3rd NATIONAL SUMMIT ON SMART CITIES INDIA 2017

18th August 2017 • The Lalit, New Delhi

Smart City as a system

A structured approach for planning & deployment...

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narnix technolabs pvt. ltd,

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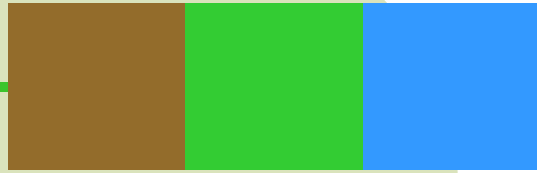
"Smart City as a System" –



A structured approach for planning & deployment

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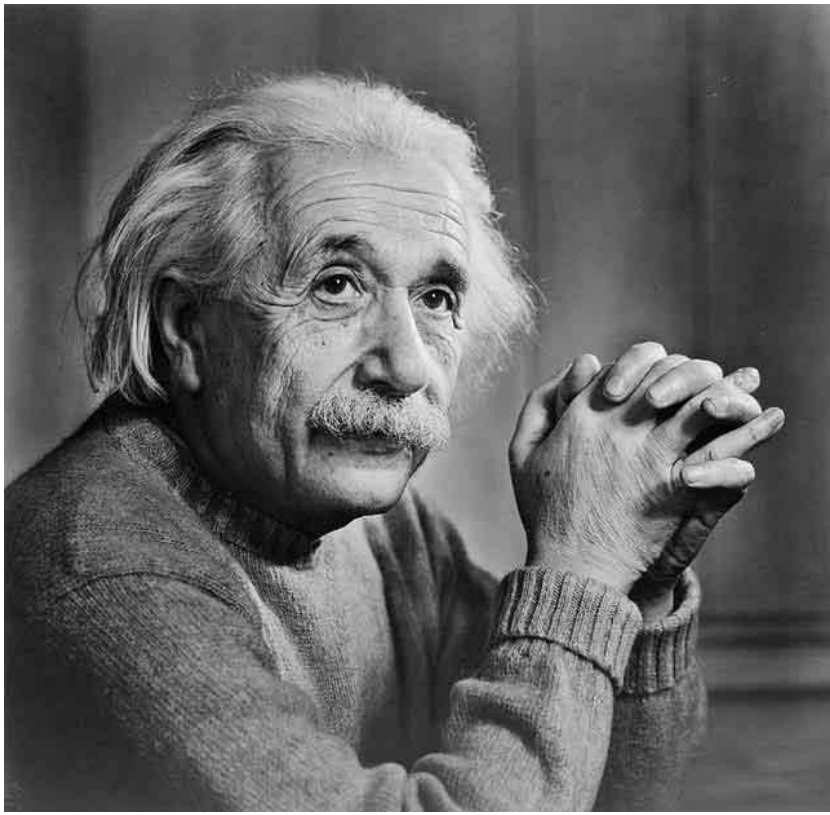
The big challenge:

Building a smart, sustainable, secure n resilient city is a big challenge

"The same way of thinking that got you into trouble won't get you out of it."



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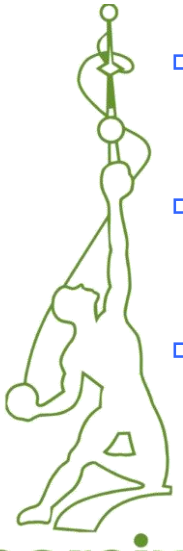
The Smart Transformation

The society, the business, the infrastructure, the services and all other aspects of the civilization on the planet Earth are going through a paradigm shift in the wake of technological advancements, especially in the field of ICT

All the ecosystems, be it Smart Cities, Smart Grid, Smart Buildings or Smart Factories now find themselves making three classes of transformations:



- ⇨ improvement of infrastructure – to make it resilient & sustainable…
- ⇨ addition of the digital layer- which is the essence of the *smart paradigm*; and
- ⇨ business process transformation - necessary to capitalize on the investments in smart technology.

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The genesis of Smart City

In a Smart City-

- ‘Sustainability is the Destination’
- ‘Resilience is the Characteristic’
- ‘Smart is the Accelerator’

Standards are the

Chromosomes of Smart Infrastructure

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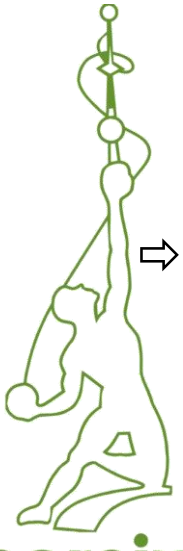
Challenges…

- Smart cities development & deployments announced without any groundwork on preparedness of the stakeholders and the ecosystem

- Multiple utilities are going to leverage and deploy similar technologies & solutions to improve the operational efficiency

- the technological trends in "smart Homes", "Smart Buildings", "Smart Cities" and "Smart Grid" are being considered and pursued in isolation from each other, by the respective stake holders.

- In fact, they form a very tightly interwoven and homogenous confluence of similar technologies being applied in different domains for a common cause of making our planet earth "smart-n-green".



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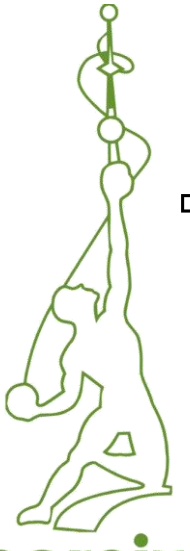
Challenges…

- There is no common framework and architecture defined for the various physical infrastructures to be deployed in the proposed smart cities to work in an integrated, harmonized and optimized manner…

- Data sharing amongst the multiple stakeholders of a smart city a major challenge

- There is also a recursive cycle to the data in a Smart City. Information that is generated is information that is consumed which in turn adds to the information generated which becomes information used again.



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Challenges…

- ⇨ Since indigenous ecosystem is not geared up to cater to the physical infrastructure needs of the smart cities, most of the systems & solutions deployed shall have to be imported from foreign vendors based on their respective proprietary technologies with limited or NO interoperability with system/solution components from other vendors.

- ⇨ Each city shall always be dependent on the respective foreign vendors throughout the lifecycle of such systems/solutions for their O&M…

- ⇨ lack of harmonized standards in the respective ecosystems of the Smart Homes, Smart Buildings Smart Grid and Smart Cities shall ensure that the smart nodes of one network cannot talk to smart nodes of the other networks.

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- All sectors in the infrastructure framework are influenced by the unified ICT backbone paradigm.
- However, a common infrastructure pool enables the creation of a interconnected and truly homogenous system with seamless communication between services.
- Coordination, collaboration and harmonization can be better implemented by the effective use of standards based open, common and shareable, information and communication technologies.
- The disconnect amongst technological trends being pursued by the stakeholders of the now homogenous smart infrastructure needs to be bridged without any further delay to maintain the Lifecycle Cost or TCO (total cost of ownership) of these individual components within viable economic thresholds.

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- In this context, we need to redefine our individual perspectives of smart grid, smart building and smart cities.

- Now, they have to work in close harmony with each other to fulfill the homogenous functioning of the smart infrastructure in any given geographical territory.

- To optimize the resources and costs, we need to design and deploy an integrated common ICT backbone for all the different components of the smart infrastructure.

- This shall need to be independent of the individual stakeholders' applications and use cases like smart grid, smart water, smart health, smart transportation, smart street lighting and or smart buildings.

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"The beauty of standards is that there are so many to choose from!"

Andrew S. Tanenbaum, 1990

"Standards & even SDOs are not at the forefront of city planners', utilities' or users' minds"

There are misconceptions on what standards are for, and, the case for use of standards has not been made.

Liberalization and Markets have a lot of great virtues, but they cannot create their own conditions of existences: they **must be designed**!

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Smart City as a System is important

- Many common goals (sustainable development, better efficiency, resilience, safety and wider support for citizen's engagement and participation)
- Many common technologies (big data, mobile, IoT, etc.)
- Smart Cities are unique and common at the same time
- But current implementation practices are rather disjointed...
  - programmes and projects are, primarily, local initiatives
  - programmes and projects are considered as technology projects
  - many independent Smart Cities interest groups
  - efforts for development of a common vision are insufficient
  - typical financing patterns do not promote a common vision
- There is a systemic problem which can only be addressed with the Systems Approach

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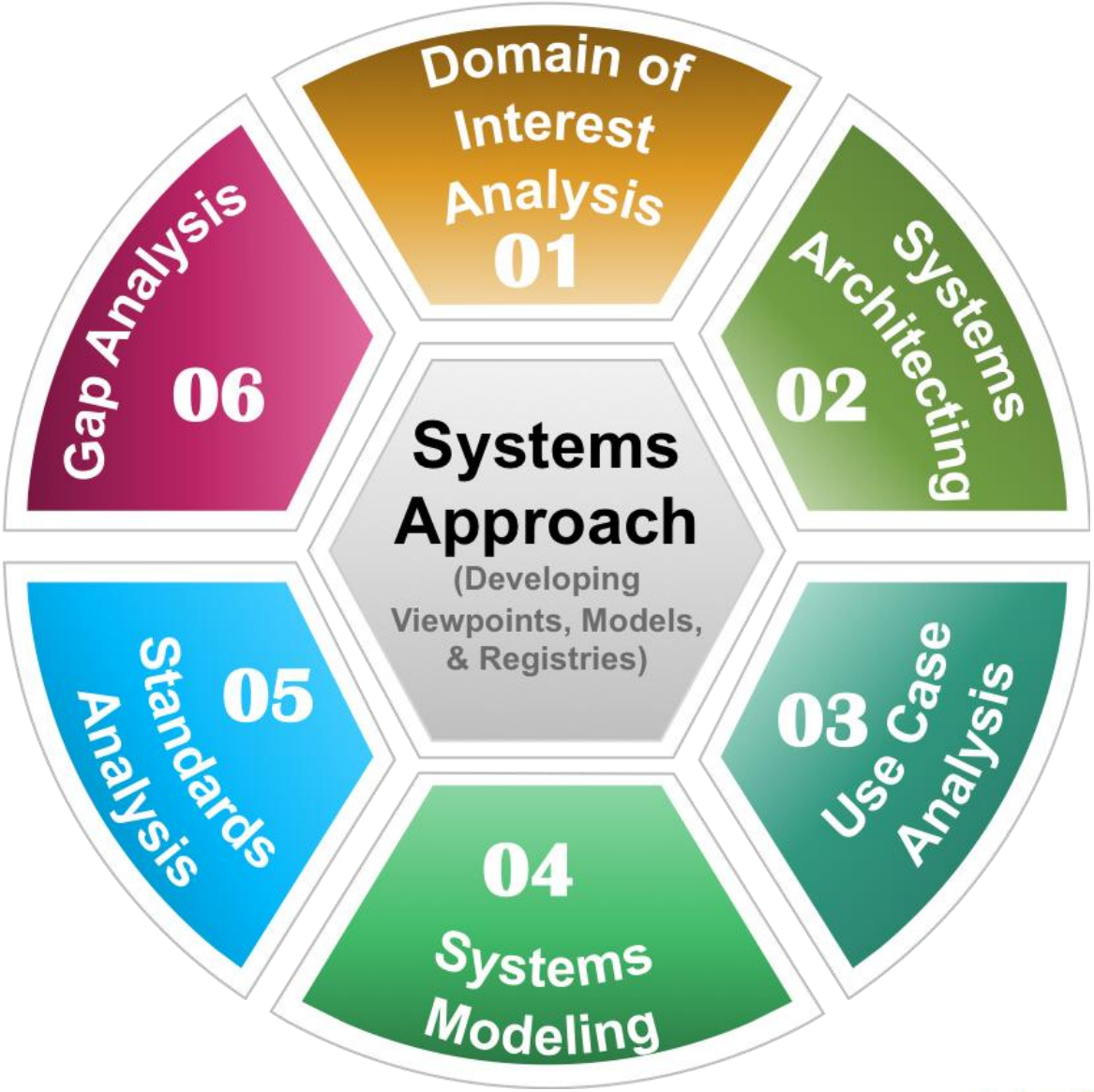
Systems Approach



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Six Stages

- There are six stages in the IEC Systems Approach. Each stage is focused on an area of understanding about the system.
- The knowledge gained from each stage builds on top of each other, therefore it is important to follow each stage in order.
- However, users are encouraged to apply an iterative approach meaning there is no constraint going back to a previous stage with new insights that was gathered in another stage.
- This "iterative" practices is described in further slides.

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STAGE 1 - Domain Analysis:

- ⇨ This initial stage is crucial in building an understanding of the mission, desired results, or objective that is driven by the market and stakeholders' needs.
- ⇨ Outputs of this stage sets the foundation, scope, and boundary of the system of interest.
- ⇨ Outputs from subsequent stages should be traceable to one or more of the needs identified in this stage.

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STAGE 2 - System Architecting:

- The second stage extrapolates on the first with a purpose to build clarity on the system through general use cases and reference architectures.

- The intent of this stage is to build a wide breadth knowledge of the system without going into details.

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STAGE 3 - Use Case Analysis:

- Stage three is focused primarily on developing detail understanding of use cases identified in Stage 2.
- Using the use case methodology in IEC 62559-2, this stage provides guidelines and templates to collect and build thorough Use Cases.
- Through these Use Cases, System Requirements can be derived, both functional and nonfunctional requirements.

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STAGE 4 - System Modelling:

- In the fourth stage, the Reference Architecture from Stage 2 is modelled in more detail based on the outputs gathered from the previous stages.

- Here the system discrete parts, interfaces, communication flow, environment factors, and such are modelled to help build a holistic perspective of the system.

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STAGE 5 - Standards Analysis:

- In this stage, the focus is on understanding and mapping what relevant standards exist for all the various parts of the system and whether they are contributing or countering the objectives identified in Stage 1.

- These standards can include IEC, ISO, ITU and other Global, Regional, National SDO standards.

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STAGE 6 - Gap Analysis:

- In the final stage, gaps where standards are missing are identified based on the knowledge of existing standards, desired system interaction, use cases and other information gathered from the previous stages.

- This will then initiate the activities for the committees to move forward with new standard development.

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How to use the Systems Approach

There are two primary issues to be considered by the users of the Systems Approach:

1. The sequence of stages and steps is not a dogma but a guideline. They can be used in iterative way if necessary.
2. It is recommended to consider some adaptation of the Systems Approach for the users' unique needs - some steps may be omitted or merged.

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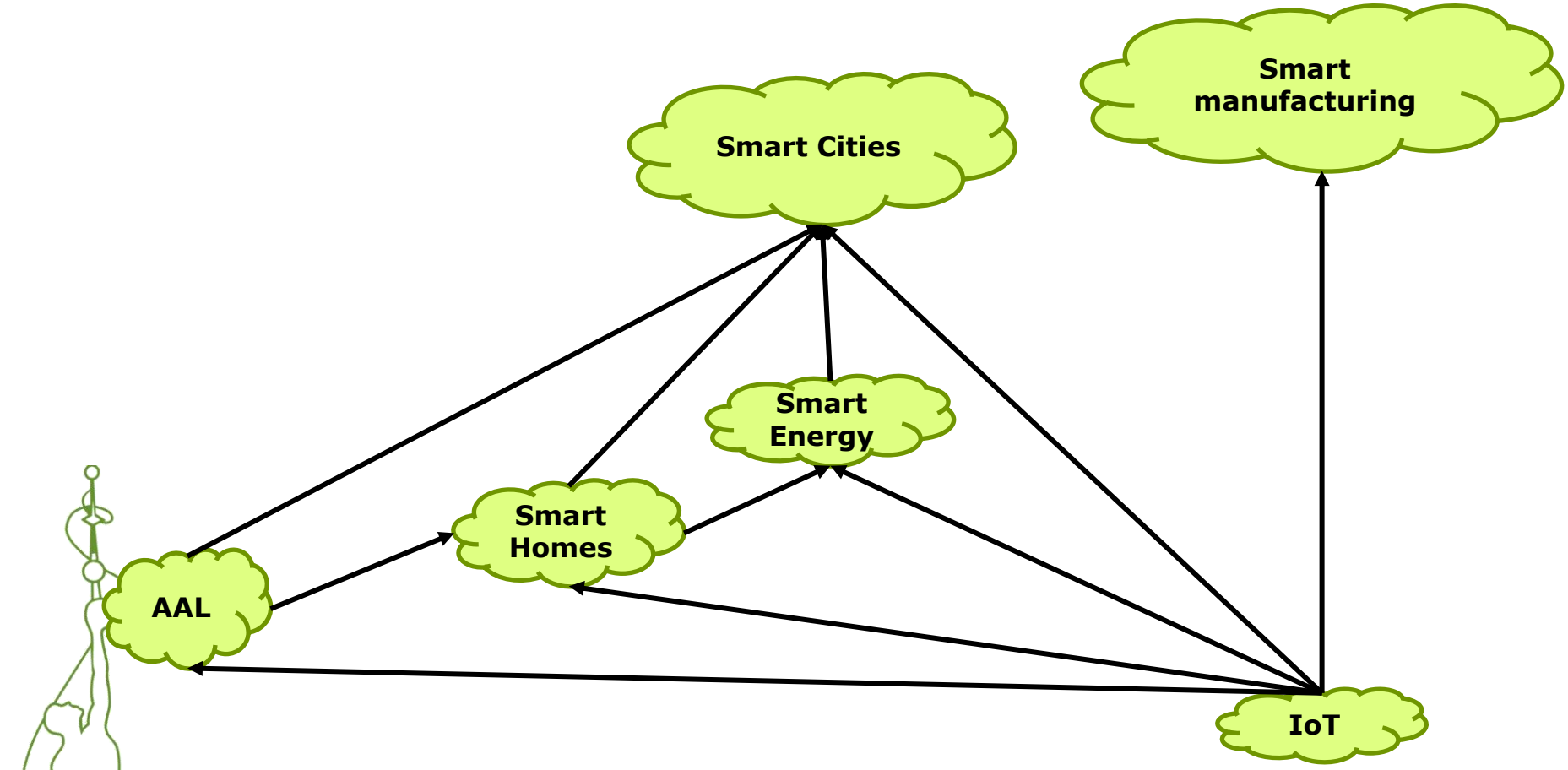
Potential question:
relations between systems domains



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Achieve synergy between diversity and uniformity

A unique	A common

B unique	B common

T unique	T common

Let us

1) Build common understanding
2) Isolate common parts
3) Find how to integrate unique and common parts
4) Develop common parts once and with high quality as a platform
5) Have a version of the common platform at each Smart City
6) Cooperate and coordinate among Smart Cities

Together Smart Cities will gain a lot in quality, time and money

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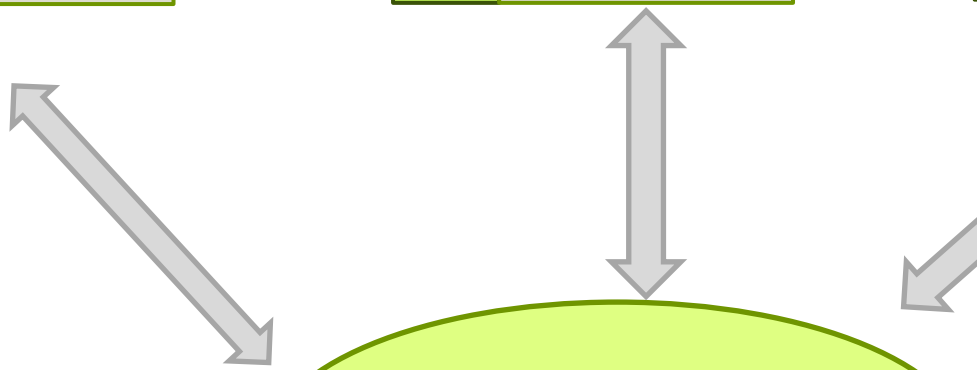
Reference architecture helps to isolate unique & common parts of Smart Cities

A unique	A common

B unique	B common

T unique	T common



Reference Architecture

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City Unified Business Execution (**CUBE**)

S1 A 2 …

CUBE platform in City A

B 1 S2 … B2

CUBE platform in City B

T1 S2 T3

CUBE platform in City T

Telecommunication providers

Industries

Academic and research institutes

Cooperation and coordination

S1 S2 … S3

Reference CUBE platform

Reference architecture

Reference model

Standards Development Organizations

Financial organisations

Specialized consulting firms

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Simple calculations

- **N** is the total cost of a Smart City implementation (construction and operating)
- **N * 100** is the total cost for 100 Smart Cities WITHOUT standardization
- N * 100 * 0.3 (unique parts) + N * 1 * 0.7 (common parts) * 3 (complexity factor) = N * (30 + 2.1) = **N * 32.1** is the total cost for 100 Smart Cities WITH standardization
- Cost difference is (N*100) / (N*32.1) ≈ **3 times**!

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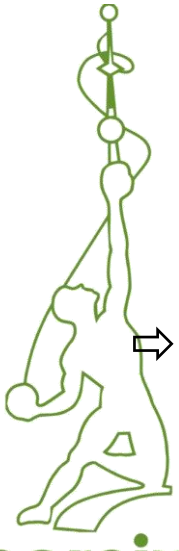
We deal with Digital Systems

- AAL, Smart Cities, Smart Homes, Smart Energy, IoT and Smart Manufacturing are **uber-complex real-time systems of cyber-physical, socio-technical and classic IT systems** with the following characteristics:
  - digital data and information in huge volumes
  - software-intensive
  - distributed and decentralized
  - great influence on our society
  - ability to interact with the physical world
  - security, safety, privacy and resilience are required by design
- To build right, good and successful Digital Systems it is mandatory to think about their architectures



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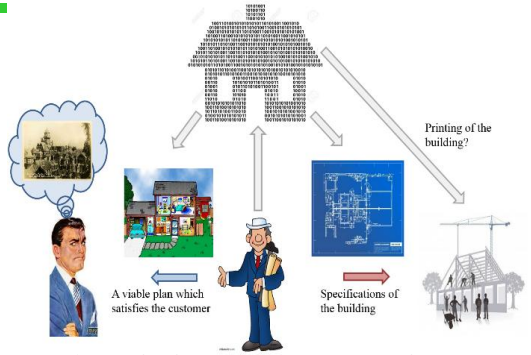
Understanding digital



- Digital organisation is an organisation in which life cycles of its primary products and services are built on the primacy of digital presentation of those products and services
- Business artefacts (including products and services) are available in **digital presentation** (thus formal and machine-executable)
- Digital is the **master media** for business artefacts
- Business artefacts can be moved **between digital, analogue and physical medias**
- Organisation, ecosystem and society "**understand**" the digital formats for business artefacts
- Organisation can transmit, protect, validate, enrich, interpret and manipulate digital business artefacts at their **whole life cycle**
- Organisation knows all the **dependencies** between its digital business artefacts
- Organisation can generate new **knowledge** from digital business artefacts
- Organisation can **adapt** digital business artefacts (extract, combine, change presentation, convert, etc.) to fit the current needs of a particular customer
- People can **delegate** to "things" (i.e. computers, sensors, actuators, robots, etc.) some routine activities with their business artefacts (e.g. with the use of IoT)
- With the progress of IoT, "things" become **more capable actors** of digital business processes ("things" may form temporary groups to carry out a particular activity)

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Four levels of abstraction in the IEC Systems Approach

1. **Reference Model**
   - abstract framework for understanding concepts and relationships between them in a particular problem space (or subject field)
2. **Reference Architecture**
   - template for solution architectures which realizes a predefined set of requirements
     - Note: A reference architecture uses its subject field reference model (as the next higher level of abstraction) and provides a common (architectural) vision, a modularization and the logic behind the architectural decisions taken
3. **Solution Architecture**
   - architecture of the system-of-interest
     - Note: A solution architecture (also known as a blueprint) can be a tailored version of a particular reference architecture (which is the next higher level of abstraction)
4. **Implementation**
   - realisation of a system-of-interest

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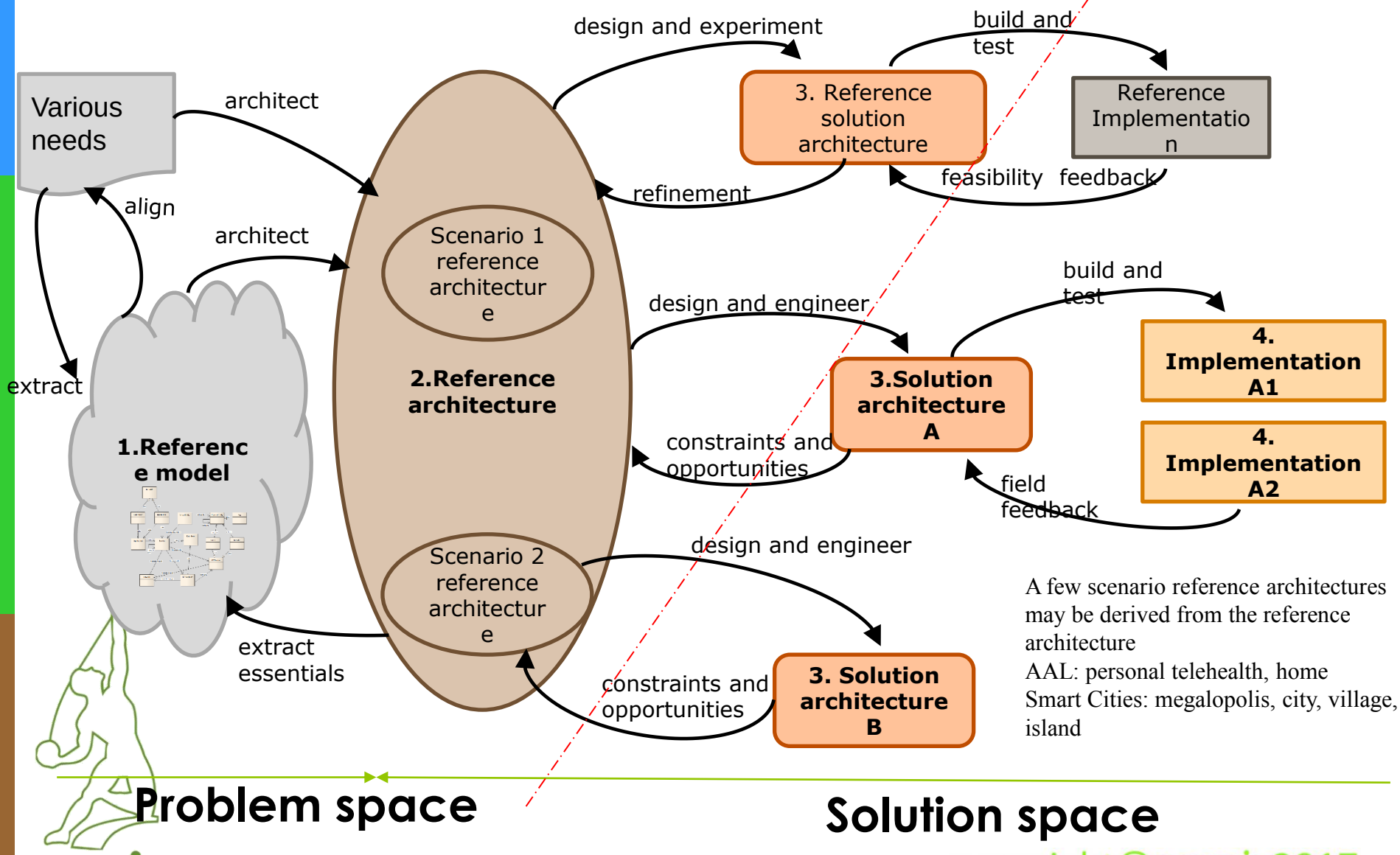
Levels of architecting



A few scenario reference architectures may be derived from the reference architecture
AAL: personal telehealth, home
Smart Cities: megalopolis, city, village, island

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Purpose of reference architecture

- **Explain to any stakeholder** how future implementations (which are based on the reference architecture) can address his/her concerns and change his/her personal, professional and social life for the better
  - explicitly link needs (or high-level requirements) with the principles of reference architecture
- **Provide a common methodology** for architecting cyber-physical systems in the particular system domain
  - different people in similar situations find similar solutions or propose innovations
- Help stakeholders, programmes and projects to **collaborate and coordinate their efforts**
  - common agreements (i.e. standards) on various system elements (e.g. services, interfaces, data, etc.), common vision, etc.

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Essential elements of any Reference Architecture

⇨ **INPUT**

- High-level requirements (or needs)
  - problem space needs
  - transversal needs (or guiding principles), e.g. security, privacy, low cost of operations, short time-to-market, resilience, etc.
  - system needs, e.g. life cycle, software-intensive, etc.
- Reference model

⇨ **OUTPUT**

- Architecture principles (top-level decisions, trade offs, etc.)
- Explicit link (or dependency matrix) between needs and principles
- Architecture description via viewpoints, models kind, views and models (in accordance with ISO/IEC/IEEE 42010)
- Reference specification of some artefacts

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Smart Cities reference model

⇨ Concepts to be defined together with the all the Stakeholders

- **city**
- **smartness**
- **smart city**
- **citizens and their classification**
- **city-related businesses and their classification**
- **city infrastructure**
- **city aspects (water management, waste management, etc.) and their classification**
- **…**

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Typical guiding principles

⇨ The guiding principles for defining the Smart Cities reference architecture are

- **interoperability**
- **safety**
- **security (including confidentiality, integrity and availability)**
- **privacy**
- **resilience**
- **simplicity**
- **low cost of operation**
- **short time to market**
- **combining diversity and uniformity**
- **self-referential**

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Some essential Viewpoints of the Smart Cities Reference Architecture

- Value Viewpoint
  - stakeholders, high-level requirements, mission, vision
- Big Picture Viewpoint
  - illustrative, essential characteristics, architecture principles
- Capability Map Viewpoint
  - level 1 modularisation, level 2 modularisation
- Engineering Viewpoint
  - function map, service map, process map, data flows, organigramme
- Implementation Viewpoint
- Security and Safety Viewpoint
- Risk Viewpoint
- Standards Viewpoint

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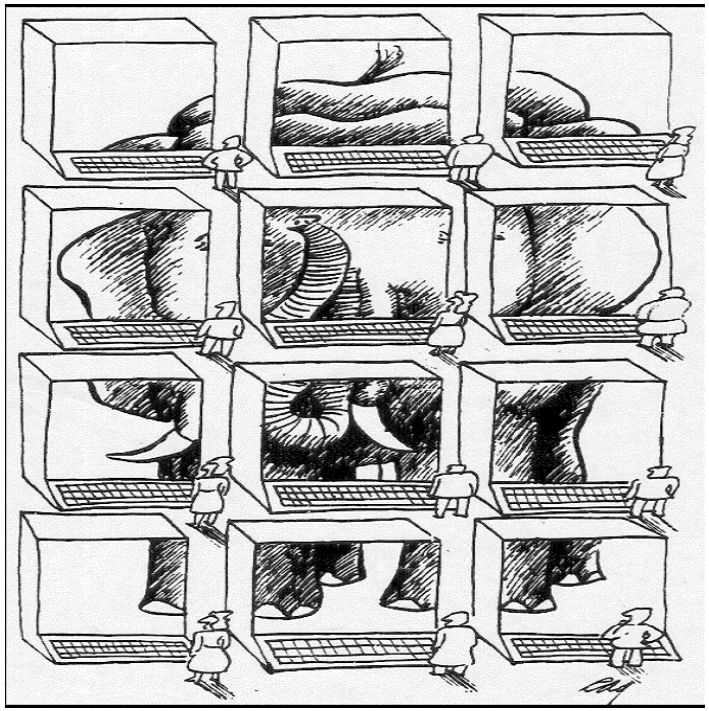
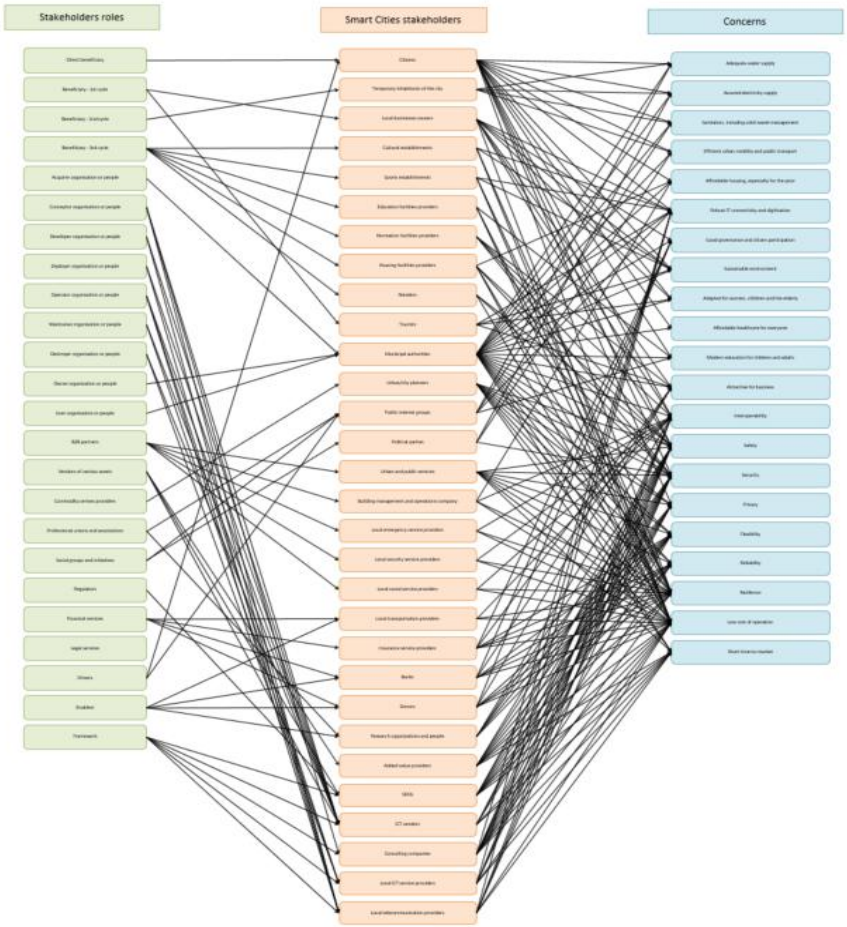
Value View:
Stakeholders' Needs Analysis

⇨ **Stakeholders, their roles and their concerns**





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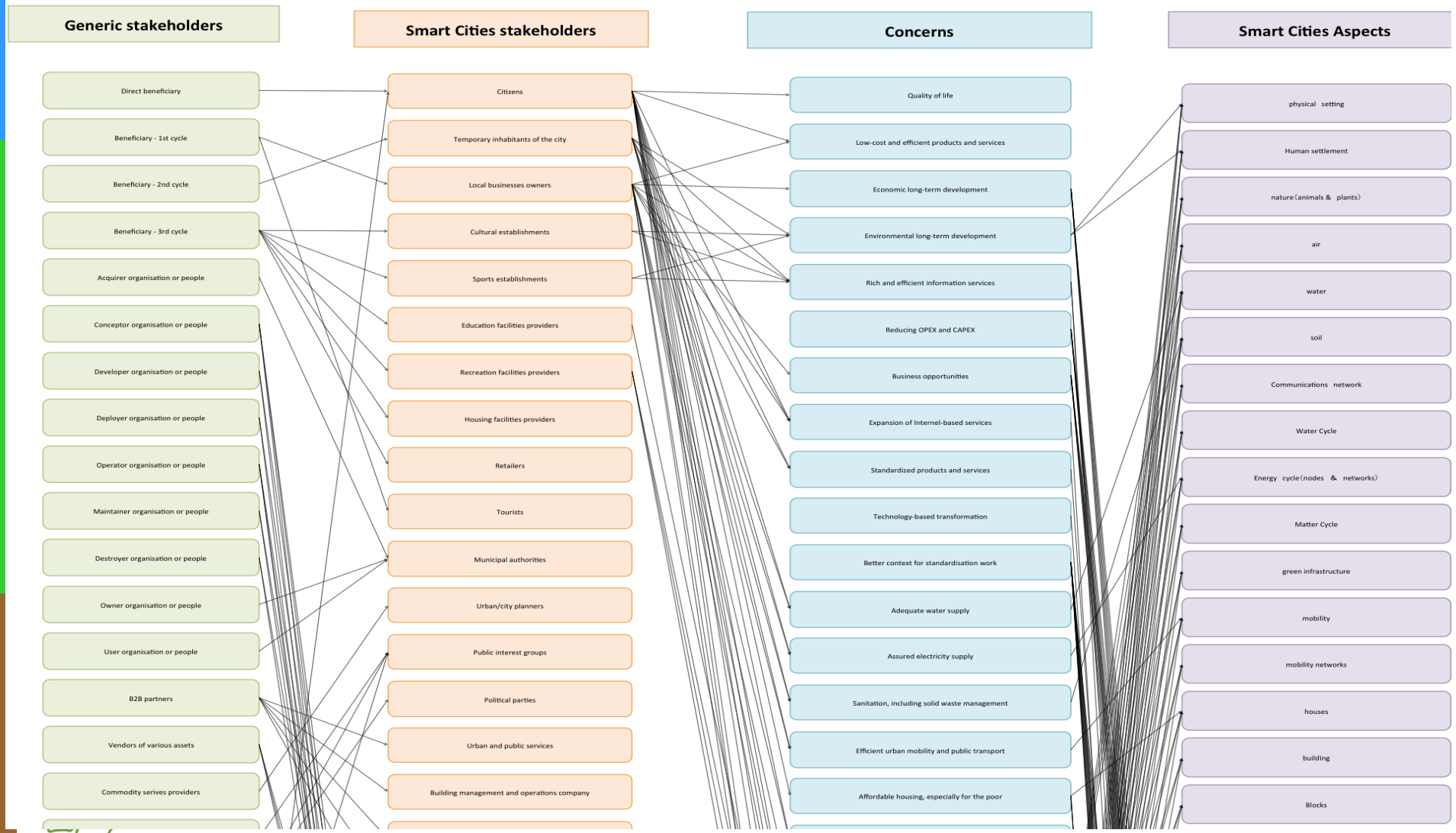
Value View:

Stakeholders' Needs Analysis



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Value View:
High-Level Requirements Needs (example)

- List of high-level requirements
  - Adequate water supply
  - Assured electricity supply
  - Sanitation, including solid waste management
  - Efficient urban mobility and public transport
  - Affordable housing, especially for the poor
  - Robust IT connectivity and digitalisation
  - Good governance and citizen participation
  - Sustainable environment
  - Safety and security of citizens, particularly women, children and the elderly
  - Affordable healthcare for everyone
  - Modern education for children and adults
  - Attractive for business

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Value view:

Mission and Vision

- Mission – a statement that describes the **problem** you are setting out to solve, typically including who you are solving it for
- Vision – an idealized **solution** that addresses the problem you've articulated in your mission

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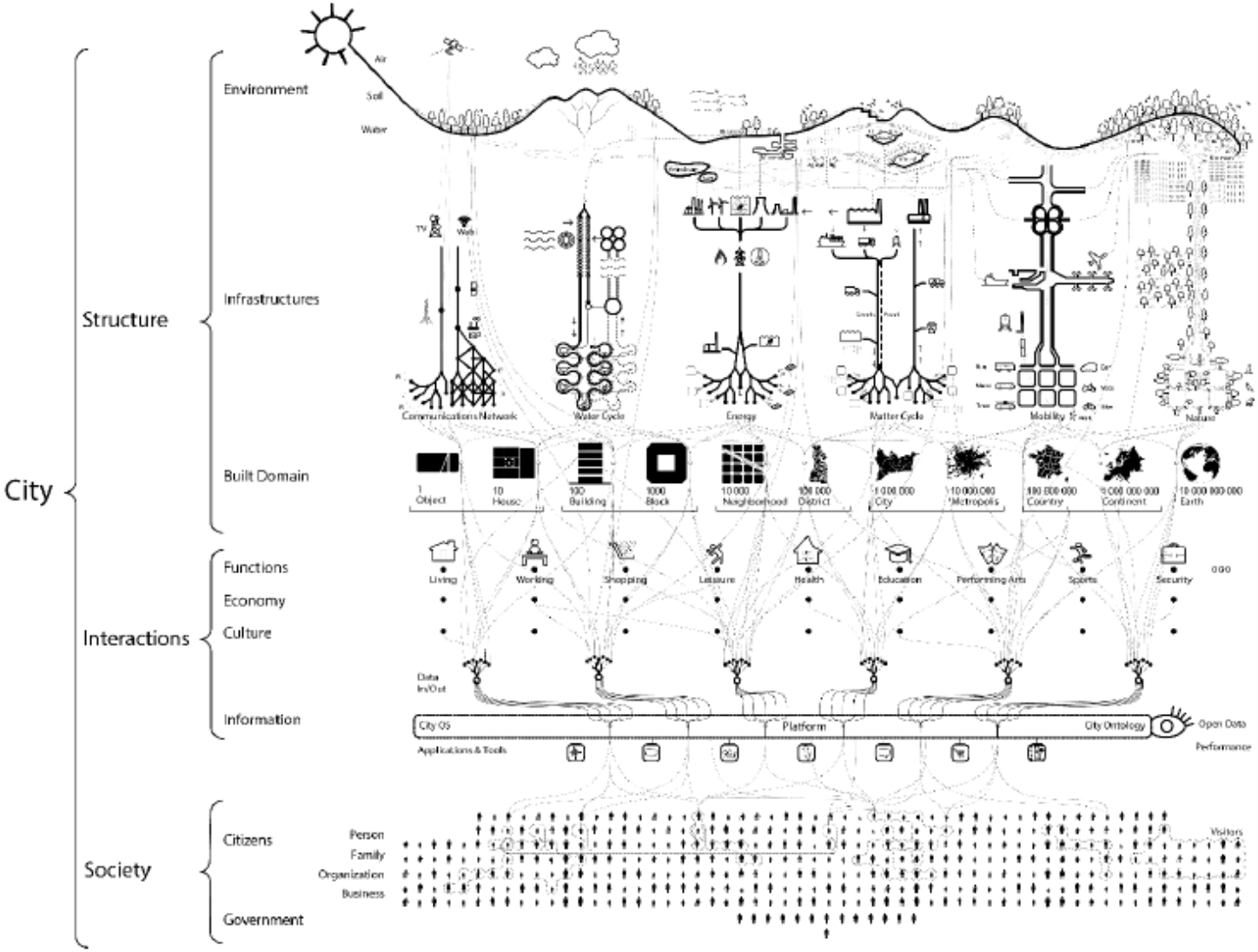
Big Picture View:

illustrative (from Descriptive framework)



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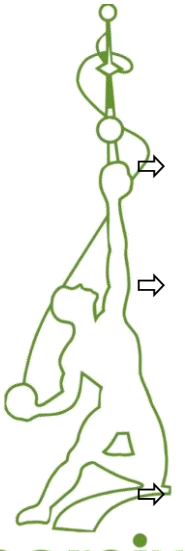
Big Picture View:

Essential Characteristics (example)

- **Flows handling**: Cities are self-referential systems of flows (see http://www.academia.edu/15717758/Conceptualising_the_Urban_System_as_a_System_of_Flows) and, those flows are flows of entities of various types: digital, physical, living, social, political, legal, etc. If no flows then a city is dead.
- **Multidimensionality**: Those flows co-exist and interrelate in the several dimensions: spatial, temporal, cybernetical, technological, etc.
- **Unpredictability of growth**: Smart Cities are organically-grown and must be scalable. (What do you see in 70 million people moving to cities every year?)
- **Technology absorption**: Because of the technology progress, many various (and unknown right now) intellectual devices (or "Things" from the IoT) and digital technologies will progressively automate, improve and drastically change various aspects of Smart Cities functioning including planning, execution, monitoring, prediction, optimisation of flows.
- **Synergy**: Intellectual devices, digital applications and digital services must work synergistically in several dimensions.
- **Holistic overview**: Various aspects of the Smart Cities functioning (e.g. level of security, environmental impact, etc.) must be integrally (i.e. including all the available data, information and knowledge) anticipated, monitored, analysed, controlled, alerted and acted on.
- **Trustworthiness**: High level of trustworthiness (includes security, privacy, safety, reliability, and resilience) is mandatory.



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Big Picture View:

Needs vs. Essential Characteristics

Needs	Flows handling	Multidimensionality	Unpredictability of grotwh	Technology absorption	Synergy	Holistic overview	Trustworthiness
Adequate water supply	x	x	x		x	x	
Assured electricity supply	x	x	x		x	x	
Sanitation, including solid waste management	x	x	x		x	x	x
Efficient urban mobility and public transport	x	x	x	x	x	x	
Affordable housing, especially for the poor		x		x		x	
Robust IT connectivity and digitisation	x			x	x	x	
Good governance and citizen participation	x				x	x	x
Sustainable environment		x	x	x	x	x	
Safety and security of citizens, particularly women, children and the elderly		x				x	x
Affordable healthcare for everyone				x	x		
Modern education for children and adults				x	x		
Attractive for business				x	x		x

Essential characteristics

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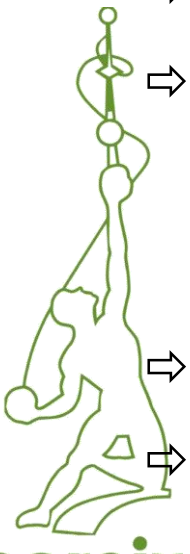
Big Picture View:

Architecture Principles (example)

- **Explicit Systems Architecting and Engineering** is only a way to achieve essential characteristics of Smart City implementations
- **Smart City as a System of Digital Interrelated Flows** (**SCaaSoDIF**) which implies total digitalisation and intensive use of intellectual devices from the IoT
- **Separation of Concerns** is very critical to reduce the complexity of Smart City implementations
- SCaaSoDIF is an **assembly** to be very adaptive and flexible
- SCaaSoDIF as an assembly is constructed and operating on the basis of explicit and machine-executable **digital contracts** between people, services, applications, devices and organisations
- **Time and place** must be integrated to handle flows properly
- **Ontology** is a must because this system-domain covers many, historically, disjoint subject fields



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Big Picture View:

Essential Characteristics vs. Principles

Essential characteristics	Explicit systems architecting and engineering	SCaaSoDIF	Separation of concerns	Assembly	Digital contracts	Time and place	Ontology
Architecture principles							
Flows handling		x		x	x	x	
Multidimensionality	x	x	x				
Unpredictability of grotwh	x		x				
Technology absorption			x	x			x
Synergy	x	x		x	x		x
Holistic overview	x	x		x		x	x
Trustworthiness	x				x	x	x

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Capability Map View:
Level 1 Modularization

Structural decomposition of the mission into groups or domains or value streams.

- **Leading** capabilities
  - Overall city governance, management and operations
- **Core** capabilities
  - water, energy, waste, etc.
- **Enabling** capabilities (shared among CORE capabilities)
  - geomatics, census, registries, etc.
- **Supporting** capabilities
  - finance, legal, PMO, ICT, media, procurement, etc.

- **All Smart Cities have the same capability map (and different levels of maturity).**
- **Each Smart City will implement (at a particular moment) only some capabilities from this map.**

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Capability Map View:

CORE Capabilities (example)

1. **Facilities & buildings management**
2. **Energy management**
3. **Water management**
4. **Waste management**
5. **Public safety and security management**
6. **Environment (nature) management**
7. **Transportation management**
8. **Healthcare management**
9. **Education management**
10. **Social side management**
11. **Economic development management**
12. **Culture & entertainment management**

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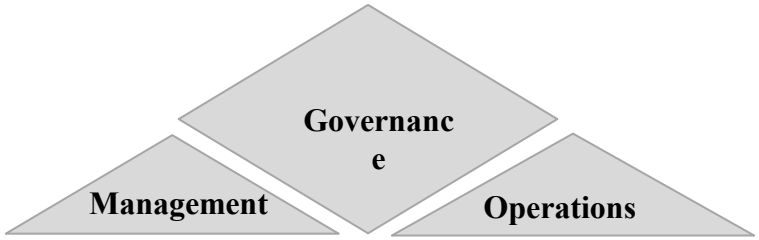
Capability Map View: Level 1 Visualisation (example)



Leading capabilities

Facilities & buildings management	Healthcare management
Energy management	Education management
Water management	Social side management
Waste management	Public safety & security management
Transportation management	Economic development management
Environment (nature) management	Culture & entertainment management

Core capabilities

Enabling capabilities

Geomatics | Census | Registries | …

Supporting capabilities

Finance | Procurement | Legal | Media | PMO | ICT | KM

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Engineering View: Explanation

Various

⇨ Function Maps,

⇨ Service Maps,

⇨ Process Maps,

⇨ Data Flows,

⇨ Organograms

which are built in accordance with the detailed (level 2 and level 3) capability

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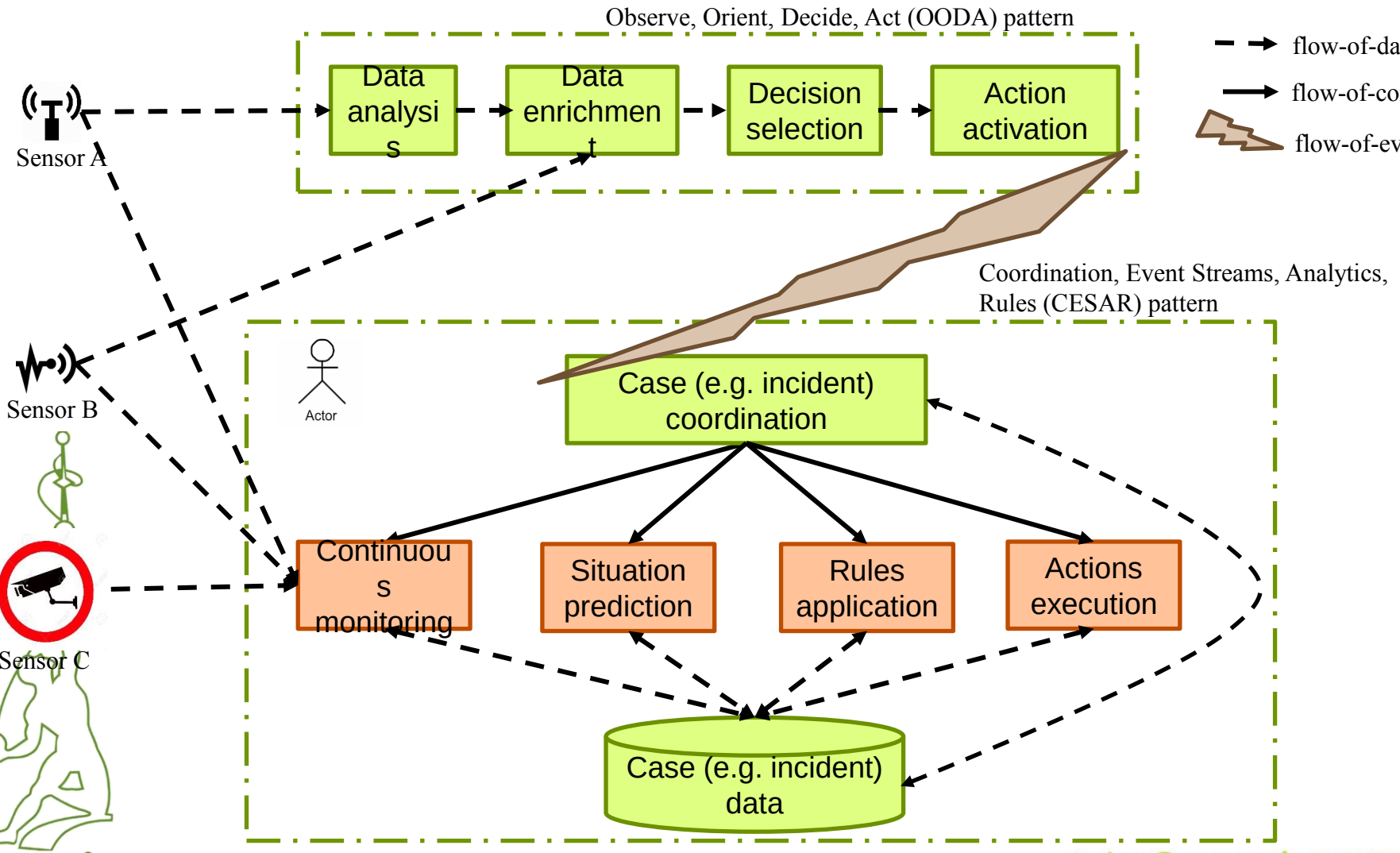
Engineering view: operational patterns (example)



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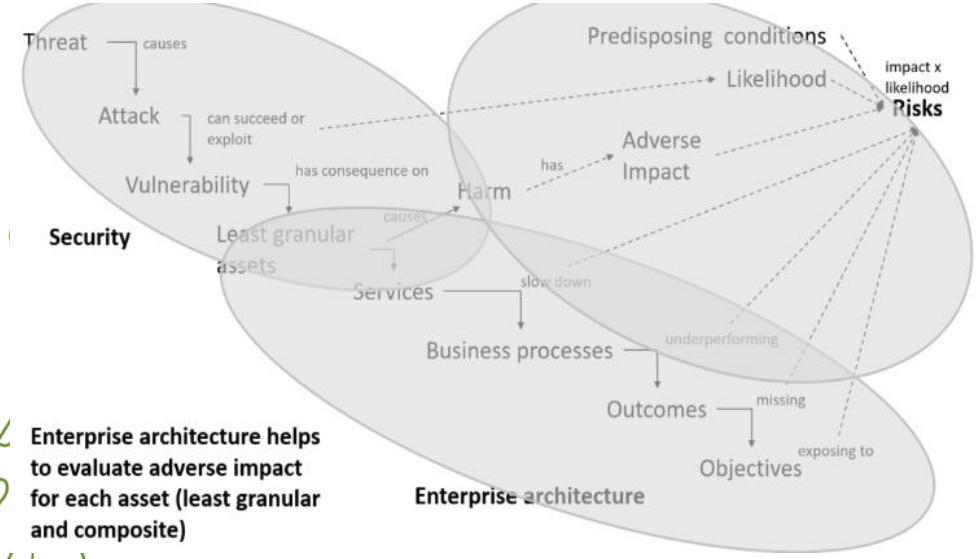
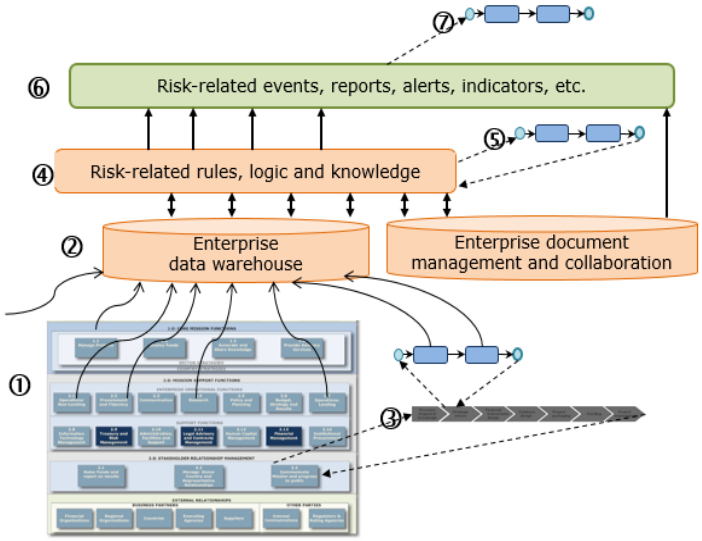
Security and safety views: Example

- ⇨ In general, no problems with the GDPR compliance:
  - ➢ Use of explicit and machine-executable business processes
  - ➢ Request GDPR compliance from all partners (including IoT devices providers)
- ⇨ Use digital contracts (see http://improving-bpm-systems.blogspot.ch/2016/07/digital-contract-as-process-enables.html)





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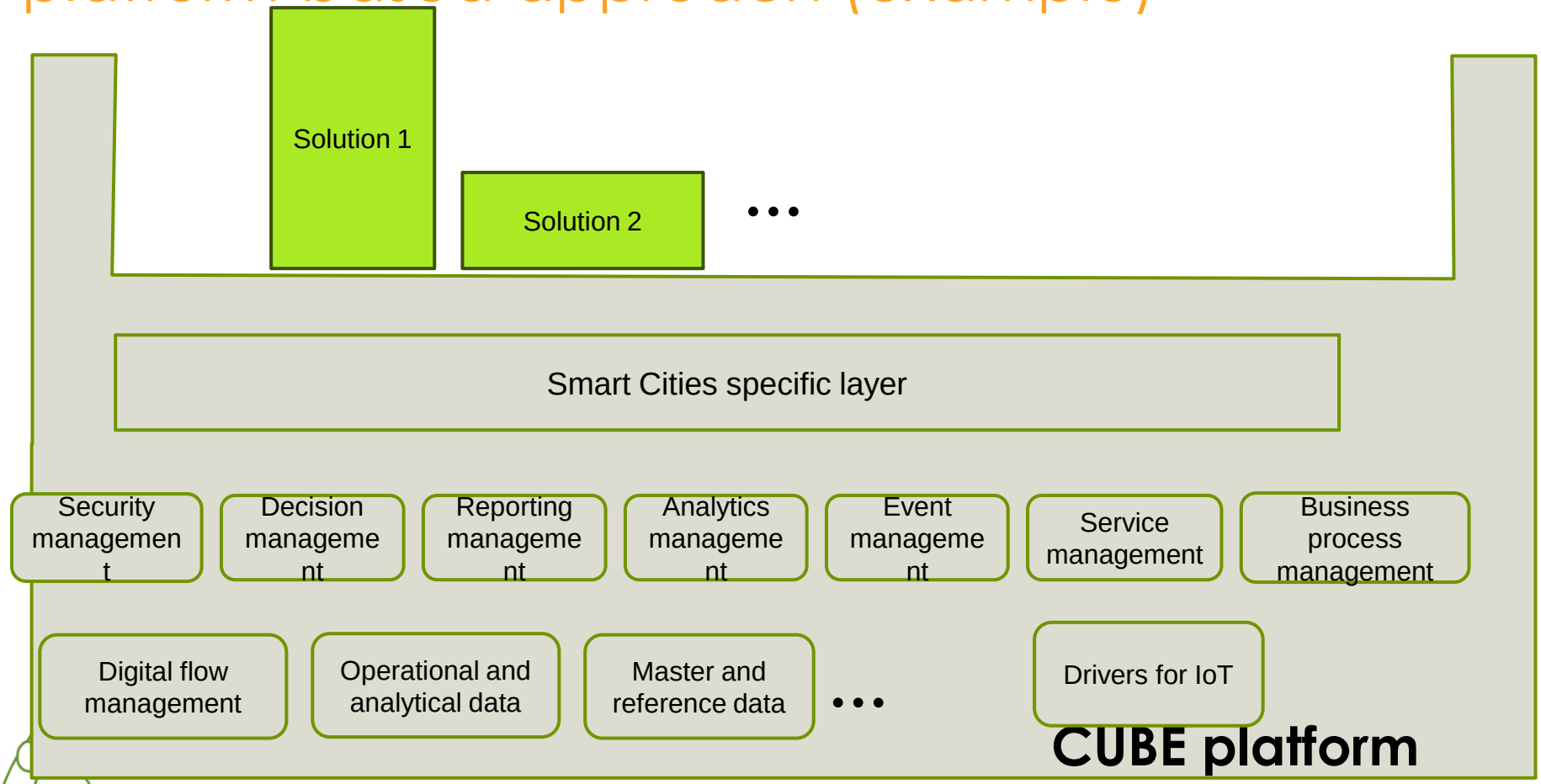
Implementation viewpoint: platform-based approach (example)



City Unified Business Execution (CUBE) platform

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Implementation view:
City Unified Business Execution (CUBE)

S1 A 2 …

CUBE platform in City A

B 1 S2 … B2

CUBE platform in City B

T1 S2 T3

CUBE platform in City T

Telecommunication providers

Industries

Academic and research institutes

Cooperation and coordination

S1 S2 … S3

Reference CUBE platform

Standards Development Organizations

Financial organisations

Specialized consulting firms

Reference architecture

Reference model

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Usage of the Smart Cities Reference Architecture Methodology

- The agreed Smart Cities Reference Architecture Methodology will be used to create the Smart Cities Reference Architecture by developing agreed views and models

- A lot of Cities are waiting for our deliverables

Population	Number of Cities
1,000,000 +	**457**
500,000 +	**1,063**
150,000 +	**2,896**

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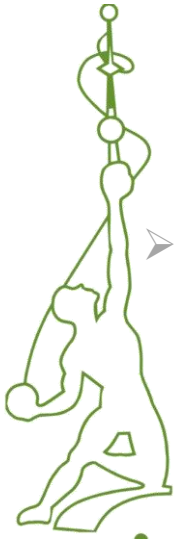
Conclusions

- **Sustainability for Cities requires independence from any technology and vendor.**

- **Wide scale deployments, require system approach and strategies to make appropriate *risk informed investment decisions*, taking into account the *legacy*, while enabling reasonable incremental *transitions***

- ***Standardization* is a key to pre-resolve the extreme challenge of complexity (common minimum or superset)**

- ***Harmonization of Standards/Specifications for device level Interoperability across the Nation… can enable the "Make in India, Design In India and Innovate in India…»***



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India is committed to building a "Smart Secure & Sustainable Nation" with comprehensive, structured & inclusive approach in Standardization, Regulatory Framework, Policy Formulation, & conducive business environment in a globally harmonized & collaborative manner....

Standards are the chromosomes of Smart Infrastructure

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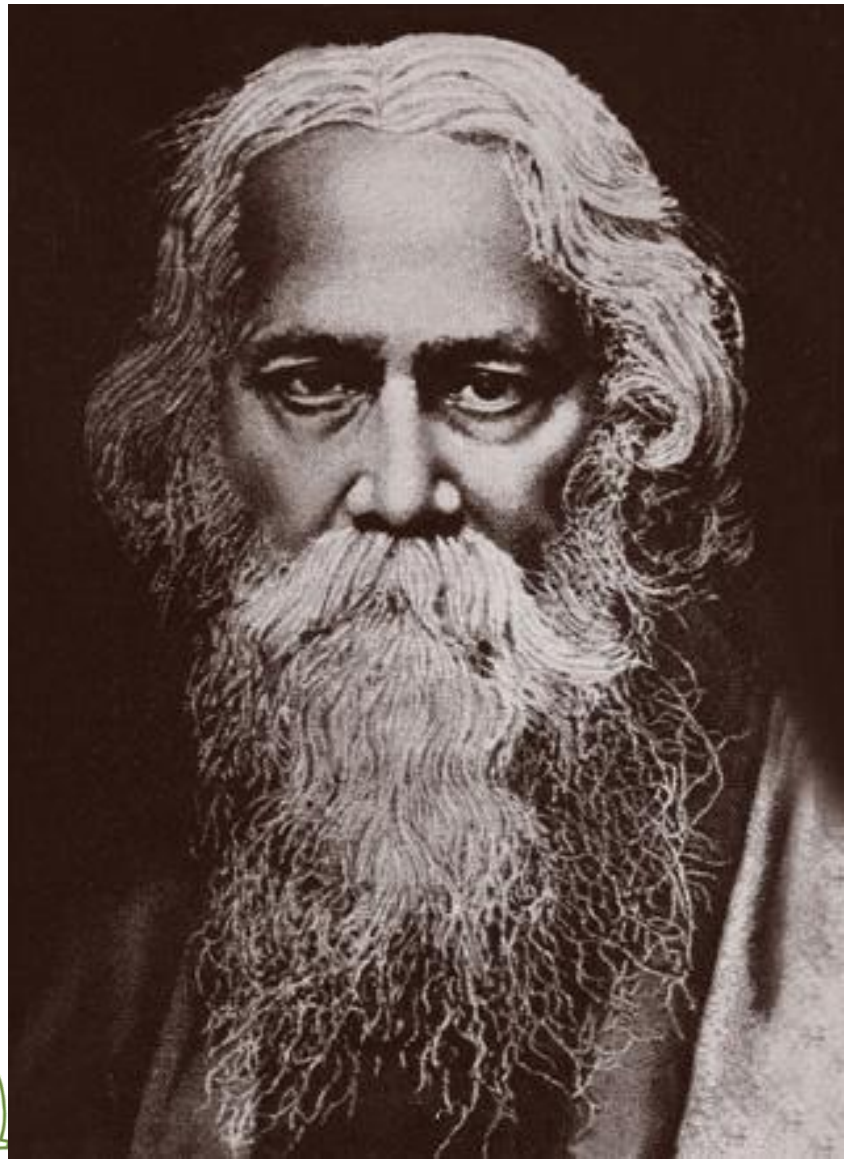
Resilience….



Let us not pray to be sheltered from dangers but to be fearless when facing them

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design is our religion
&
we are fanatically religious

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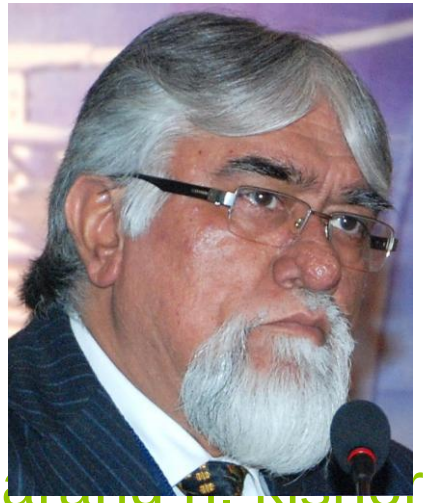
narnix technolabs designing with secure n sustainable dna

Brief Profile - narang n. kishor



narang n. kishor

Mentor &

Principal Design Architect

narnix technolabs pvt. ltd.

Technology Philanthropist,

Innovation & Standardization Evangalist…

Technology Consultant, Mentor & Design Architect in Electrical, Electronics & ICT…

- Over 39 years of professional experience in education, research, design and consulting .
- Over 25 years of hardcore Research and Design Development Experience in Solutions, Systems, Products, Hardware, Software & Firmware (Embedded Software) in fields of Industrial, Power, IT, Telecom, Medical, Energy and Environment.
- Over 10 years of Consultancy Experience to different segments of business & industry.
- Over 200 Research & Design Mentees in the Electronics & ICT Ecosystem.
- Leading & contributing in multiple National & Global Standardization Initiatives at BIS, TSDSI, IEC, ISO, ITU, IEEE etc…

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Brief Profile - narang n. kishor

Leading Standardization activities @BIS - the Indian National SDO in - Smart Cities, Smart Manufacturing, Smart Energy & Active Assisted Living as the Convener of Panel on **Smart Infrastructure.**

Contribution in Global SDOs:

- Convener – Reference Architecture Work Group in IEC SyC Smart Cities.
- Co-Editor – ISO 30145 on Smart City ICT Reference Framework
- Co-Editor – ISO 30146 on Smart City ICT Indicators

Representing Indian National Body BIS & contributing with Indian perspective in

- IEC – SyC Smart Energy, SyC Active Assisted Living & SyC Smart Cities. IEC - SEG4, SEG6, SEG7, SEG8 & SEG9
- ISO - TC 268 on Sustainable Development in Communities.
- ISO/IEC JTC1 - WG7 on Sensor Networks, WG9 – Big Data, WG10 – Internet of Things & WG11 – Smart Cities.
- ITU-T SG20 - Internet of Things (IoT) and its applications including smart cities and communities (SC&C).
- IEEE Smart Cities & Internet of Things Steering Committees.
- ……. …….

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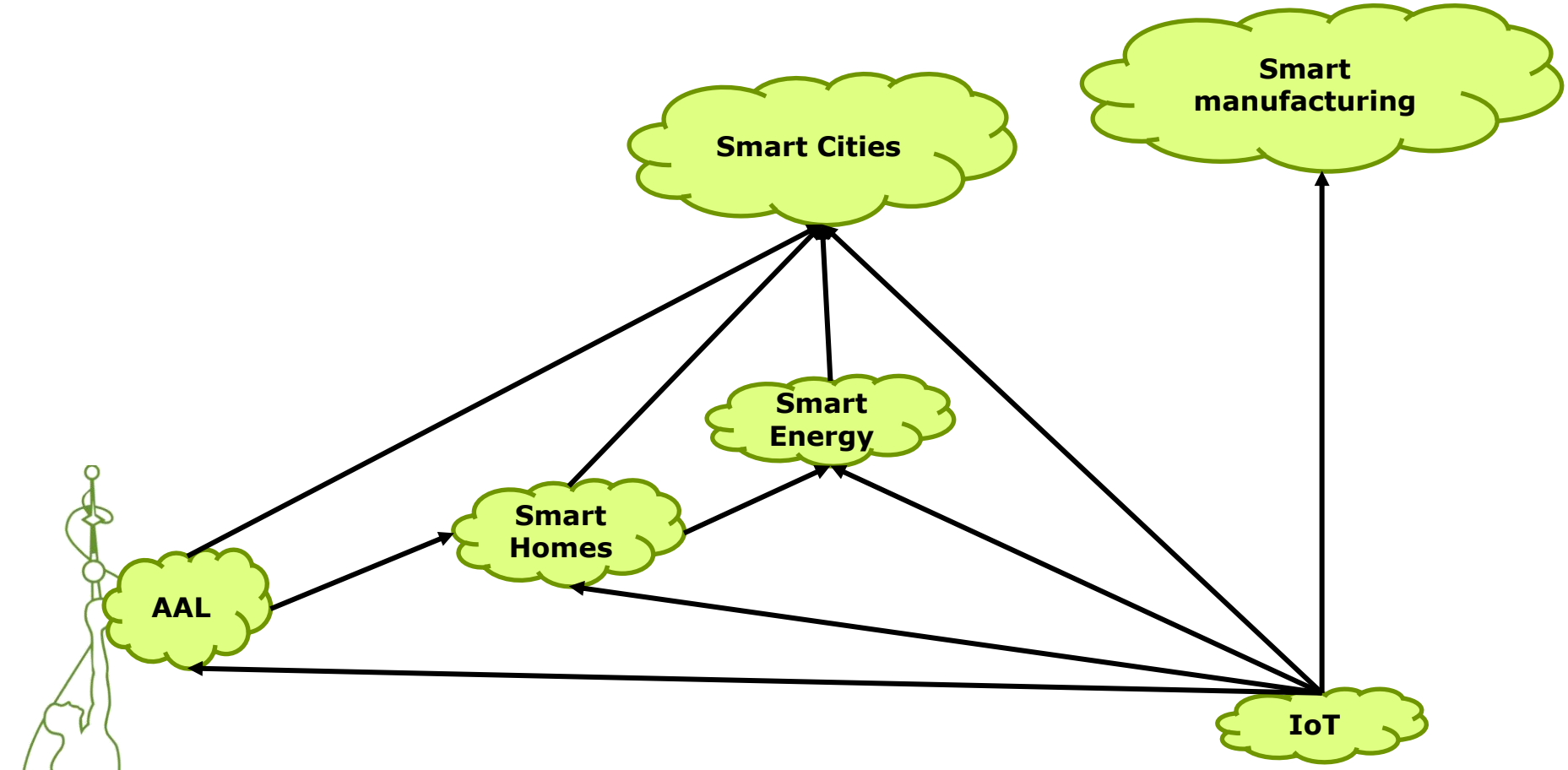
Potential question:
relations between systems domains



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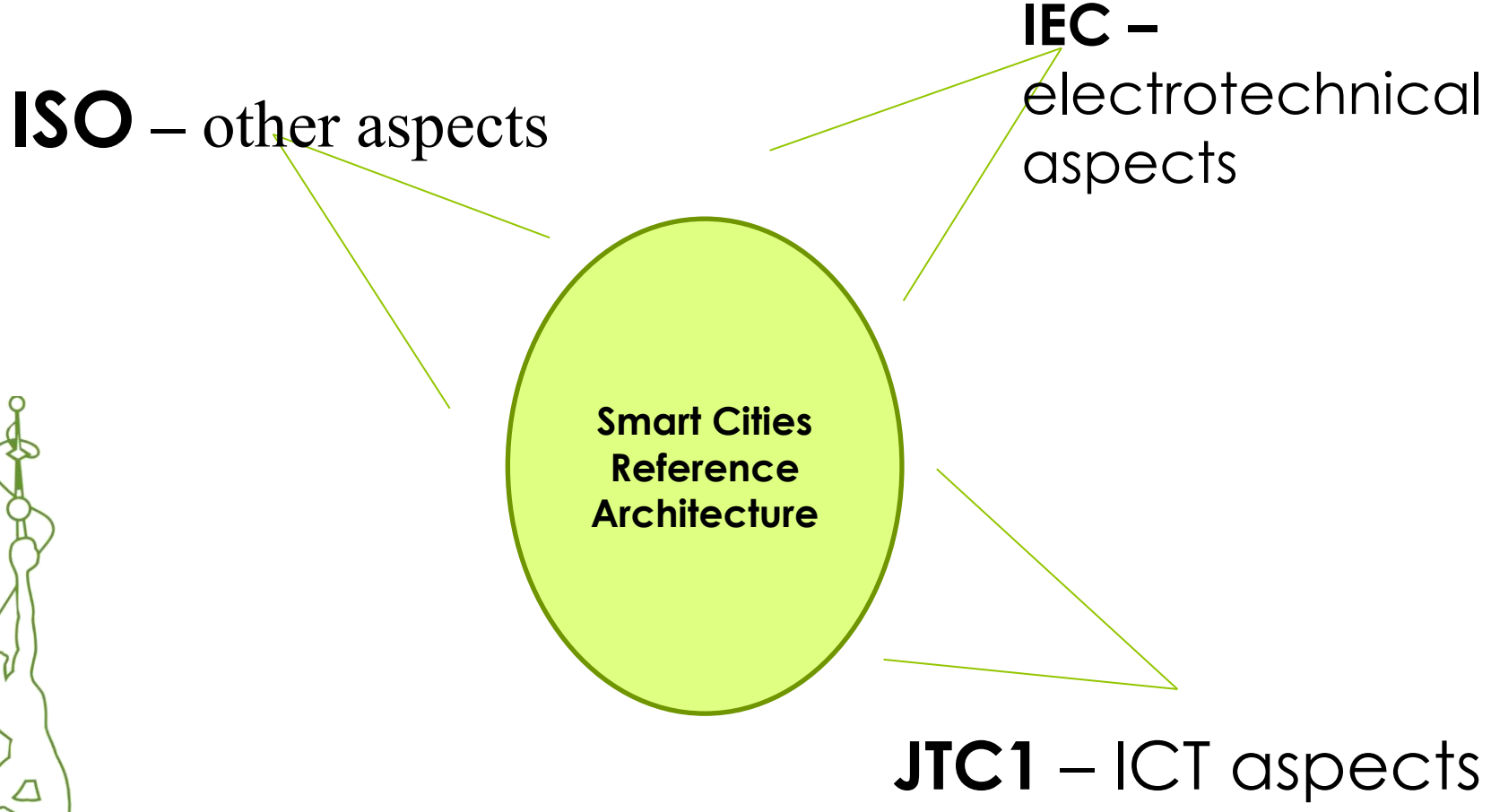
Potential question:
Achieving synergy between SDOs



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Definitions (1)

Reference Model

abstract framework for understanding concepts and relationships between them in a particular problem space or subject field

- ⇨ A reference model is independent of the technologies, protocols and products, and other concrete implementation details.
- ⇨ A reference model uses a concept system for a particular problem space or subject field.
- ⇨ A reference model is often used for the comparison of different approaches in a particular problem space or subject field.
- ⇨ A reference model is usually a commonly agreed document, such as an International Standard or industry standard.

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Definitions (2)

Reference Architecture

Template for solution architectures which realize a predefined set of high-level requirements

- A reference model is the next higher level of abstraction to the reference architecture.
- A reference architecture uses its subject field reference model and provides a common (architectural) vision, a modularization and the logic behind the architectural decisions taken.
- There may be several reference architectures for a single reference model.
- A reference architecture is universally valid within a particular problem space or subject field.
- An important driving factor for the creation of a reference architecture is to improve the effectiveness of creating products, product lines and product portfolios by
  - managing synergy,
  - providing guidance, e.g. architecture principles and good practices,
  - providing an architecture baseline and an architecture blueprint, and
  - capturing and sharing (architectural) patterns.

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Definitions (3)

Solution Architecture

System Architecture (or Solution Blueprint)

Architecture of the System-of-Interest

- ⇨ A solution architecture can be a tailored version of a particular reference architecture which is the next higher level of abstraction.
- ⇨ EXAMPLE Smart city London solution architecture

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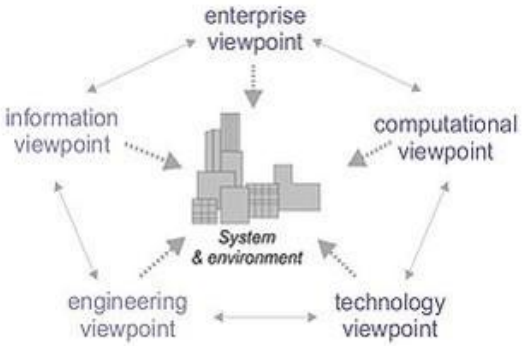
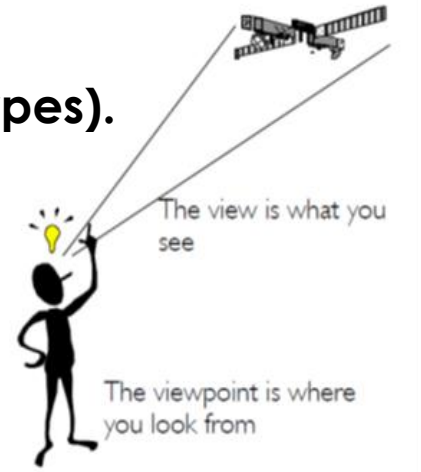
Architecture description:

Viewpoints, models kind, views and models

Many viewpoints are possible.
Each viewpoint is a set of model kinds (or model types).





Each model kind consists of artefacts (e.g. applications, servers, etc.) and relationships between them (those applications are deployed on this servers).

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Some recommendations related to digital systems

- Employ the concept of "digital twins"
  - **Digital twins** refer to computerized companions of physical assets that can be used for various purposes. **Digital twins** use data from sensors installed on physical objects to represent their near real-time status, working condition or position.
- For a man-made object, a digital twin comes first
- For a nature-made object, a digital twin comes second
- Versioning and configuration management are fundamental
- Versioning of atomic objects
- Versioning of compound objects

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