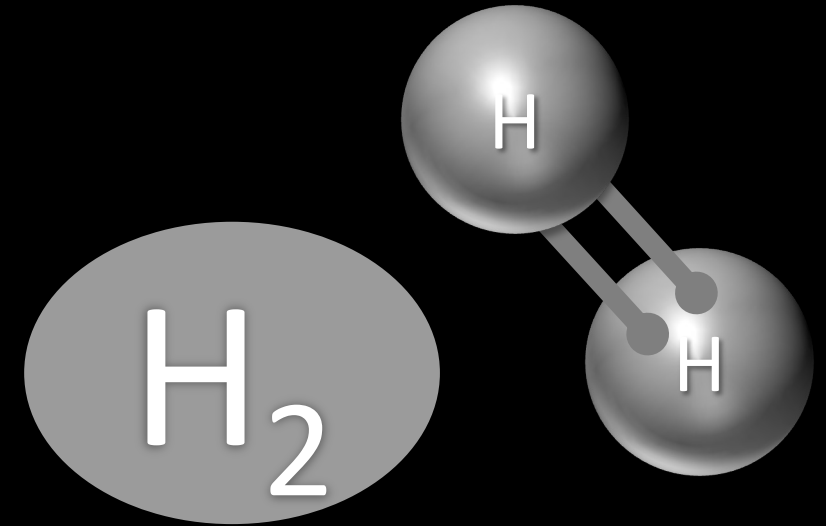




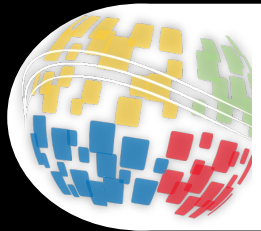
# Emergence...



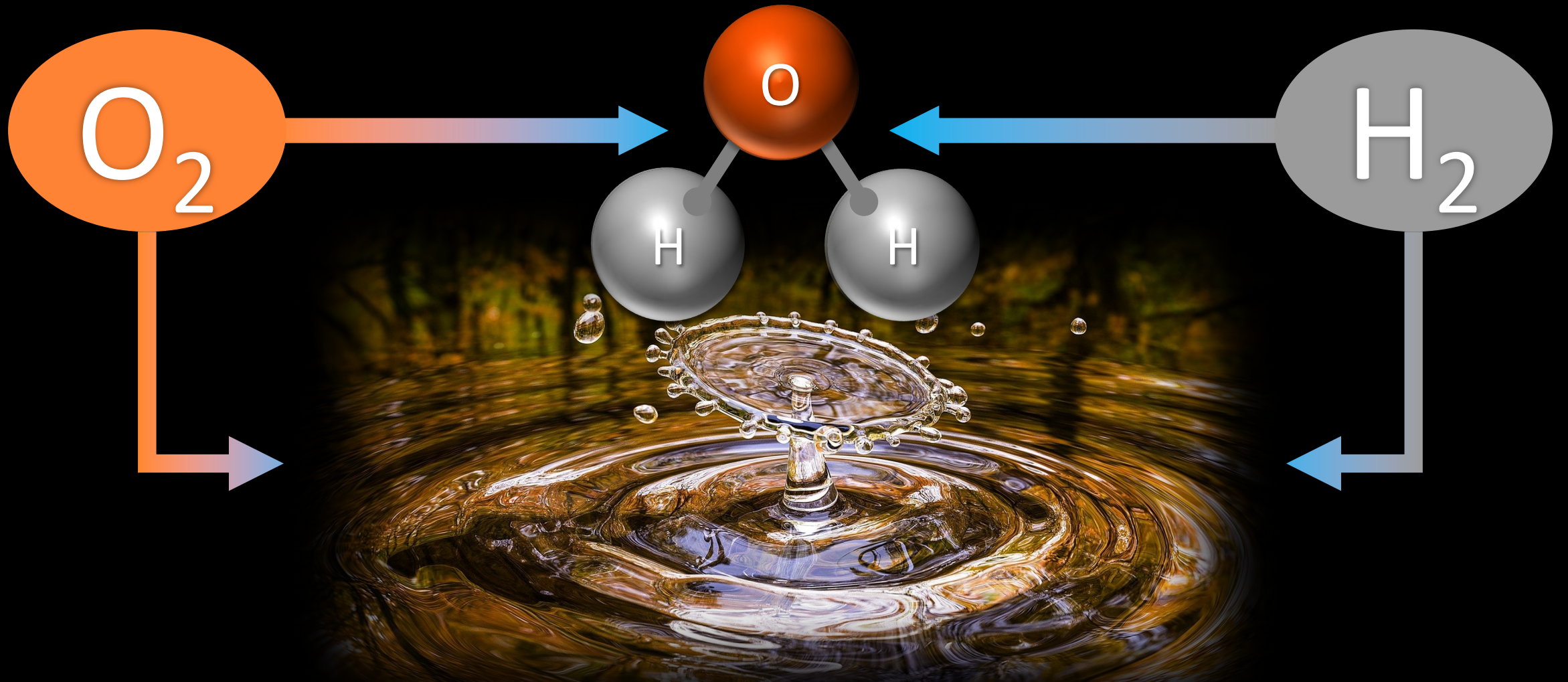
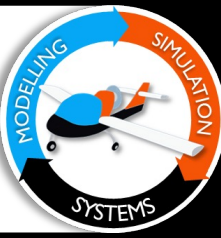
+



Emergent Interactions....bring together two gasses....

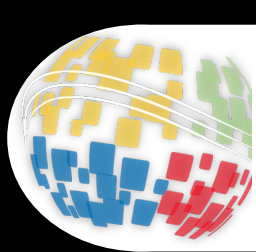


# Examples of “Emergence”



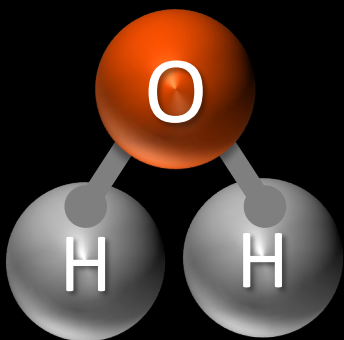
“wetness” – more than the sum of its parts??





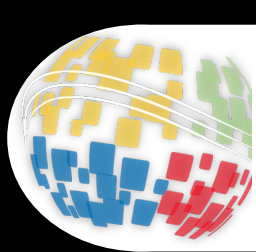
# Examples of “Emergence”

Image Credit – Ian Lindsay from Pixabay

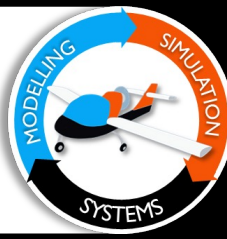


Starling  
“Murmuration”

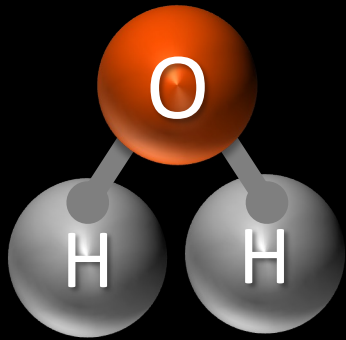


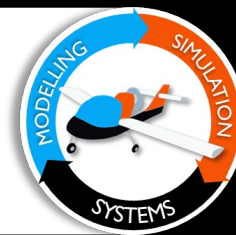
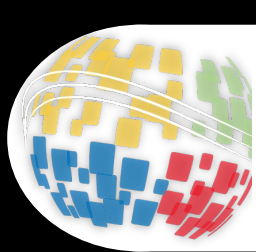


# Examples of “Emergence”



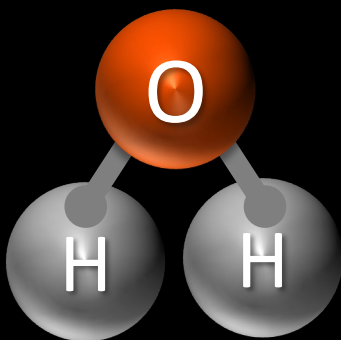
Video Extracted from - “Starling Murmuration 2020 #Geldermalsn”



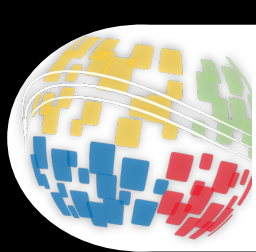


# Examples of “Emergence”

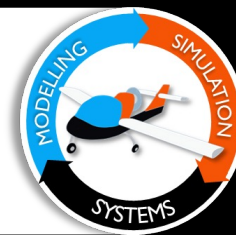
Image Credit – Kie-Kie from Pixabay



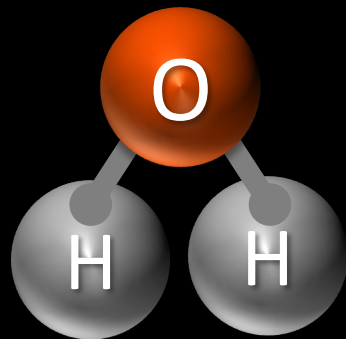
Ant Colony's



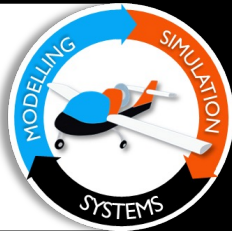
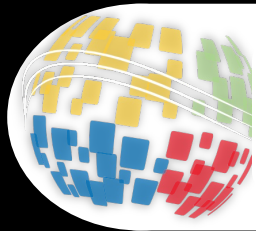
# Examples of “Emergence”



Video Extracted from - “Emergence – How Stupid Things Become Smart Together”







# What is “Emergence”?

## Dictionary

The act or an instance of emerging (Meriam-Webster)  
The fact of something becoming known or starting to exist (Cambridge)

## Wikipedia

In philosophy, systems theory, science, and art, emergence occurs when an entity is observed to have properties its parts do not have on their own, properties or behaviors that emerge only when the parts interact in a wider whole (Wikipedia)

## SE-BOK

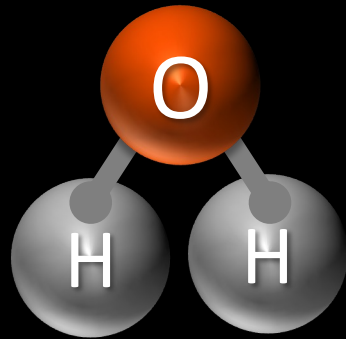
The principle that entities exhibit properties which are meaningful only when attributed to the whole, not to its parts (Checkland)

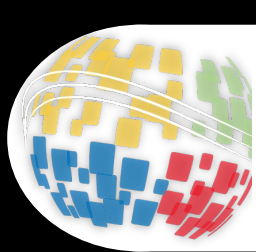
## INCOSE

A **system** “is an arrangements of parts or elements that together exhibit behavior or meaning that the individual constituents do not”, and that “the system’s properties (as a whole) result, or emerge from” the parts and their interactions (INCOSE definitions)

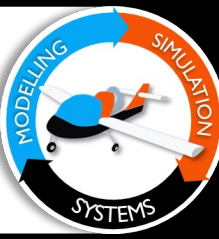
## Personal

Emergence is a **fundamental systemic property** that explains a systems behaviors as (a balance between internal and external forces that are the) product of internal and external interactions, resulting in intended and unintended outcomes (a WIP!)



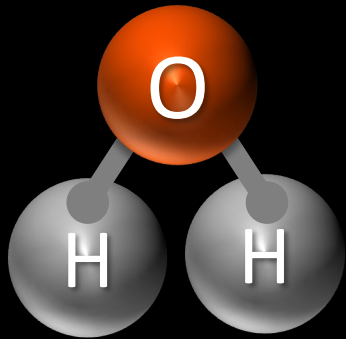


# What is “Systems Thinking”?

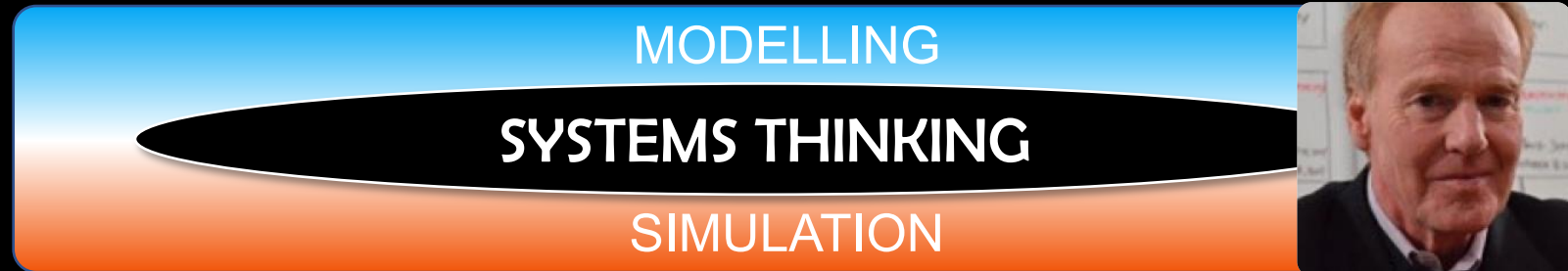


WHAT?

Peter Senge → “Systems Thinking is a *conceptual framework*, a *body of knowledge* and *tools* that have been developed over the past fifty years, to *make the full patterns clearer*, and to help to *change them effectively*.”

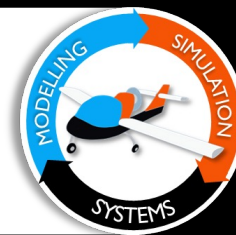
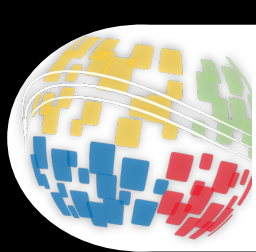


HOW?

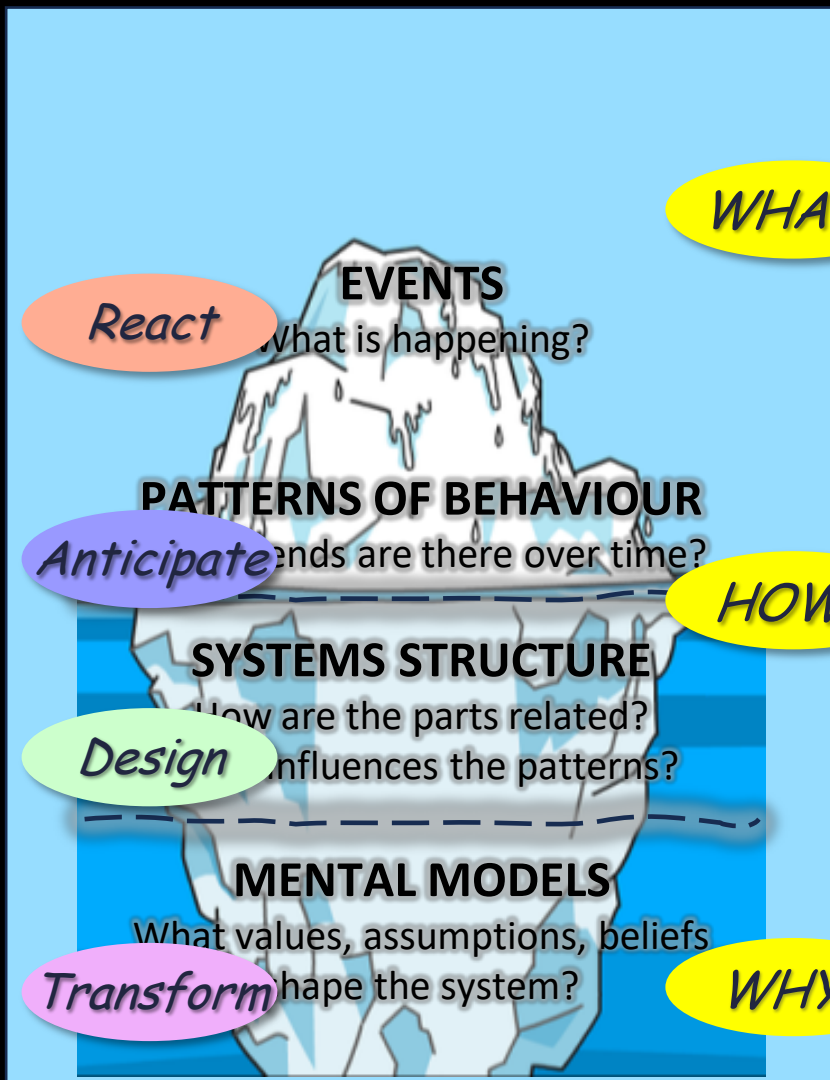


WHY?

Personal view → Systems Thinking is a *conceptual framework and methodology* to *understand and make sense* of the world we live in, that helps us deal *efficiently* and *effectively* with the *challenges we perceive* and to *create the reality we desire*.



# What is “Systems Thinking”?



**WHAT?**



Emergent behaviour?



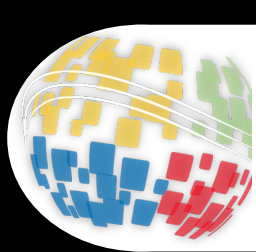
MODELLING

**SYSTEMS THINKING**

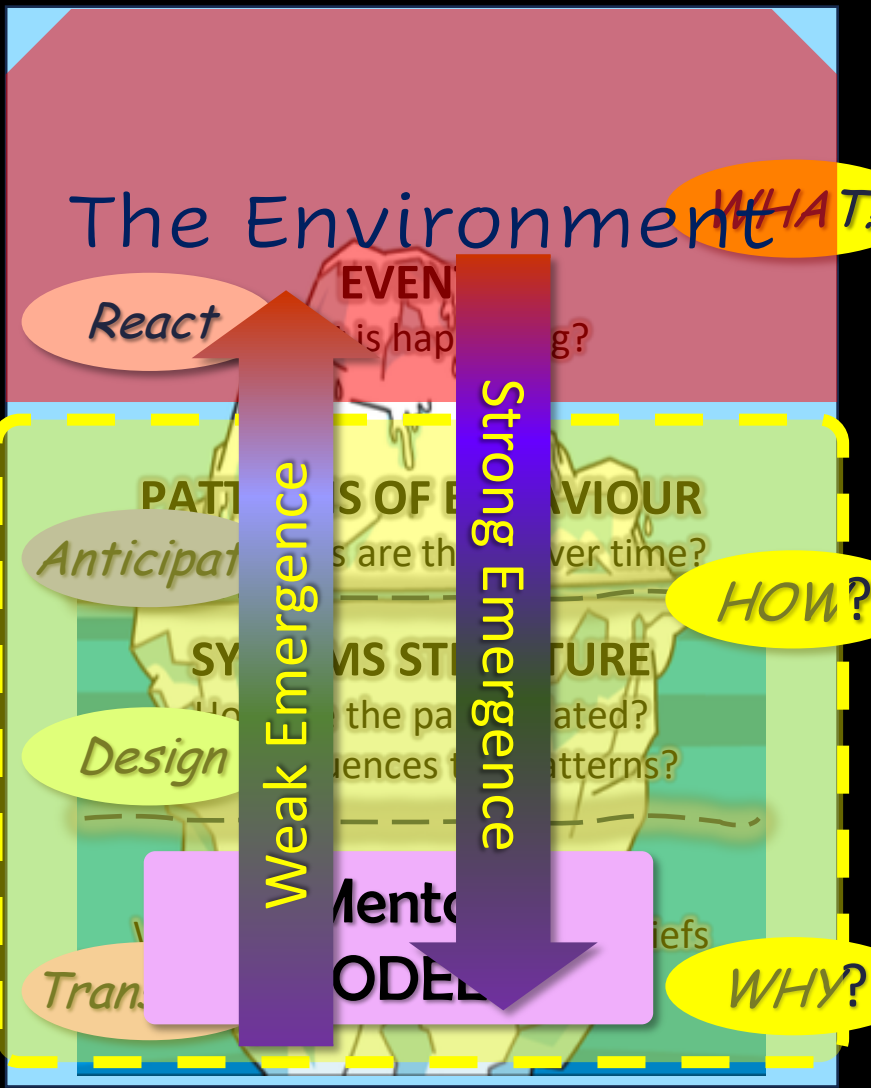
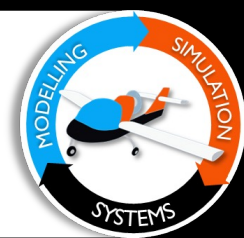
SIMULATION

Personal view → Systems Thinking is a *conceptual framework and methodology* to *understand and make sense* of the world we live in, that helps us deal *efficiently* and *effectively* with the *challenges we perceive* and to *create the reality we desire*.

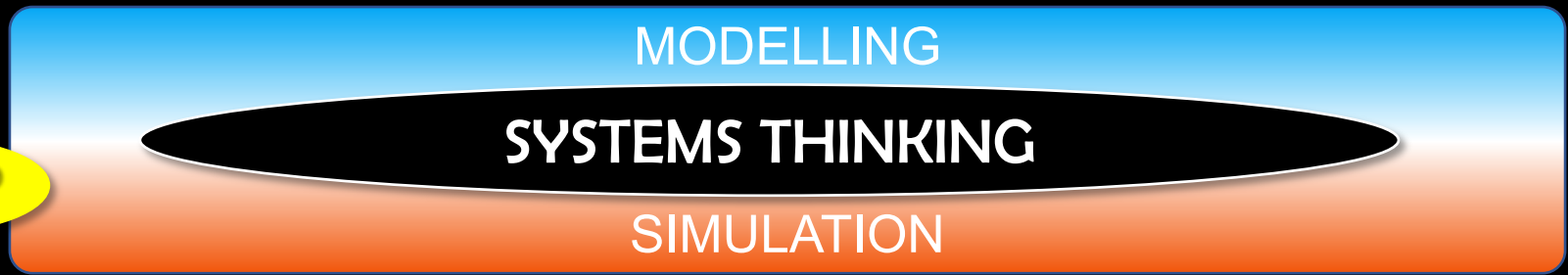




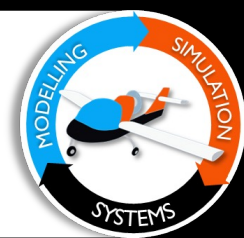
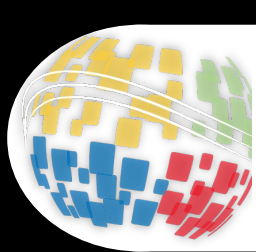
# Emergence & Systems Thinking



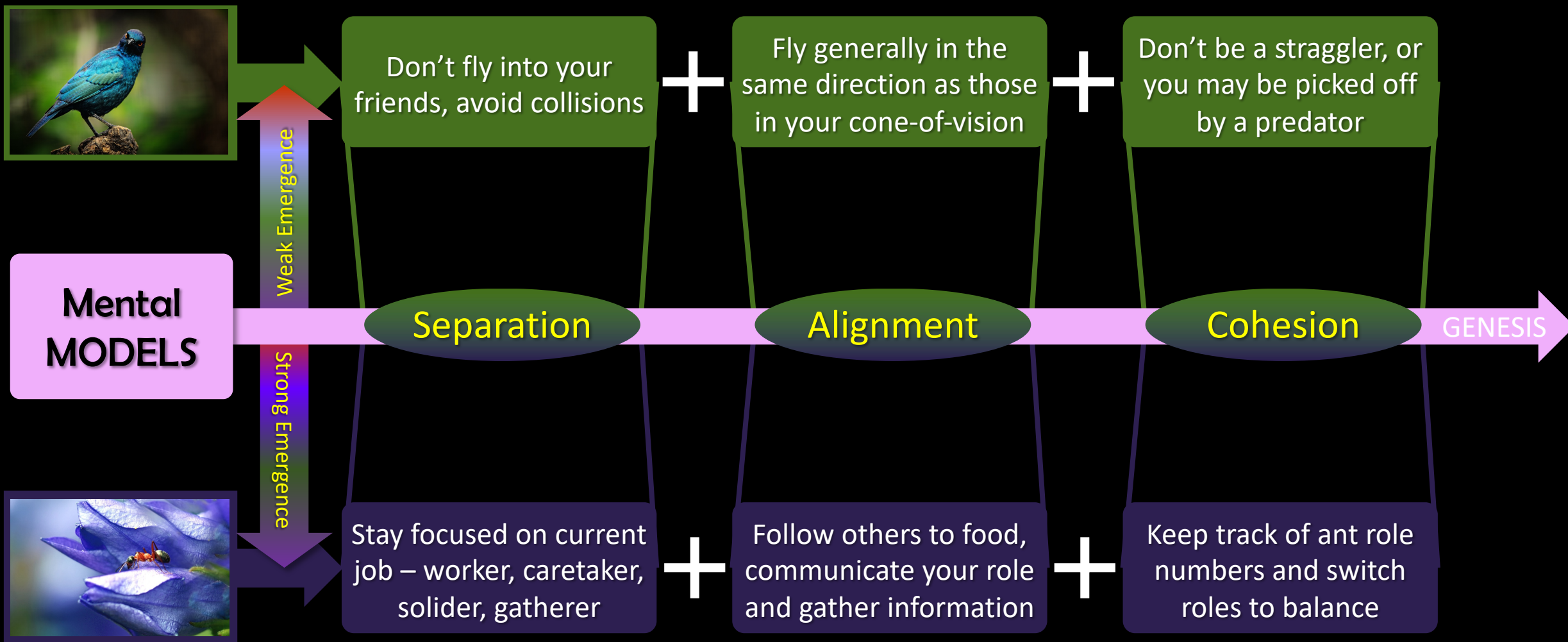
Emergent behaviour?

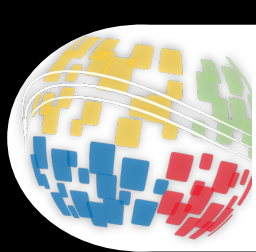


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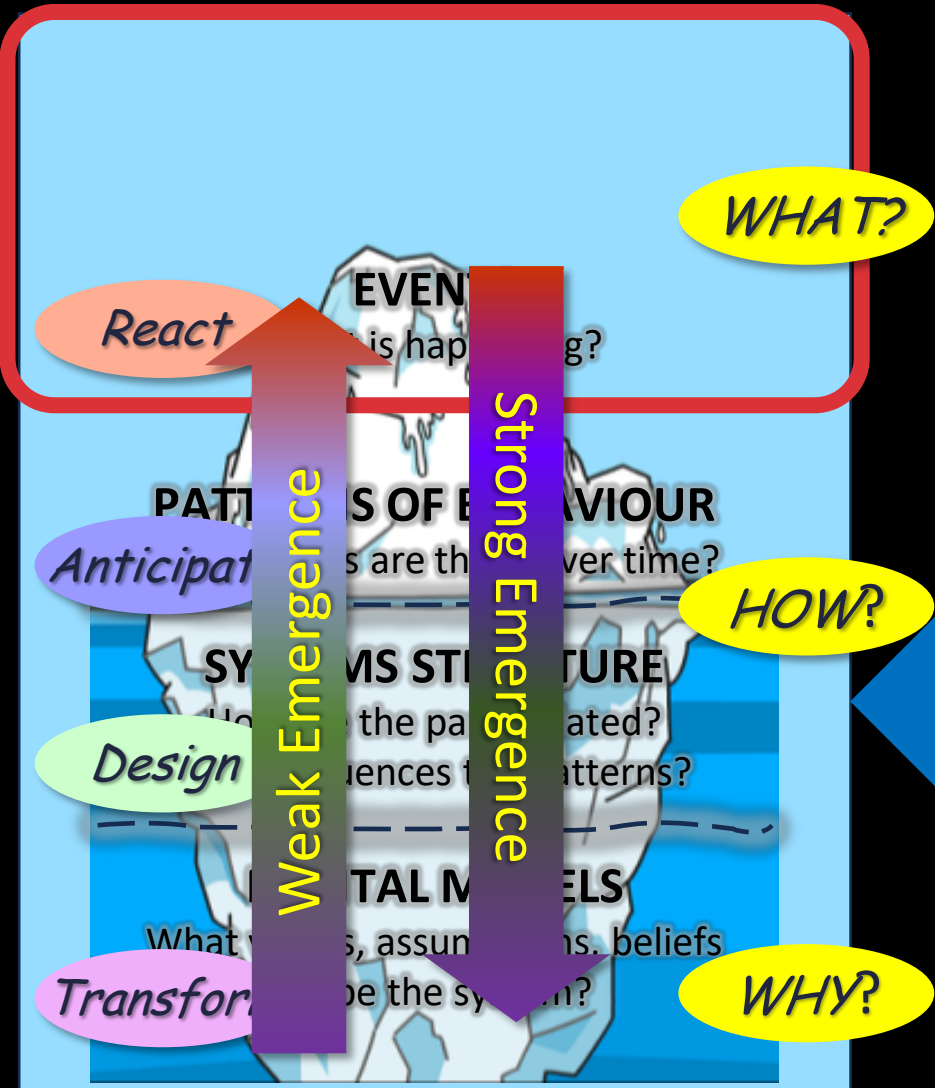


# Modelling “Emergence”

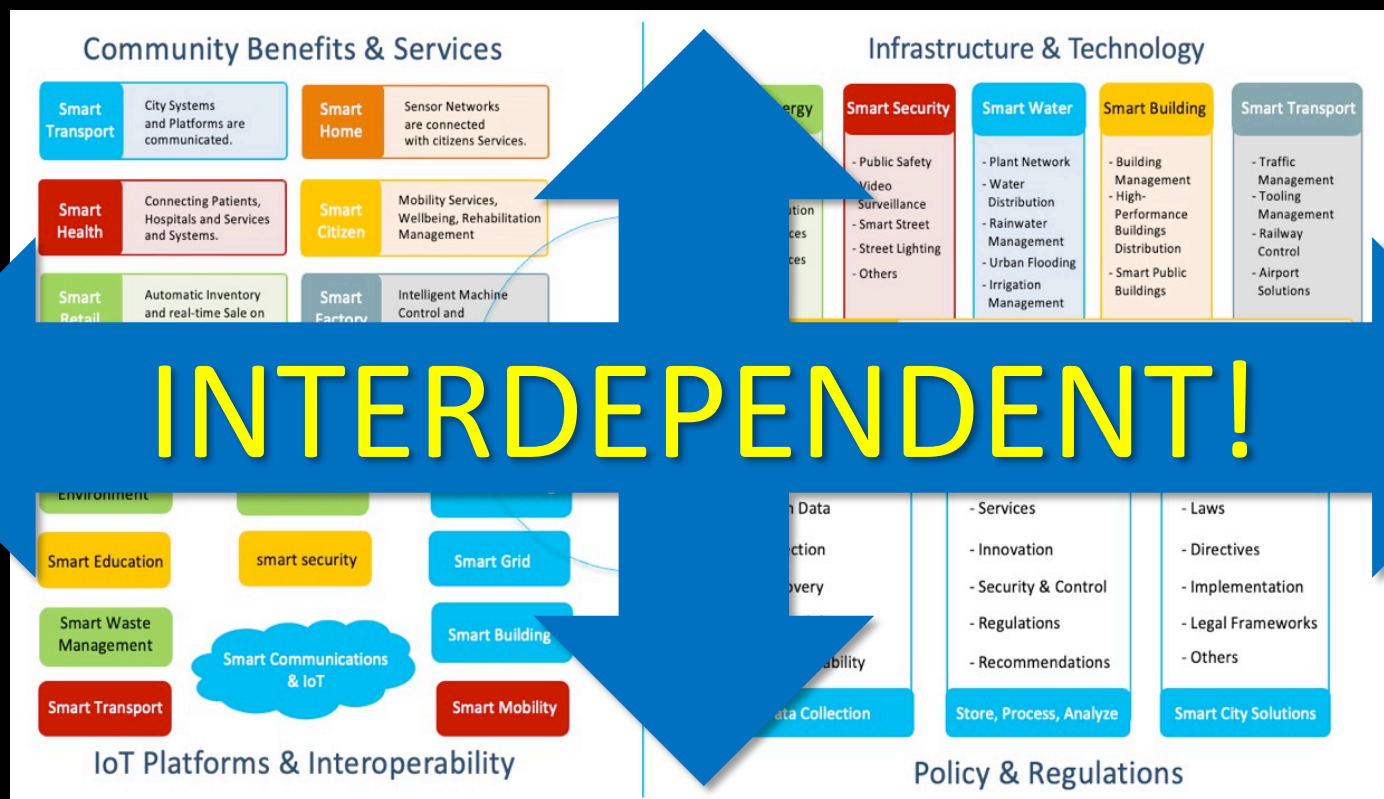




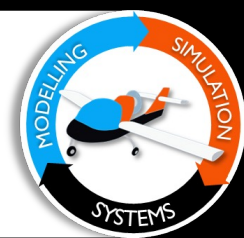
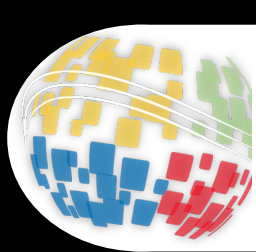
# "Emergence" in Smart-Cities



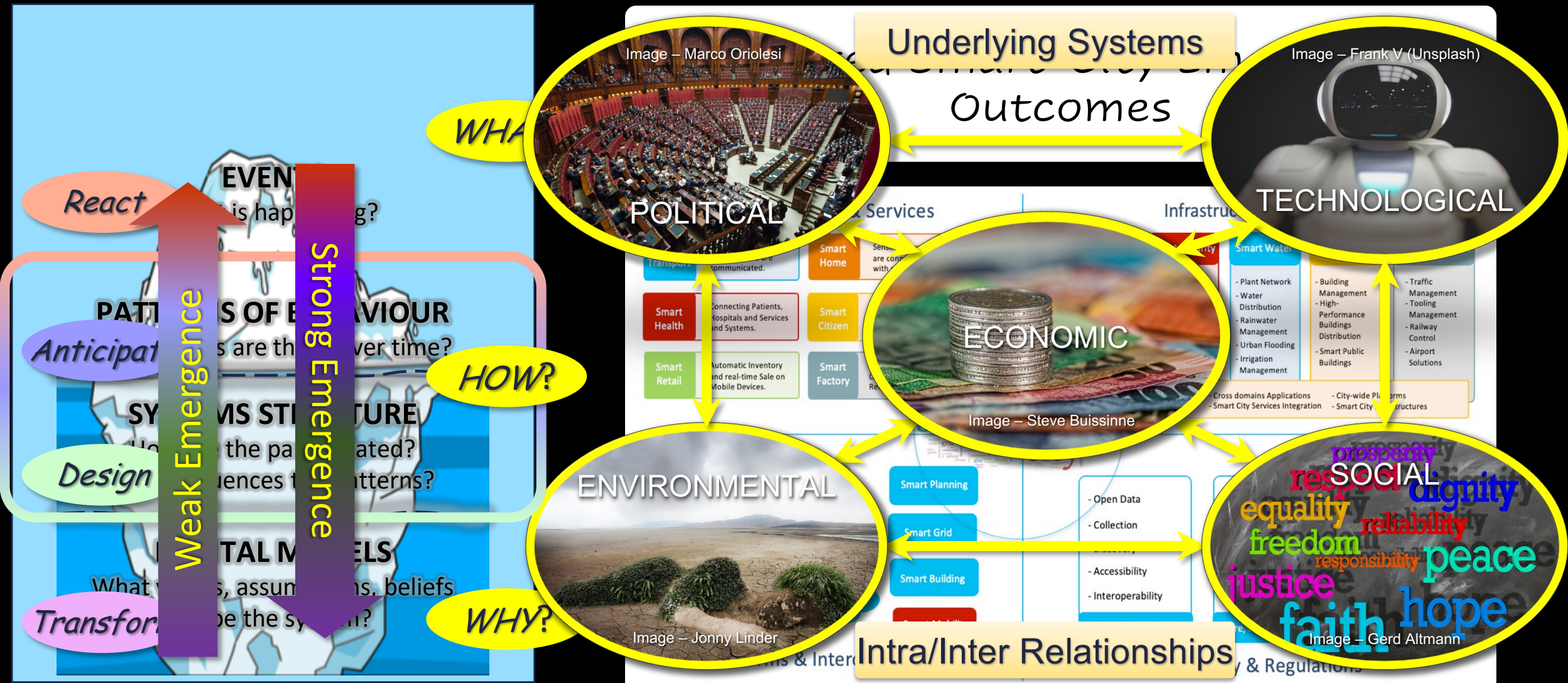
## Desired Smart-City Emergent Outcomes



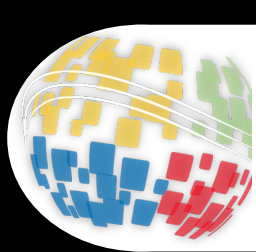




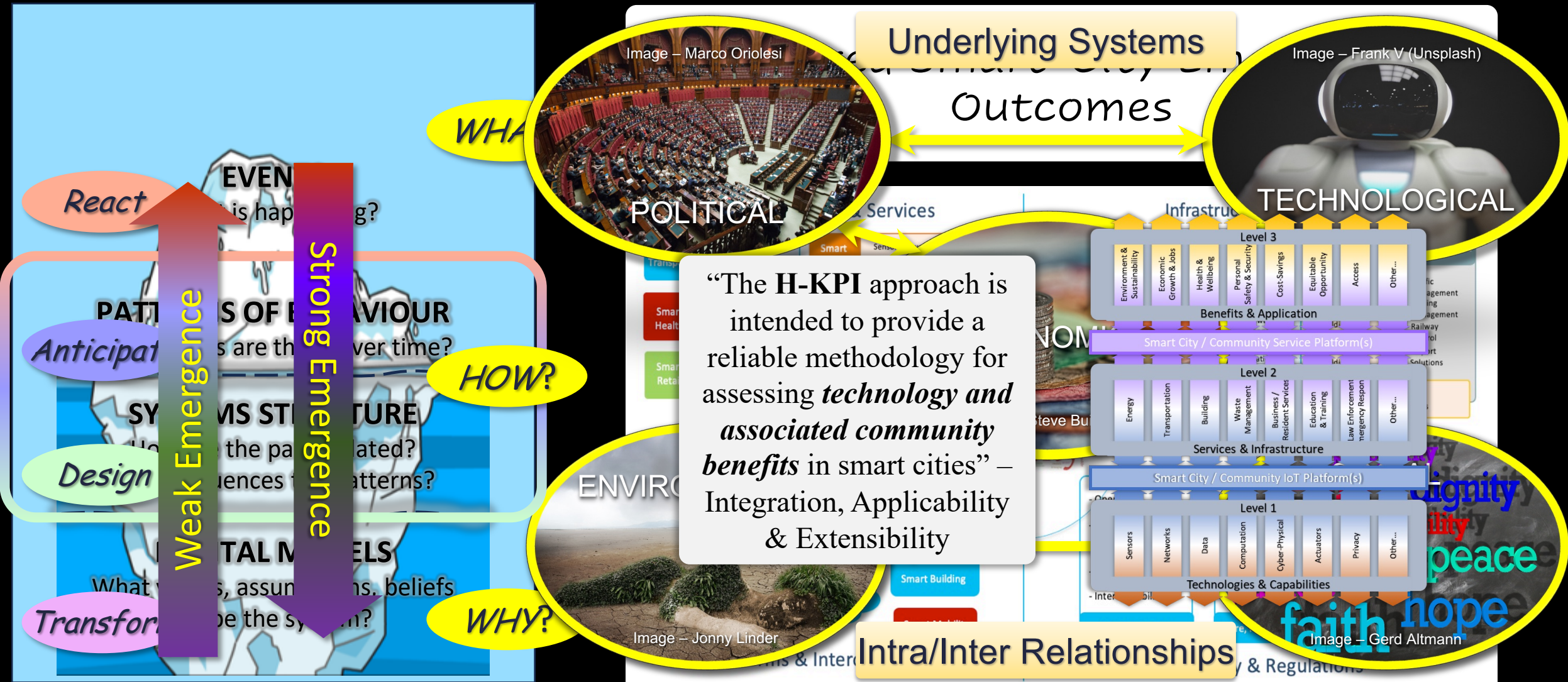
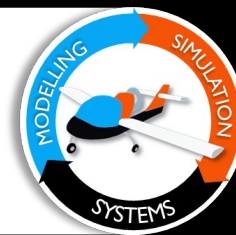
# "Emergence" in Smart-Cities



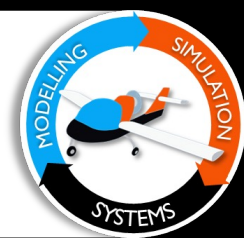




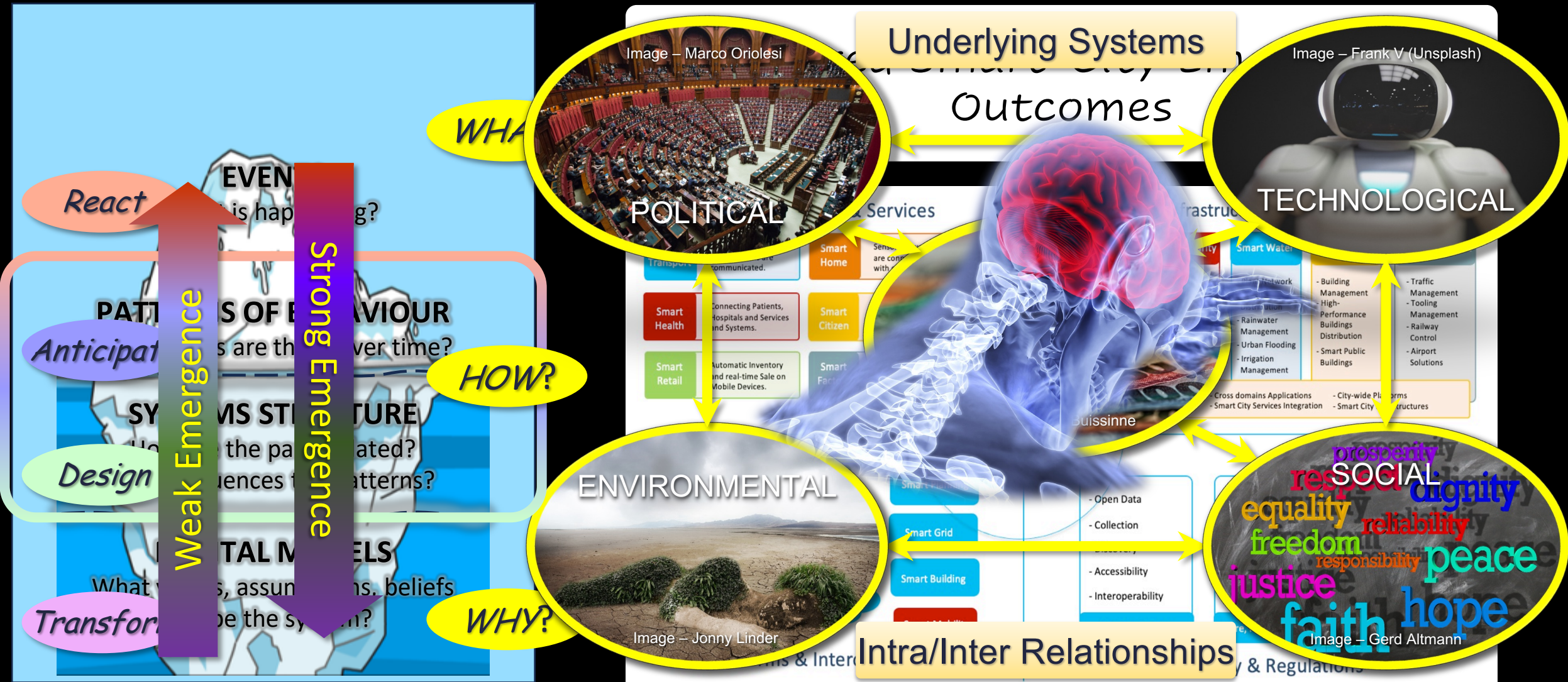
# "Emergence" in Smart-Cities



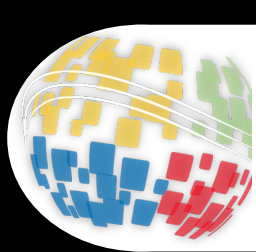




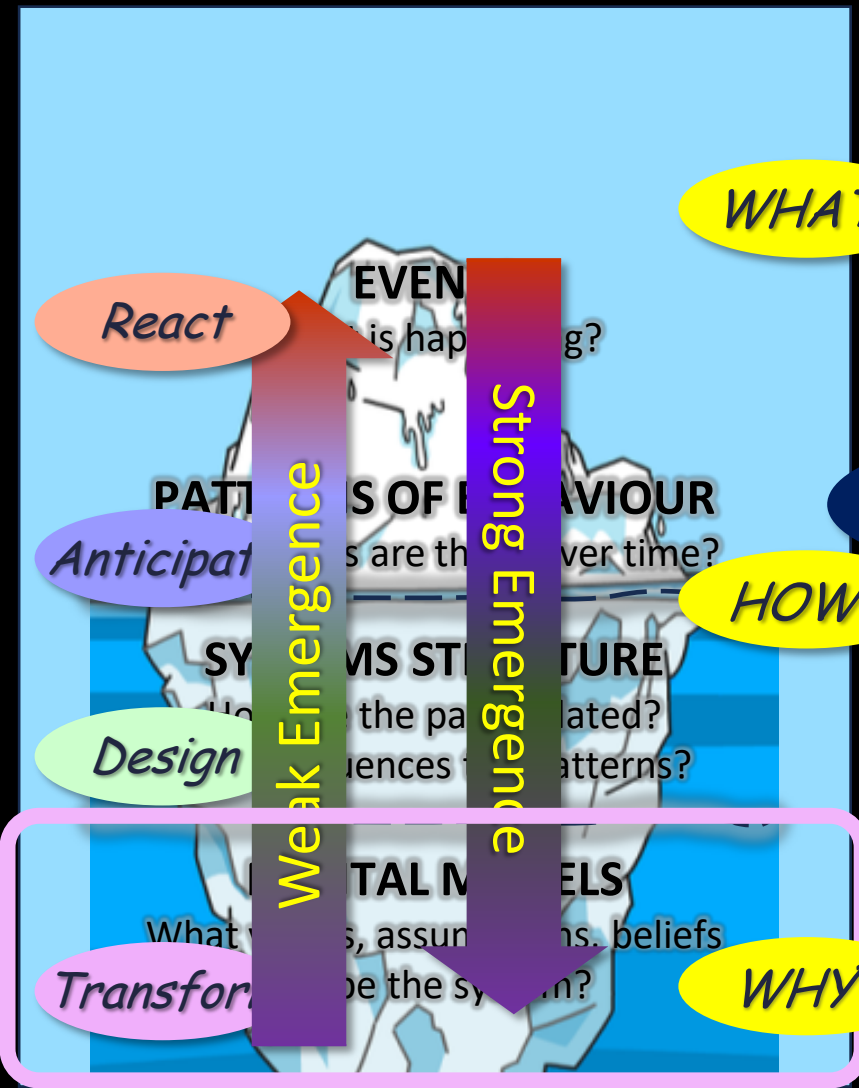
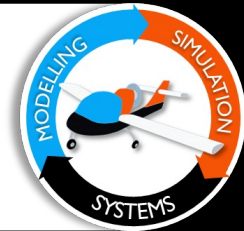
# "Emergence" in Smart-Cities







# "Emergence" in Smart-Cities

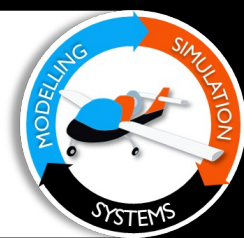


WHAT?

HOW?

WHY?





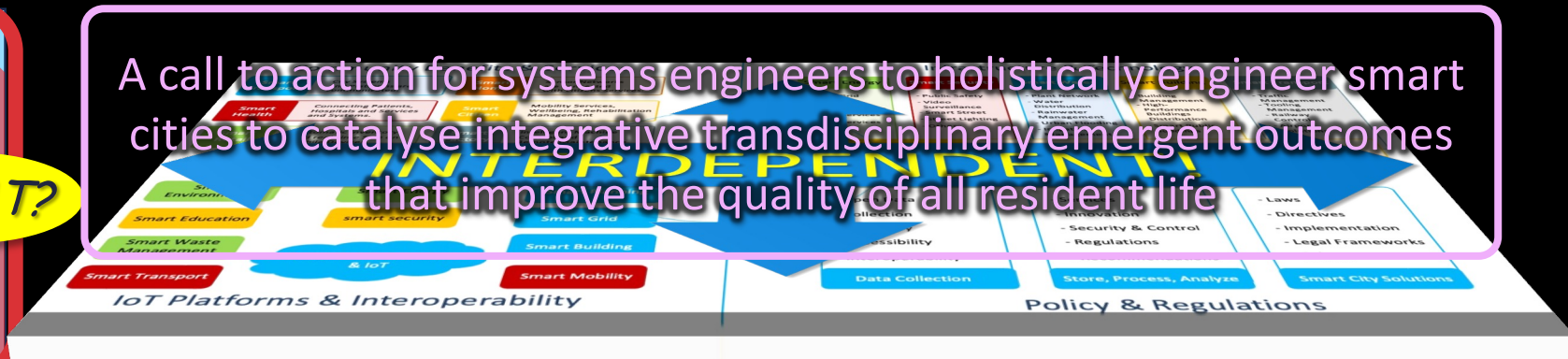
# The Environment **WHAT?**

# EVENT

What is happening?

# WHAT?

A call to action for systems engineers to holistically engineer smart cities to catalyse integrative transdisciplinary emergent outcomes that improve the quality of all resident life



## Anticipat

# PSYCHOLOGY OF BEHAVIOUR

## HOW?

## Design

# We k Emergence

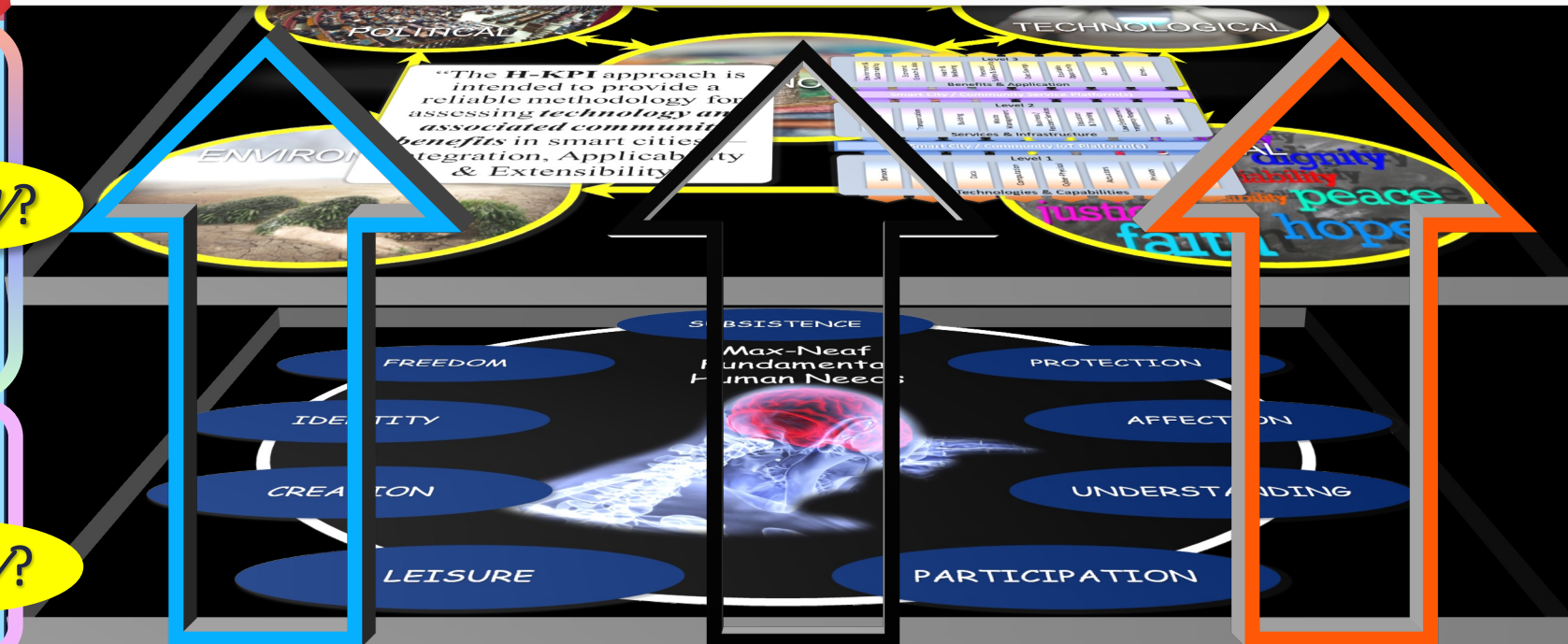
trong Emergen e

## Transform

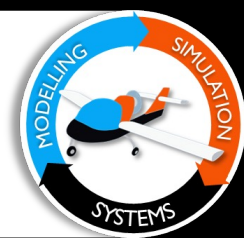
# TOTAL MODELS

s, assumptions, beliefs

## WHY?





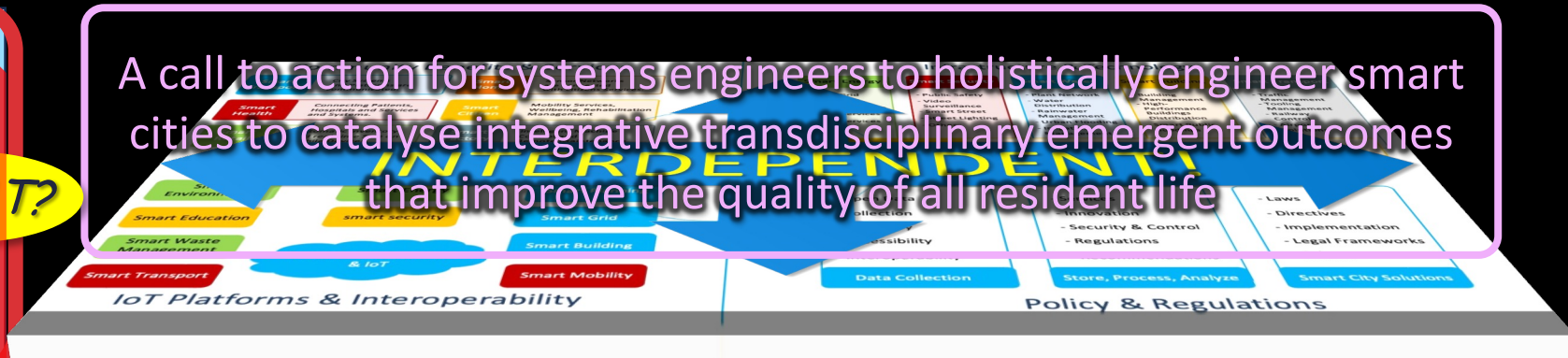


# The Environment

## WHAT IS HAPPENING?

# WHAT?

A call to action for systems engineers to holistically engineer smart cities to catalyse integrative transdisciplinary emergent outcomes that improve the quality of all resident life

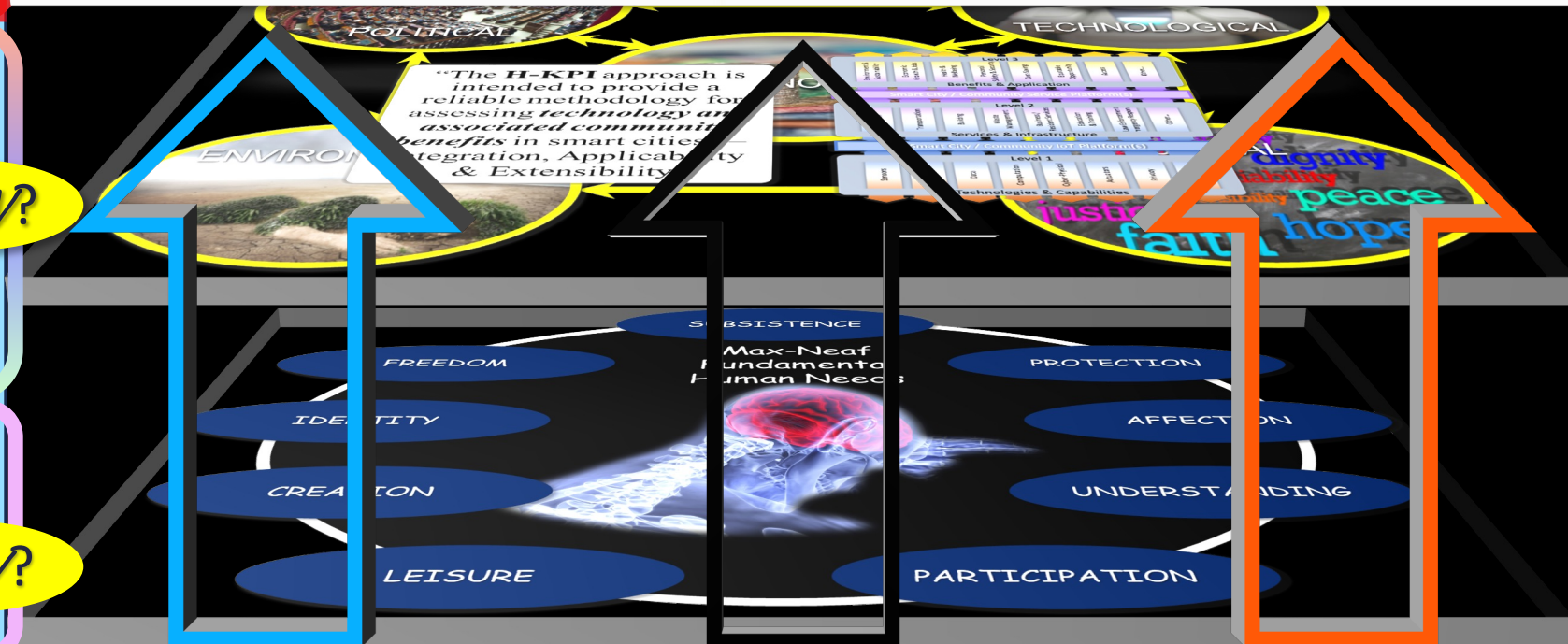


# Weak Emergence

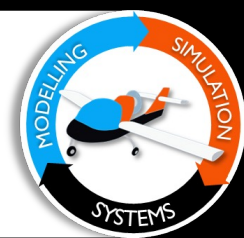
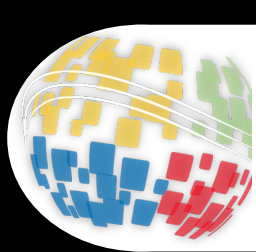
# Strong Emergence

## HOW?

## WHY?







# "Emergence" in Smart-Cities

## The Environment **WHAT?**

React

EVEN  
is hap

PATTERNS OF BEHAVIOUR  
**Anticipate** What are the patterns over time?

SYSTEMS STRUCTURE  
**Design** How are the patterns created?  
What are the patterns?

SYSTEMS BELIEFS  
**Transform** What are the assumptions, beliefs  
What are the system?

Weak Emergence

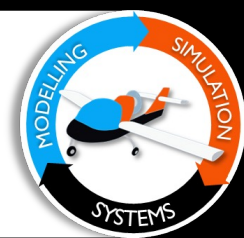
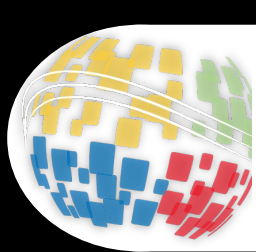
Strong Emergence

**HOW?**

**WHY?**

A call to action for systems engineers to holistically engineer smart cities to catalyse integrative transdisciplinary emergent outcomes that improve the quality of all resident life





# 5 Postulates & 1 Fundamental Value

(1) The Economy Should Serve the People and not the other way around....

(2) Development has to do with People and not with Objects...

(3) Development is Not the same as Growth, and does not necessarily require Growth...

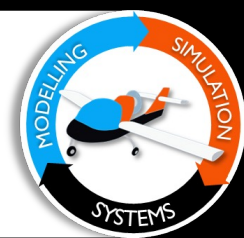
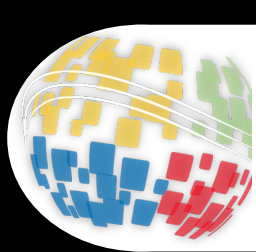
(4) No Economy is possible in the Absence of Eco-System Services...

(5) The Economy is a Sub-System of a larger finite system, the Bio-Sphere, hence permanent Growth is impossible...

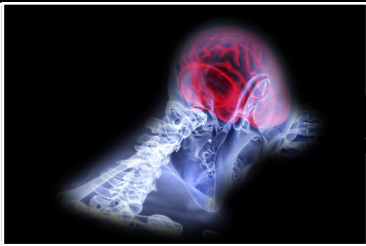


*No economic interest whatsoever, under any circumstances can be above the relevance (and miracle) of life in all its manifestations...*

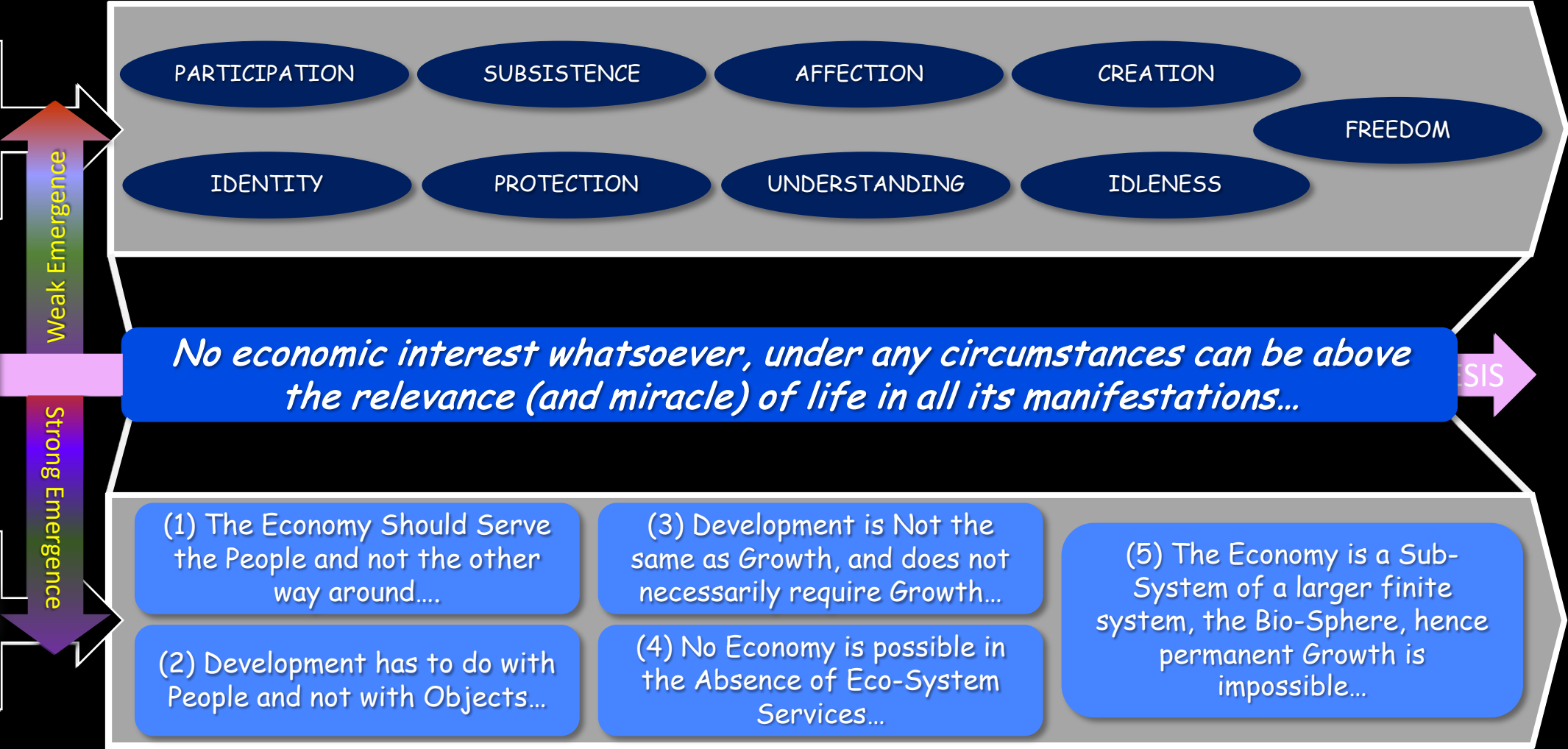




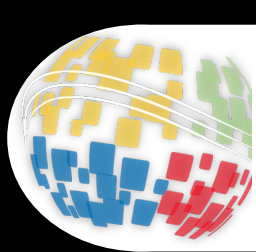
# SE for “right Emergence”



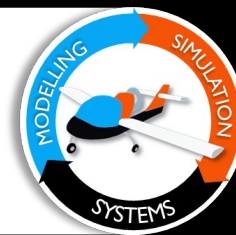
SMART  
CITIES



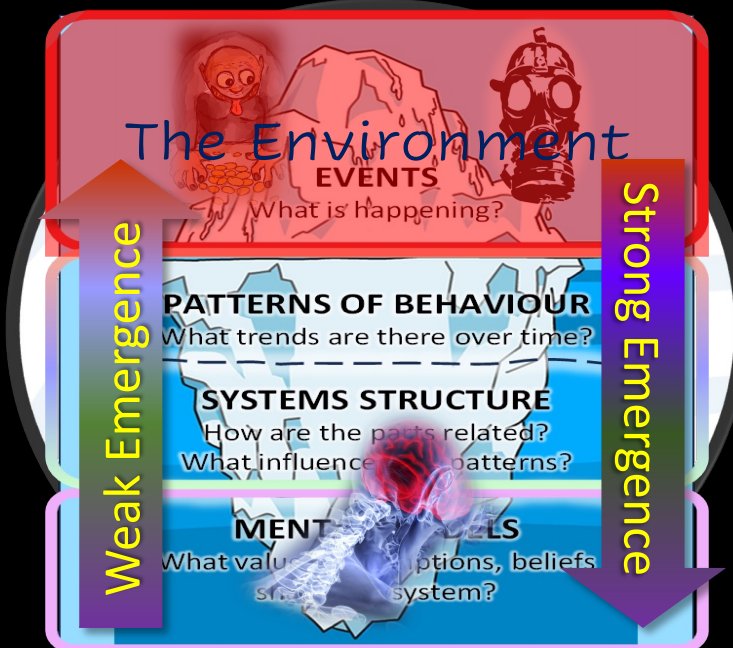




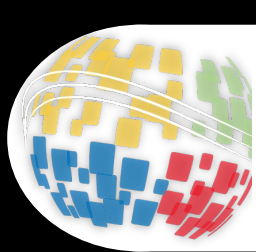
# The Smart Cities Challenge for SE



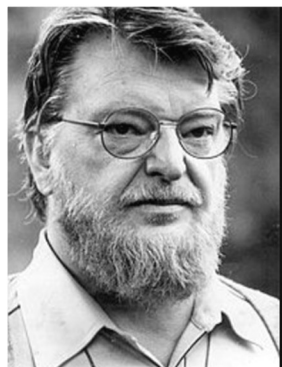
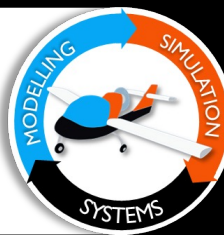
Smart cities represent a transformative approach to urban living, utilizing advanced technologies and data analytics to enhance the effectiveness, efficiency, sustainability and overall quality of urban environments.



Perhaps the greatest challenge for **systems engineers** will be delivering holistic solutions that stay true to the smart cities vision of improving the quality of life in this disruptive, complex and ever-evolving socio-technical context.



# The Smart Cities Challenge for SE

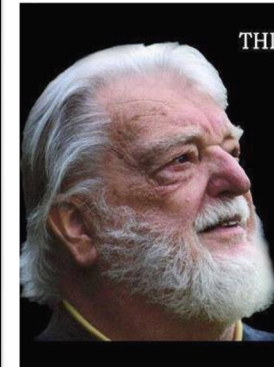


The aim of development must be neither producerism nor consumerism, but the satisfaction of fundamental human needs, which are not only needs of humanity...

— Manfred Max-Neef —

AZ QUOTES

Freedom of Speech, Choice and Expression, not Imposition, mandates, lockdowns or one-size fits all solutions.



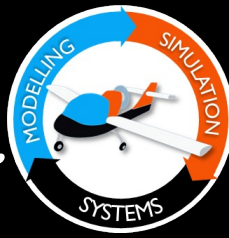
## THE 5 PRINCIPLES - Manfred Max-Neef

- \*One, the economy is to serve the people and not the people to serve the economy.
  - Two, development is about people and not about objects.
  - Three, growth is not the same as development, and development does not necessarily require growth.
  - Four, no economy is possible in the absence of ecosystem services.
  - Five, the economy is a subsystem of a larger finite system, the biosphere, hence permanent growth is impossible.
- And the fundamental value to sustain a new economy should be that no economic interest, under no circumstance, can be above the reverence of life.\*

*Disclaimer – the concepts expressed in this presentation are personal opinions and insights that continue to evolve based on theoretical and experiential learning and should not be taken as suggesting the truth nor be associated with any organisation that I have been part of or affiliated with.*

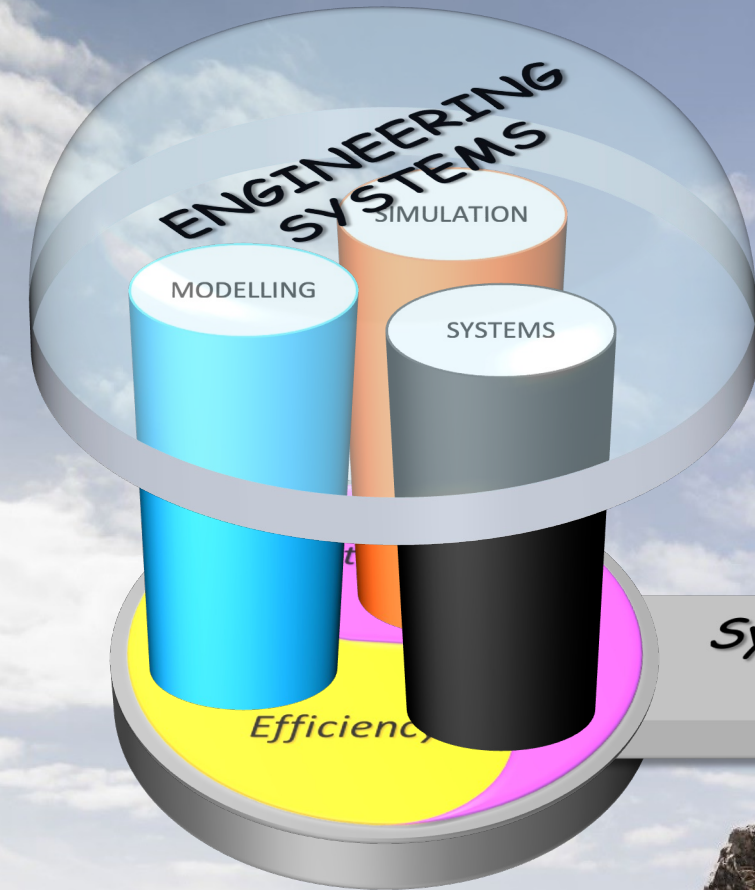


# Systemic and Systematic – Doing the Right Job Right!



## Motivation....

Elevate the application and understanding of the *Engineering of Systems* and the relative-standing of *Systems Engineers*



Enabled by Systems Thinking (GAS)

*Systems Engineers enable the **efficient** and **effective** realization, sustainment and retirement of complex capabilities!*

Complimented by Modelling & Simulation

The **foundational responsibility of Systems Engineers** is to **maximise the right emergence** while **minimising the wrong emergence** and associated unintended outcomes **in the engineering of systems** through **Systemic Thinking**, complimented by **Modelling and Simulation**