

# SMART CITIES: SYSTEM-ORIENTED APPROACH WITH CITIZENS IN FOCUS

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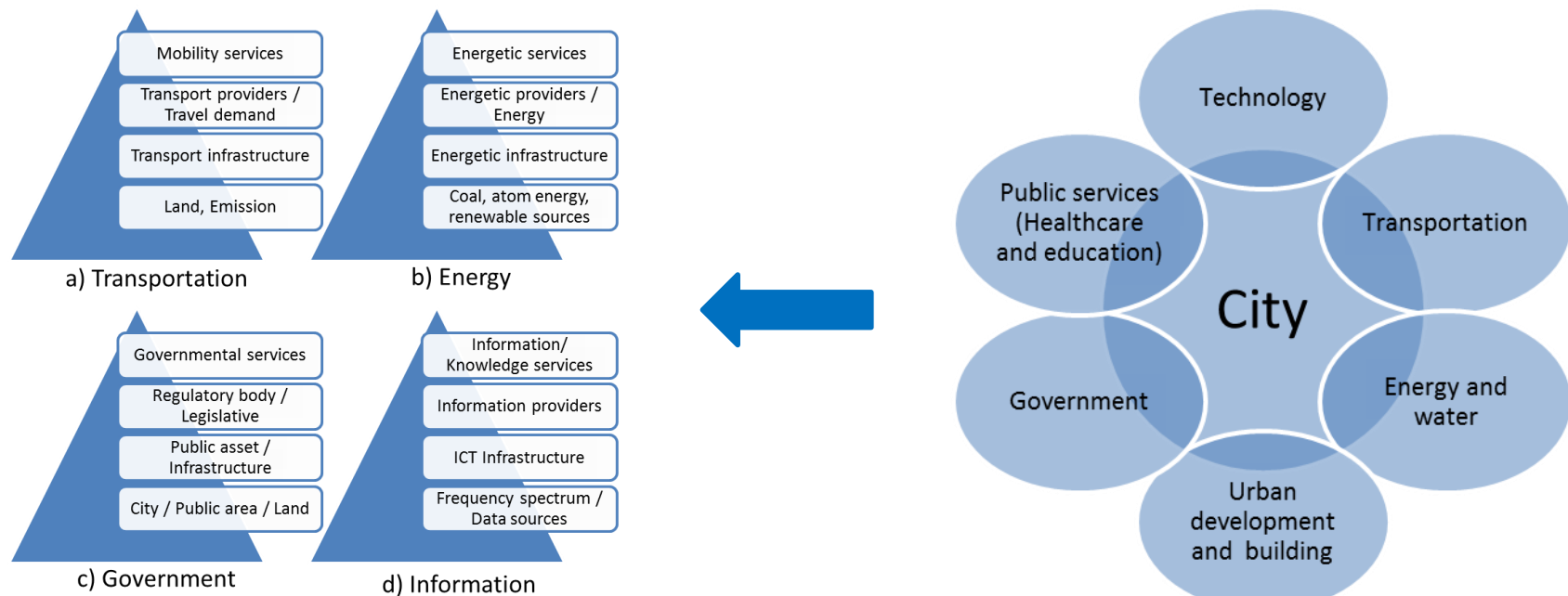
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# PRESENTATION OUTLINE

- System science and Smart Cities
- Smart Cities concept
- Proposed Smart Cities Framework
- Multi-Agent Systems and Smart Cities
  
- Individual perception of Smart Cities strategies
- Pilot survey

# SYSTEM SCIENCE AND SMART CITIES

- City perceived as a **system composed of subsystems**.
- Each **subsystem** is **typically considered** to be **independent**, but sharing **common goals**: to create a city which is **efficient, livable** and **sustainable**.
- In order to address Smart Cities concept, it is necessary to analyze each subsystem in detail:



# SMART CITIES CONCEPT

- According to EU, **Smart Cities should provide:**

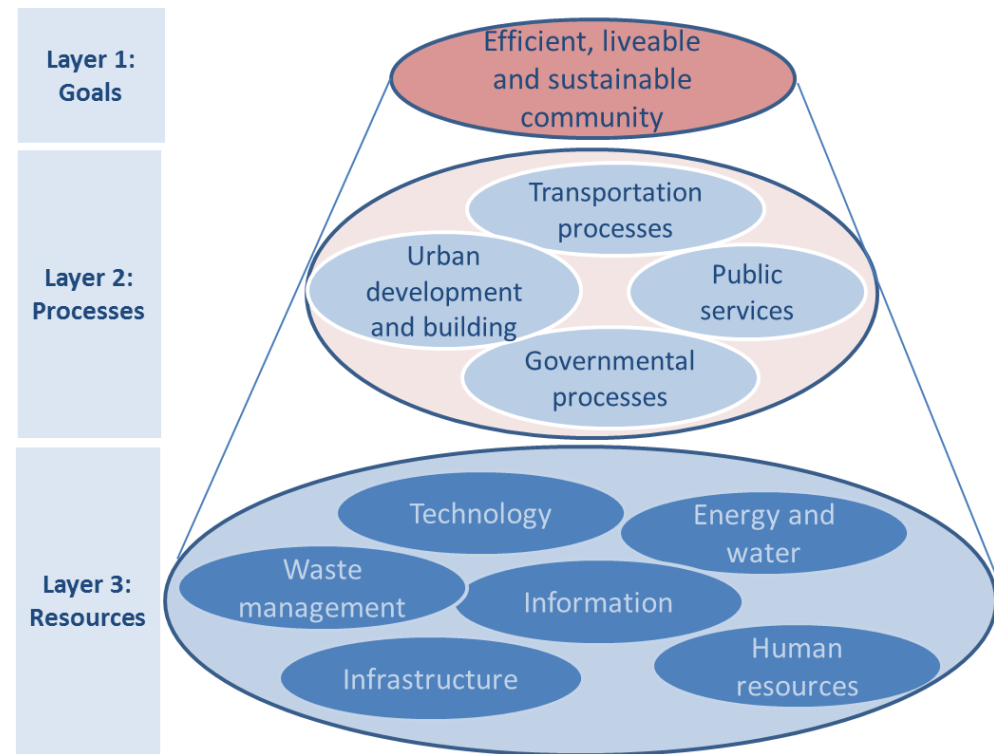
*“...a significant improvement of citizens' quality of life, an increased competitiveness of Europe's industry and innovative SMEs together with a strong contribution to sustainability and the EU's 20/20/20 energy and climate targets.”*



Source: European Innovation Partnership on Smart Cities and Communities Operational Implementation Plan

# SMART CITIES CONCEPT

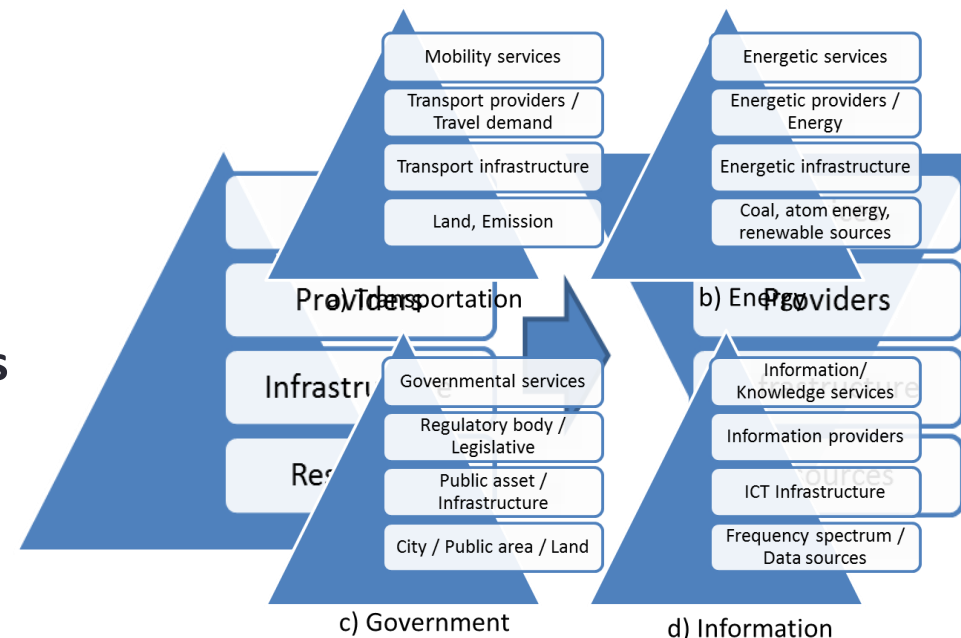
- SC concept should aim to create a **livable** not **only high-tech city !**
- SC concept shall **consider several** (or all) **subsystems at once** using a **common objective function improving individual citizen's quality of life**.
- Such SC concept expects the **subsystems to cooperate** and **share resources**.



# PROPOSED SMART CITIES FRAMEWORK

## Service oriented approach

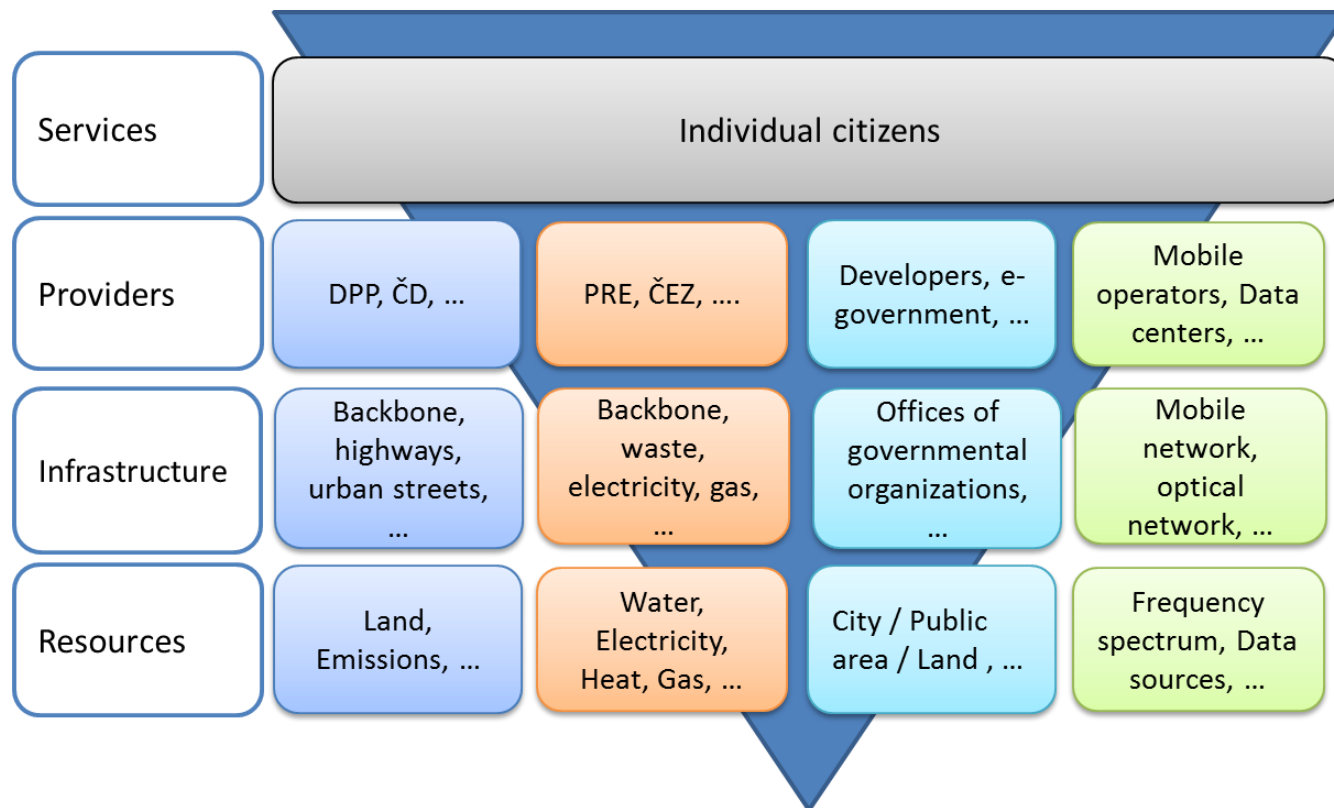
- The traditional approach to a city's subsystem is focused on infrastructure and resources (two bottom layers) that usually play major role when considering funding.
- In order to make a city smarter (= efficient, livable and sustainable) we **need to shift** our **focus** to **services** provided to city's inhabitants.
- The new goal shall therefore be...  
... to **provide the best services** with min. resources on limited infrastructure.
- In order to do that, **city subsystems must cooperate to achieve synergic effect.**



# PROPOSED SMART CITIES FRAMEWORK

## Service oriented approach (cont.)

- Example of a service-oriented **modular framework**:



# PROPOSED SMART CITIES FRAMEWORK

## Definition of objective function

To measure the effect of different SC measures on efficiency, livability and sustainability of a Smart City, **objective function** must be defined:

$$\begin{aligned} \max \Phi_c &= \max \sum_i QoL_i \quad \forall i \in I_c & \Phi_c & \text{quality of life of the individual inhabitants} \\ \min \psi_c &= \min \sum_j R_j \quad \forall j \in L_c & I_c & \text{city population} \\ & & \Psi_c & \text{resources utilization} \\ \Gamma_c &= \text{const} & R_j & \text{pool of resources} \\ & & \Gamma_c & \text{city identity} \end{aligned}$$

- **city identity must not be sacrificed** in favor of efficiency
- **quality of life** is highly individual => need to apply methods from social sciences such as **theory of life stages**

# PROPOSED SMART CITIES FRAMEWORK

## Hierarchical management level

We propose to look at the city from three perspectives:

### 1. Strategic level

- long-term planning of services, surveys, infrastructure assessment

### 2. Tactical level

- set mid-term objectives, Key Performance Indicators (**KPIs**) and Service Level Agreements (**SLAs**)

### 3. Operative level

- monitor and maintain KPIs and SLAs

- each level must have its **Level Performance Indicators (LPis)**
- **goal:** to find the best solution to improve quality of integrated services on all three levels ...and thus **quality of life**

# MULTI-AGENT SYSTEMS AND SMART CITIES

- SC system is **heterogeneous**, contains **uncertainties** and interacts with **people** => it is difficult to find a solution...

... we propose the use of artificial intelligence, in particular **Multi-Agent Systems** (MAS) and **Belief-Desire-Intentions** (BDI) architectures.

## MAS

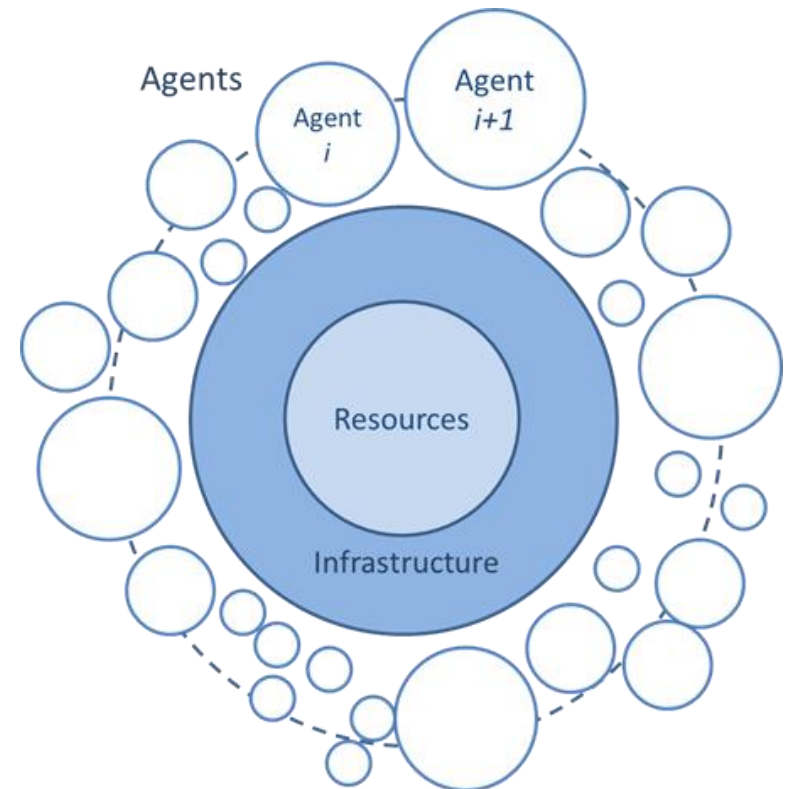
- work with multiple agents interacting with environment and each other
- each agent has an objective and is capable of autonomous action => can **represent individual citizen** or a group of citizens

## BDI

- Beliefs ... represent agent's perception of the environment
- Desires ... represent agent's motivations (objectives)
- Intentions ... represent what the agent has chosen to do to fulfill Desires

## MULTI-AGENT SYSTEMS AND SMART CITIES

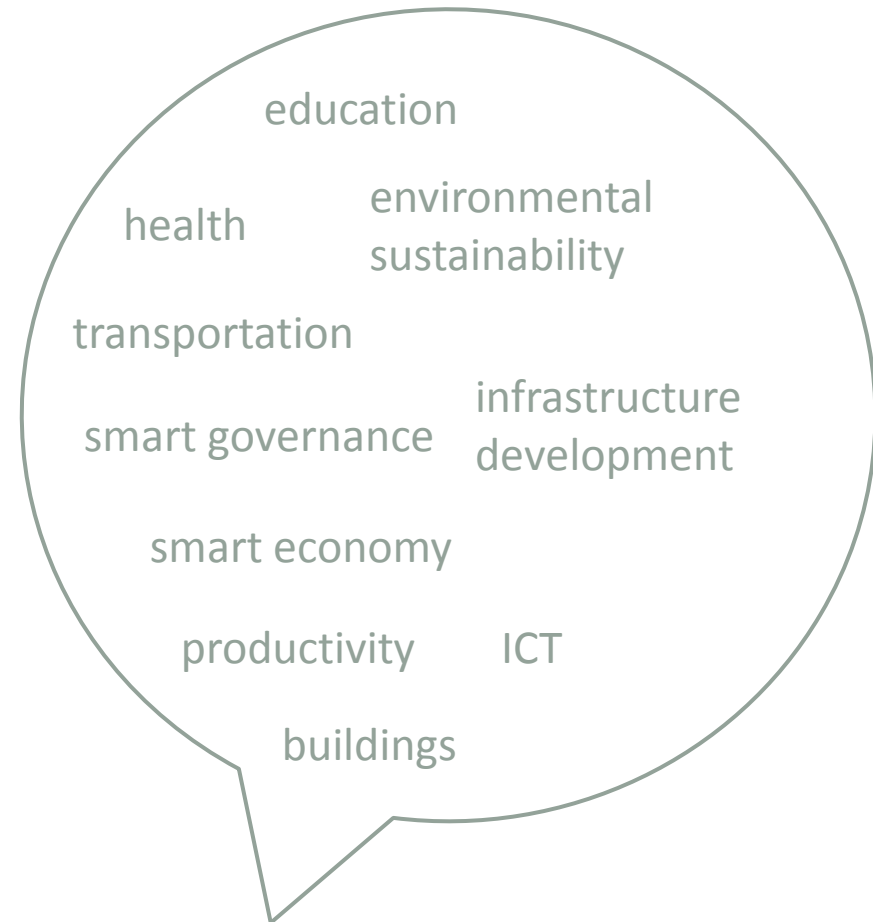
- **Agents interact** with SC **subsystems** and **negotiate** to use **resources**.
- **The key principle:** Resources are not pre-allocated to agents, but are shared by agents.
- Each agent or group can have different **negotiating power**.
- To study a smart city from a **different perspective**, we need only to change the **set of agent's Desires**.
- **Flexibility** is very important – each agent can be **unique** and thus representing **diversity of the real world**.



## WHERE IS INDIVIDUAL CITIZEN ?

- Each organization defines its own **KPIs** for Smart Cities:
  - ISO – ISO 37120 and ISO 37150
  - EU - Mapping Smart Cities in the EU
  - UN – UN Habitat Program
  - ITU – Overview of key performance indicators in smart sustainable cities
  - Fraunhofer – Morgenstadt Project
  - GSMA – Guide to Smart Cities: The Opportunity for Mobile Operators

What about citizen's opinion?



**KPIs for Smart Cities ?**

## LET'S ASK INDIVIDUAL CITIZEN

All common approaches to Quality of Life focus on general, high-level city indicators!

Our objective is to **understand**:

- what effects *Quality of Life* of *individual citizens* and
- how individual citizens perceive *particular SC strategies*

**Survey must be conducted.**

If it is done properly, we can:

- **understand** how individual citizens perceive particular SC strategies
- **model** the effect of particular SC strategies
- **influence** the quality of life for particular target groups



# SURVEY - INDIVIDUAL PERCEPTION OF SC STRATEGIES

## Socio-demographic characteristics

- Creating a socio-demographic profile of each respondent and of his/her household.

## Usage of ICT and smart applications

- Determine the extent of the ICT solutions and smart applications use by respondent and his/her ability to use them.

## Mobility

- Determine typical mobility patterns while commuting to work, local government institutions and entertainment.

## City infrastructure and public space

- Respondent's perception of the city's infrastructure quality and usage of public space in the city.

## Smart governance

- Determine the degree to which the municipality uses ICT and smart applications.

## Environmental sustainability

- Measures implemented by the municipality in order to balance development and environmental protection.

# SURVEY ESSENTIALS

*A random, unbiased and representative sample of a population is targeted.*



## A. Pilot Survey

- online survey was conducted
- colleagues and acquaintances of the authors

### **Advantages**

- easy set-up in a web-based tool
- low cost
- data filled directly into a database

### **Disadvantages**

- there is clear bias
  - selection method
  - response medium

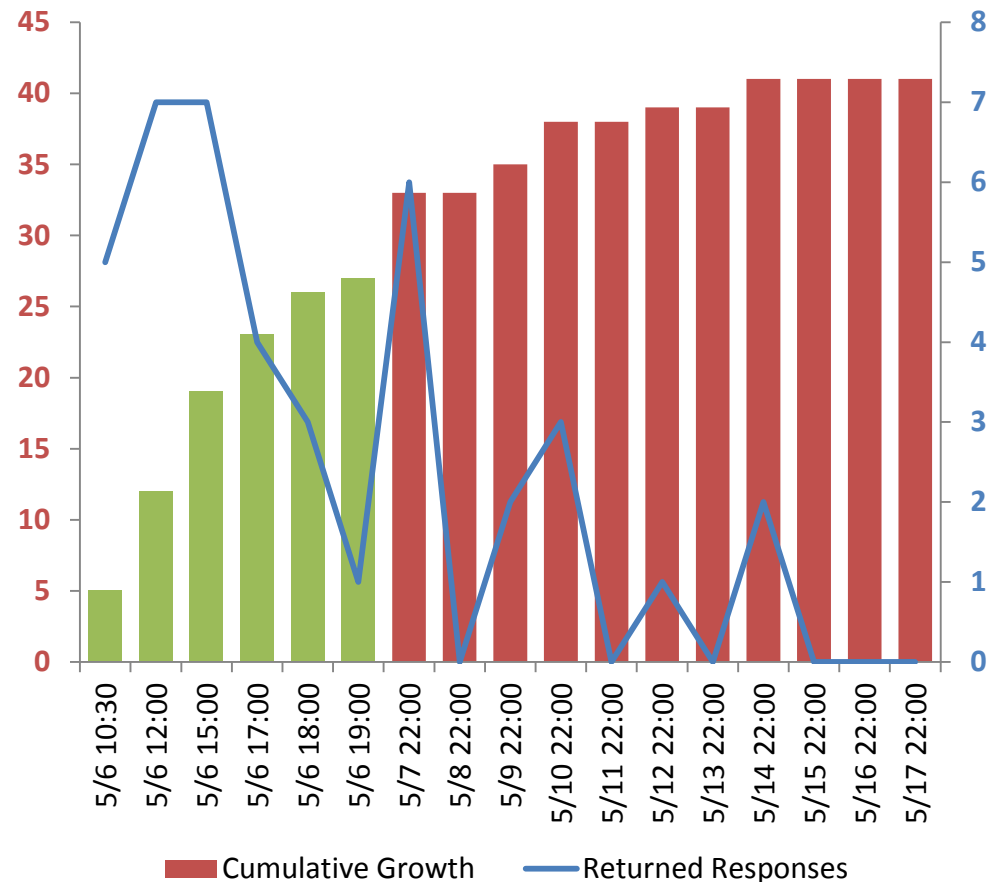


## B. Survey in Písek

- online survey supported by:
  - information on official municipality websites
  - information through a local newspaper
  - cover letter from the municipality as well as the university
- possibility to answer the survey in a paper form

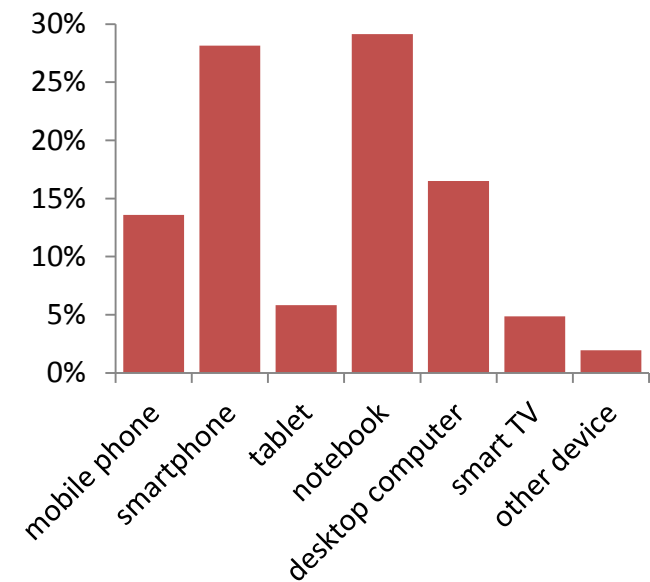
## PILOT SURVEY EVALUATION – RESPONSES

- Online survey with **32 questions**
- Average time for completion was 12 minutes
- Focus on **ICT and mobility**
- Conducted between May 6, 2015 – May 17, 2015
- **85 valid invitations sent** by e-mail to colleagues
- Overall response rate **48.2 %**
- 65.6 % of responses returned during the first day
- Median age 34.5 years
- 48.8 % females, 51.2 % males



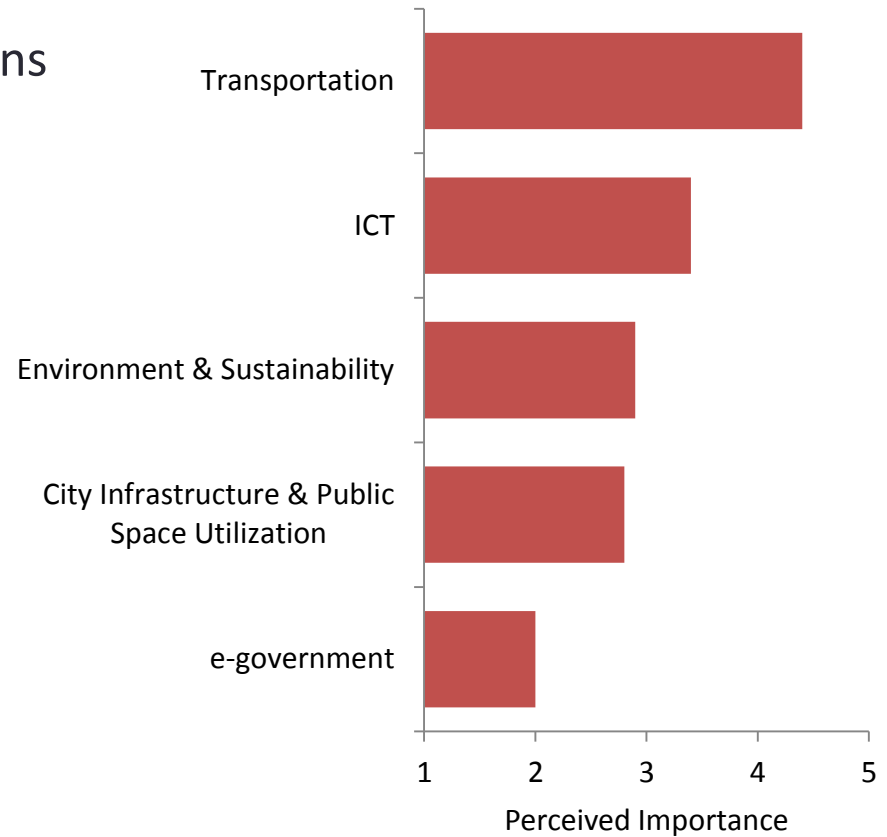
## PILOT SURVEY EVALUATION – SELECTED RESULTS

- **43.9 % of respondents regularly undertake longer trip** (e.g. for weekend)
- **68.3 % seek information before such trip**
  - connections, other services such as weather forecast, opening hours and traffic
- **80.0 % occasionally change travel plans** based on acquired information
- **Information is mostly acquired from websites**, only 12.5 % use applications
- **traffic information** and **parking information** perceived to be needing improvement
- electronic devices used most frequently during the day include notebook and smartphone
- 85.3 % consider themselves to be common or advanced users of electronic devices



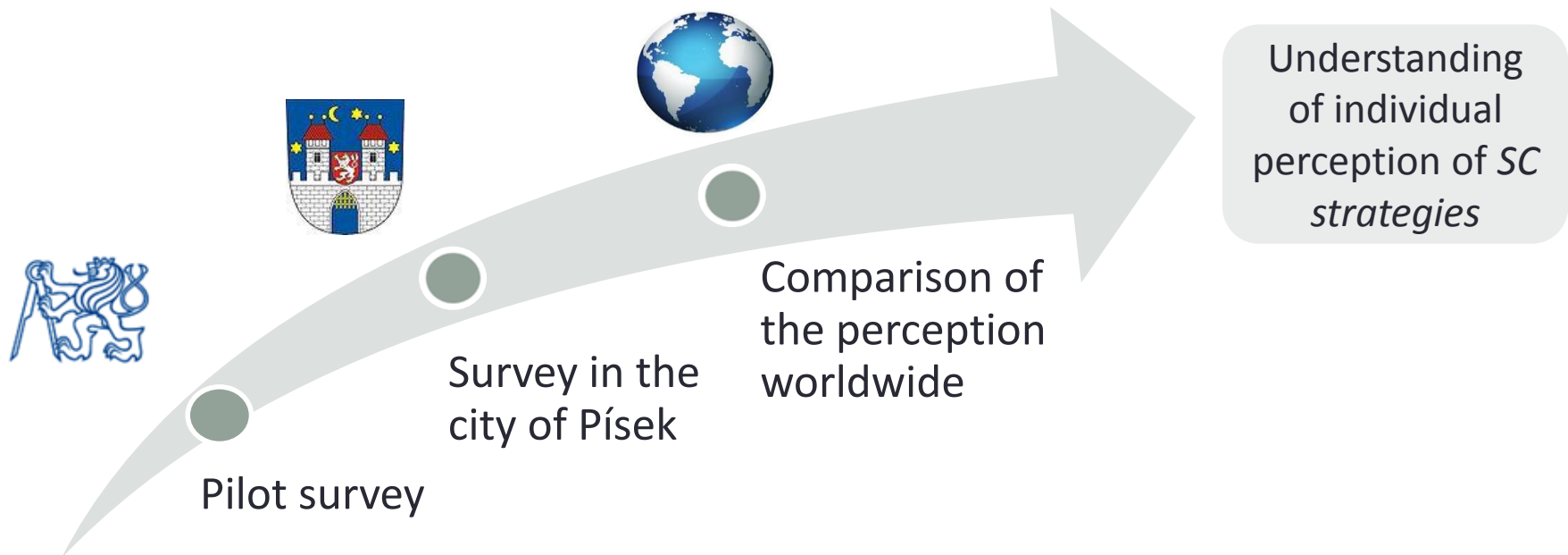
## PILOT SURVEY EVALUATION – RECOMMENDATIONS

- generally **positive feedback**
- some complex or misleading questions were identified
- respondents confirmed suitable research focus and the survey length
- **Transportation and ICT are most important** from the SC areas



## WHAT IS NEXT ?

- current Smart Cities approaches focus on general city indicators
- proposed approach allows us to **understand motivation and behavior of citizens**
- motivation and behavior patterns can be further analyzed using system oriented Smart City model supported by Multi-Agent Systems
- results will allow adopting proper measures and strategies



# THANK YOU FOR YOUR ATTENTION !

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