TOWARDS ECONOMIC AND SOCIAL "SENSORS": CONDITION AND MODEL OF GOVERNANCE AND DECISION-MAKING FOR AN ORGANOLOGICAL SMART CITY

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Abstract

This article aims to shed a new light and framework on Smart cities by a model of "Smart City – organological [1]". This governance model consists of an adaptive device built around a differentiation of smart sensors and tags to improve human decision-making. More specifically, this device is based on taking into account both, by a normative approach, "physical sensors", and, by a positive approach, "economic and social sensors". Thus, this model is a guidance for the city governance by introducing decision criteria beyond the simple technical requirements. This mechanism design is based on the attempt to capture the explicit or implicit needs in the form of "weak signals", or their consequences. It should capture the diverted actions from the objectives pursued by the "decision maker". Thus, a "regulation" of the system becomes possible. Therefore, the Asset management planning of Buildings and Urban infrastructures benefit of a better "alignment" for consistency with the economic and social.

1 Introduction: Origins by the "mechanistic" sensors

Historically, in the West, in the wake of the industrial revolution of the 19th century, proposals for scientific organization of the industry by Frederick Winslow Taylor [2] and Henri Fayol [3] as well as those of urban dynamics of Jay Wright Forrester [4] or Joël de Rosnay [5], have led to the establishment of a "mechanistic" model of governance and decision-making for cities whose structure and form are composed of the articulation of its parts. The "normative" approach of the City takes the form of a system whose data are captured, are statistically treatable and infinitely reproducible. Such a model seems to reconcile an apparent respect for the complexity with the search for a static balance which becomes both the law of operation and the objective to achieve therefore the standard.
Developers and creators of the city then play a traditional role of "planner" with a classic urban logic distribution and concentration of activities in space subdivision with predefined functions on time horizons varying from 30 years to 70 years in the case of China (2007 law) or more in other legal contexts. This fragmented approach of physical objects and of social and economic realities led to a governance that is often limited to arbitration in the expression of basic needs and a realization of projects from a raw land. The decision flow is then essentially a waterfall – "top down" - of "mandatory compliance" measure between different stakeholders at different scales of decision (micro, meso, and macro) as shown in Figure 1.

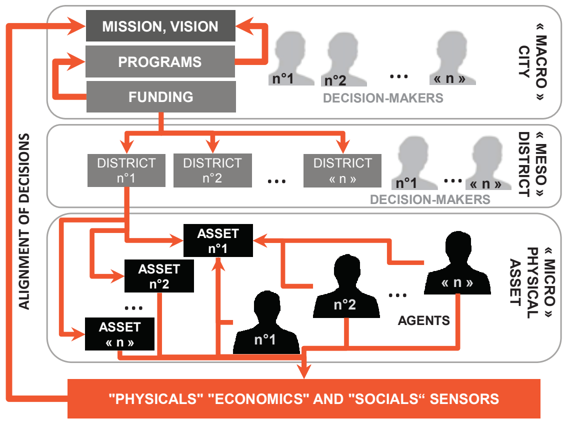

Figure 1. Human dynamics diagram of the "Smart City – organological": capture of ascending and descending flow to amplify bidirectional incentives.

At best, this type of governance and decision-making for the city is then pushed towards a model of "Smart City – mechanistic". The change and evolution of the phenomenon of capture, extraction and data analysis is guided by a normative approach - ex ante - coming from observation of technical and environmental expert. (Figure 2). This organization, representation and optimization of the city

[1] "The "general organology" is a method of joint analysis of the history and fate of physiological organs, artificial organs and social organizations. It describes a transductive relationship between three types of "bodies": physiological, technical and social. The relationship is transductive if the variation of a term of one type will always be changes in terms of the other two types." [1]

will focus on the Buildings and Urban infrastructures by their "physical sensors".

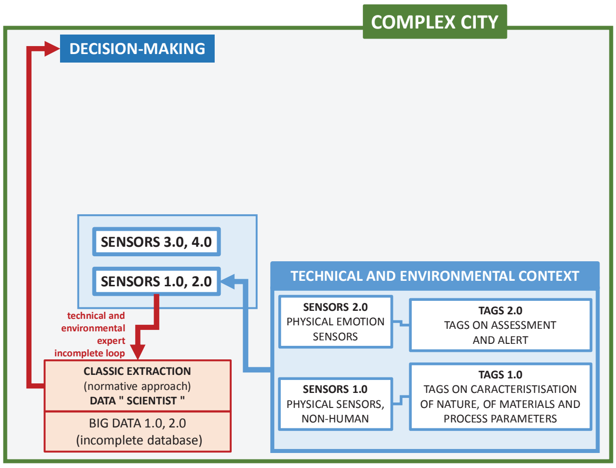

Figure 2. Diagram of the "Smart City- mechanistic" model.

The nature of these sensors is relatively simple and predictable because rarely the design of physical assets is done with a strong integration and interdependence with economic or social behavioral phenomena from which can emerge exogenous shocks.
The predictive model of the city is then based on assumptions of an aging infrastructure and built on a statistically deterministic evolution, sequentially and on the basis of limited information recursive. Each of the components constituting the City have a specific functionality to meet a desired use and considered as sustainable. Of course, digital technology comes to store information continuously put at the disposal of the agents but it is always objective measures leading to a big data processing method according to a judged too quickly as "scientific". It remains in a dashboard form of the situation e.g. a sensor of available places for downtown parking will seek to optimize the occupancy rate, with an optional alternative to apply a tariff policy to encourage agents to change their behavior. Such a control of the city will be described as mechanistic: the rational responses are listed in preprogrammed responses to values of number of parking places availability. The specialized expert - credited with a reliability that is not demonstrated nor falsifiable by experiment - will have to determinate ex ante solutions themselves controlled by optimal physical use rate without questioning the effects of providing car parks in the city center on the growth of individual motorization. Furthermore, such a tool works in a stationary equilibrium loop that immediately excludes a dynamic mutation perspective of urban transport towards more satisfactory environmentally solutions from the perspective of energy transition.

2 Integrate the necessary change: quality and dynamics of city aging

But what about taking into account the complex interactions within a variety of uses [6], at multiple scales and in different life cycles, which corresponds to both the theoretical description of the complexity by E. Morin [7] but also to the most ordinary daily life of the city dweller? What consequences should we expect from a "Smart City-mechanistic" model on agents, their needs and ways of expression? Will we have doubts emerging from agents concerning maintenance and adaptiveness capacity of the city on the medium and long term? But, to its inhabitants and for investors, the dynamism and attractiveness of a big city often refer to innovation in solutions. Exactly the type of challenges that closely combines the temporal scales and planning of plurals multi-functional space.
For example, how can we reconcile sanitation, renovation, construction with both keeping low income agents in the city center and mastering car pollution if we maintain a trifunctional partition of the city - inherited from industrial Fordism - in business center, leisure center and habitat? Could a doubt on the possibility of urban policies to meet these challenges lead to the appearance of a real distrust? Will this be translate sooner or later into spontaneous creation of new uses in disorganized ways in inappropriate places to meet inevitable changes of any city? This would mean "Exit" solution instead of "Voice" solution [9]. How to manage and anticipate simultaneous needs for City's maintenance and transformation? With which model should we manage the shift of scale between simple physical component found on a building, for example, and the shape and the overall morphology of the city? What governance model and intertemporal decision-making must be put in place to try to solve the consequences of asymmetric information whatever the geographic situations, among decision-makers and agents [10]? Could the city governance and decision-making model be built around the formation of a group of agents (points) in a regulated structure (rules) requiring information system (arcs) in order to respond to the expression of explicit and implicit needs (recursive effect)? [11]? Is it not rather a step towards a more comprehensive model? The smart and sustainable cities trend has been the subject of much criticism [12] - including those of Antoine Picon which achieved a fairly complete and concise overview [13]. The main problem is to integrate complexity into the dynamic models. Antoine Picon would summarizes wondering "how will age smart cities?"
This approach is still largely into an exploratory mode. And this is located at the conjunction of the predictive statistical models and algorithms - or neural networks - to help [14] with sociology decision-making relied on sophisticated statistics on small samples is expected to no longer oppose frustrates correlation (inductive method from Big Data on unstructured data) to hypothetical deductive causality on small samples [15] to approach urban complexity.
In this sense, lacunar decision-making loops will appear between the normative approach - ex ante - and the positive approach - ex post -, by isolation, decoupling of capture, extraction and analysis of data. This will lead to a system failure (Figure 3).

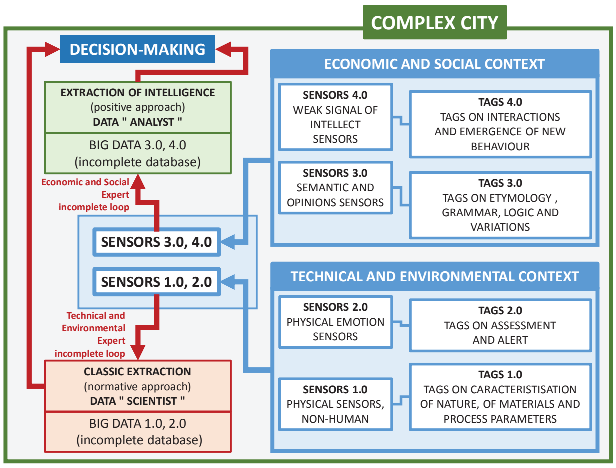

Figure 3. Diagram of model failure of the “Smart City”.

What we propose here is to get closer to economic and social sensors taking into account the emergence of intelligent solutions to complex problems in using this first step to a city model type “Smart City – mechanistic”, whose components include although multiple “physical sensors” but can scale the model of urban governance and management decision in a less self-fulfilling and often fictitious.

3 The “Smart City – organological” the alignment model of decision-making

The “Smart City – mechanistic” generates an optimization around the object in which it is very difficult to consider the internal and external phenomena causing chaos in the model. Performing statistical calculation of risk becomes impossible even though the degree of complexity increases. Those are “black swan”, which are unexpected and unpredictable phenomena in terms of probability calculation [16]. The problem of urban governance is no longer limited in this case to assess the objective risk measured by physical sensors that can lead to making almost automatic decision, but to make - different types of agents - less vulnerable to the possible occurrence of a “black swan” [17]. Thus the number of fire hydrant and sprinklers, checking their remote status or testing them regularly is a 1.0 and 2.0 sensor approach. But weak signal of trust or distrust between security team’s members is a sensor 3.0. While elements that reflect a high degree of exchange and discussion within teams or its members are a 4.0 sensor. Therefore, in "disaster's management as in their prevention, resilience of collective organizations is decisive. [18]. The City becomes under uncertainty and not just under the calculable risk, to summarize the Frank H. Knight's difference proposal. [19]. What would that mean concretely? Of course the uses of physical sensors that are important to signal (to select and judge) explicitly and direct a position, on a physical asset, a perception. But they are not enough: we must also integrate an “implicit and indirect” reporting that incorporates an intelligent judgment. In fact, all cultural backgrounds, social affiliations and economic relations found in a city unite the agents and generate interdependencies that add an extra degree of complexity to the decision-making. In this sense, to better manage the consequences of asymmetric information between decision-makers and agents, the model of governance and decision that allows “regulation” must be based on both the tagging “explicit and direct” on tagging “implicit and indirect”. This will change from one mode of governance and decision "regulation" to a mode "regulation" by identifying incentives “technical”, “economic” and “social” suitable to find a balance.

It is important to note that the concept of “incentive” proposed is not only that found in a conventional way in the literature and which means that the “decision maker” will establish a policy or regulation to cause a desirable behavior of agents (top down). The incentive is bidirectional (top down and bottom up). In addition to observing the expression of explicit needs, an ascending information allow integration, deduction and the formatting of the mapping of implicit preferences of agents. This come from returns of knowledge found at the scale of micro activities in the city. Thus, an ascending incentive is constituted and a response is created by the “regulation”. This leads to adaptation of the response by the observation of the expression of the bidirectional needs.

We must also consider that the arbitration between the preferences and choices expressed by different types of agents are not simply a calculation of risk. In a complex world, in the kingdom of decision-making, for all that is not part of an autopilot we can deal most often with the emergence of non-Gaussian distributions bipolar, that NN Taleb calls the “country of the Extremistan” instead of “Mediocristan”. The use of “economic and social sensors” becomes obvious to build new data sets. It allows the emergence of a greater consistency and closer alignment between economic and social decision wills, in a virtuous loop that aims to create a constantly renewed harmony [20].

Thus, it is essential to take into account the factors of complexity of the model of governance and decision:

- The ones transmitting at all levels (macro, meso and micro) the knowledge of the state of the city in all its parameters and indicators in bidirectional mode (top down – bottom up) (Figure 1) ;
- That of the desired or necessary harmony in intertemporal decision-making [21] should take account of new cultural and social trends and the emergence of innovation (Figure 4).

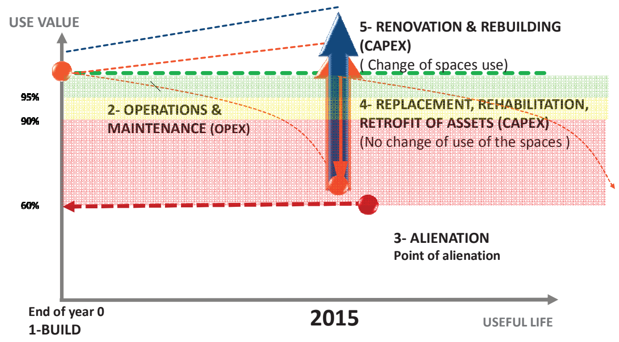

Figure 4. Dynamic model of the physical assets and inter-temporal decision-making [21].

The confrontation of the use of physical assets to this path of "bounded rationality" - especially because the information is often incomplete and expensive to obtain or treat - usually leads to propose a decision-making and governance "adaptive anticipation" which merely a criterion of "satisficing" rather than optimization [22]. So the "Smart City – mechanistic" turns into "Smart City – organological" (Figure 5). The smart city model than captures the "weak signals" emitted by the preferences of agents in the city.

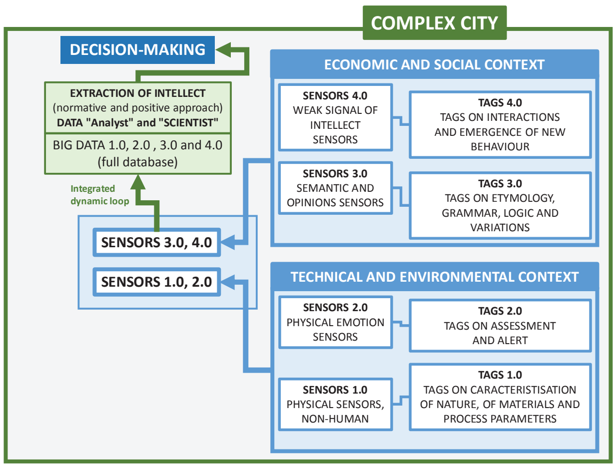

Figure 5. Diagram of the "Smart City- organological" model: integrated loop of normative and positive approaches to capture, extract and analyze data.

4 The "Smart City- organological" model: A case study on the city of Niort, France

The following case study is based on an extract of data included in City of Niort's report on the asset maintenance deficit (AMD) [23]. The aim is to illustrate that by using different types of sensors on buildings and urban infrastructure it is possible to give a better understanding at governance on the base of the model "Smart City – organological".

4.1 Urban context and scope of the study

Capital of the Deux-Sèvres (79), France, Niort is the third most populated town in the Poitou-Charentes region (59 504 inhabitants). It covers about 70 square kilometers and has a relatively constant density since the 1980s at a rate of 841 inhabitants / km².
An audit on all buildings of Niort city was conducted in 2012-2013. The result of the study revealed that the projects required to maintain the use-value of the 201 buildings amounted to a sum of 67.31 million €. To apply the model of "Smart City – organological" at multi scales, the study focus on the schools data (Table 1).

Table 1. City of Niort 2013 characteristic

Population	59 504 habitants
Area	70 km^2
Density	841 hab/km2
Number of district	9
City (all equipment, all districts) - macro scale	
Number of city buildings	201
Gross buildings area	245 000 m^2
Current replacement value (CRV)	598,42 millions €
Asset maintenance deficit (AMD)	67,31 millions €
Physical asset condition index (AMD/CRV)	11,25 %
Schools (all districts) - meso scale	
Number of schools	20
Gross school buildings area	51 054 m^2
Current replacement value (CRV)	116,71 millions €
Asset maintenance deficit (AMD)	13,69 millions €
Physical asset condition index (AMD/CRV)	11,73 %
École Ferdinand Buisson - échelle micro	
Number of schools	1
Gross school buildings area	3 670 m^2
Current replacement value (CRV)	8,40 millions €
Asset maintenance deficit (AMD)	1,26 millions €
Physical asset condition index (AMD/CRV)	15,10 %

For the 20 schools, the result of the audit corresponds to a sample representing about 20 % of gross area of buildings comparing to the city, 20% of the current replacement value[2] and 20% of the asset maintenance deficit[3] of the city.

4.2 Methodology

The study methodology and protocol (Table 2) are processed through trained experts conducting an audit aimed to "capture" with "tags" (Table 3) characteristics for

[2] Current replacement value (€) [21] : Average cost of construction and development of buildings, land and infrastructure - excluding the costs related to land acquisition but including professional fees, those of architects, engineers studies, inspection and surveillance, contingencies and all related costs to connect to the city civil engineering systems.
[3] Asset maintenance deficit (€) [21]: Estimated cost of asset replacement, heavy maintenance, rehabilitation, retrofit projects to be done within maintain, restore , conserve or enhance the existing use value of the buildings, land and infrastructure. This is done without changing, partially or totally, the space use. The inventory of projects usually come from inspection and evaluation of the asset condition - building or infrastructure.

each component of the school buildings. The ASTM E1557 - 09 - Standard Classification for Building Elements and Related Sitework-UNIFORMAT II - served as a model for technical breakdown of buildings. The goal is to build new sets of data that serve to reveal the technical and environmental issues (1.0 and 2.0 sensors) as well as economic and social issues (3.0 and 4.0 sensors) found in buildings. All data are collected from observations, visits and interviews by experts with users' daily living in the buildings. The tool to collect and process the data is the software platform 3t, by tbmaestro™ [24].

Table 2. Methodology and protocol

n°	Task	Internal referent*	External referent**
1	Internal referents training.		X
2	Consult the documentation of existing assets.		X
3	Conduct interviews with the asset managers (accounting, maintenance, projects and users) and inspections.	X	X
4	Assess of the technical and economic aspects of assets on site.		X
5	Analyze data , performance indicators , thresholds and their associated targets.		X
6	Produce a summary report of assets condition, by asset group and for the whole asset park.		X
7	Measuring satisfaction and strategic directions of the client (steering committees, technical committees, etc.).	X	X
8	Establish and follow the Asset Management Plan.	X	X
9	Realize rehabilitation and retrofit projects on assets.	X	

** Technical users and buildings users.*

*** Experts of the technical and environmental context AND experts of the economic and social context.*

Table 3 Sensors and associated tags

	SENSORS 1.0 PHYSICAL SENSORS, NON-HUMAN	SENSORS 2.0 PHYSICAL EMOTION SENSORS	SENSORS 3.0 SEMANTIC AND OPINIONS SENSORS	SENSORS 4.0 WEAK SIGNAL OF INTELLECT SENSORS
TAGS 1.0 TAGS ON CARACTERISTISATION OF NATURE, OF MATERIALS AND PROCESS PARAMETERS	**Nature of the projects to be performed on a component:** - Mandatory Compliance; - Obsolescence corrective.			
TAGS 2.0 TAGS ON ASSESSMENT AND ALERT		**Remaining life of a component :** - End proved useful life.		
TAGS 3.0 TAGS ON ETYMOLOGY, GRAMMAR, LOGIC AND VARIATIONS			**Risks, with a qualitative approach "consequentialistic"** - Impact on people ; - Impact on the services capability	
TAGS 4.0 TAGS ON INTERACTIONS AND EMERGENCE OF NEW BEHAVIOUR				**Political and regulatory intentions of a project:** - Energy efficiency ; - Universal Accessibility.

The information analysis retrieved using various sensors lead to the assumption that without differentiation issues, governance would be poorly informed of the consequences of its decisions and the choice of project to be done to not to fail to respect the real priorities.

4.3 Results

The first scenario to test the effect of the decision by a "normative" approach uses "sensors 1.0 and 2.0" and their associated tags. The data show that:

- A sum of 33.79 million € is needed for the resorption of 50% of asset maintenance deficit at the macro scale.
- The proportion reduces while the observation is down scaling (42% meso, micro 35%) (Figure 6).

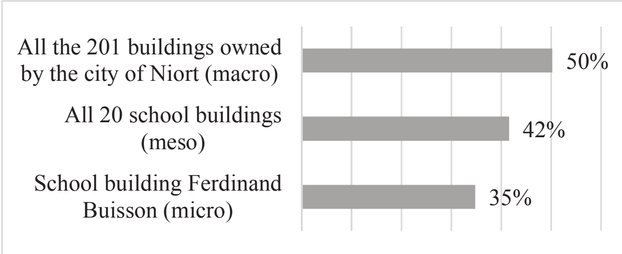

Figure 6. Decision exclusively based on the "normative" approach. Asset maintenance deficit of 33.79 million €. Reduction of percentage of the potential resorption of the asset maintenance deficit at each scale level.

The second scenario is oriented towards testing of "sensors 3.0 and 4.0" and their associated tags, used to test the effect of decisions by a "positive" approach. The observed data shows that:

- The budget needed for priority projects for resorption of asset maintenance deficit is estimated at € 5.83 million €, representing 9% of the total needs 67.31 million €.
- The proportion of budget required at meso and micro scales is significantly bigger (17% meso, micro 21%) (Figure 7).
- There is an important inversion of the relative importance of the project budgeting at the three scales.

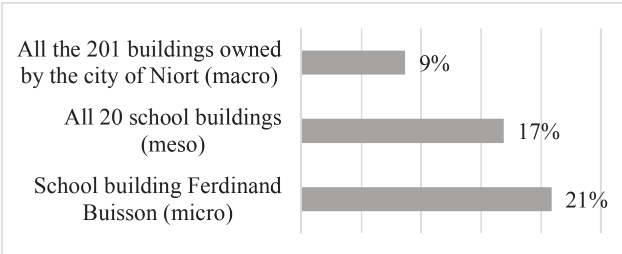

Figure 7. Decision exclusively based on the "positive" approach. Asset maintenance deficit of 5.83 million €. Reduction of percentage of the potential resorption of the asset maintenance deficit at each scale level.

The final scenario involves the assumption of using integrated decision around the "normative" and "positive" approaches. Thus, all sensors are used to treat the data. It is clear from this analysis that:

- The budget oriented on priority projects to resorb the asset maintenance deficit is estimated at 5.3 million €, representing 8 %, an equivalent proportion to the previous scenario.
- A stabilization of the budgets needed to resorb the asset maintenance deficit between the micro and meso scales while it increases significantly between the macro and meso scale (8% micro , meso 20% , 19% micro) (Figure 8) .

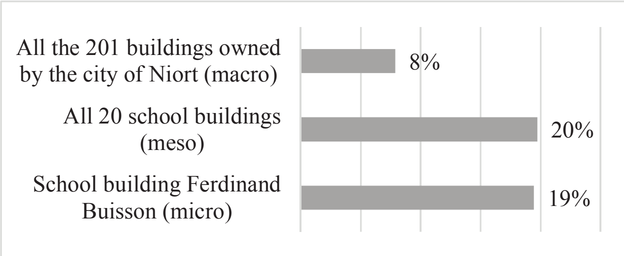

Figure 8. Integrated Decision on “normative” and "positive" approaches. Asset maintenance deficit of 5.3 million €. Reduction of percentage of the potential resorption of the asset maintenance deficit at each scale level.

5 Conclusions and prospective

This article shows the interest and usefulness to look beyond the simple “Smart City- mechanistic” model to implement a better complexity integrated approach with the “Smart City – organological” model. The integration of socio-economic sensors to the panoply of physical sensors assessing buildings and infrastructures conditions gives a better alignment of governance and decision-making with day-to-day city life.

To go further, a subsequent study on the multi-criteria analysis and processing of the data could be used to test a prioritization model in a context of financial constraints. Such a study could better differentiate between 3.0 and 4.0 sensors and propose their inclusion in a protocol ensuring a better quality of maintenance.

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