Anticipatory Rule Based Socio-Spatial Simulation Systems for Participatory Development, Implementation, and Evaluation of Corporate and Governmental Plans and Policies

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Abstract
Participatory Anticipatory Rule Based Socio-Spatial Simulation Systems (PARBS4) is in this paper presented as an emerging field for studying questions related to the participatory development, implementation, and evaluation of corporate and governmental plans and policies. Fields like anticipatory rule based simulation, GIS, policy, international business, and regional economics could support and/or hinder the development of PARBS4. In reviewing those, possibilities for advancement are identified, along with some of the gaps that need to be filled. Specific combinations of such possibilities are proposed, along with the criteria that could be used to evaluate them. At last, ERASE is proposed as an instance of an international interdisciplinary research programme whose pursuit could lead to the development of PARBS4 as a cognate field.
Keywords: Anticipation, Rule Based Systems, Spatial Systems, Simulation, Inter Regional Policymaking.

1 Introduction

Introducing a novel international "undisciplinary"[1] research programme is no easy task and it is more so doing it in the abstract. An empirical referent could thus be of help to that effect. Although the choices are plenty the referent to be utilised should satisfy at least two constraints: a) sufficient complexity and b) requisite familiarity.
In this paper the European Union (EU) is thus utilised as such a referent. It provides a sufficiently complex, evolving and highly interdependent empirical referent. For example new member states join; policies change and/or new ones are developed. There are also important differences in: geography (coastal-, mountainous-, border-, and central-regions, small and large member states), growth rates, levels of income,

[1] According to Lunca (1996:145) an "undisciplinary" research programme allows undisciplinary entities (e.g. activist groups, the mentally-ill) to contribute to the development of its discourse. Its results will thus depend "on the isomorphism (reciprocal adequacy) between an object of study and [its] discourse" [bracketed words added].

employment-, legal-, taxation-, accounting-, transport-, and healthcare- systems and regimes; forming a mosaic of dozens of regions, hundreds of cities, millions of inhabitants, with a variety of languages, cultures, religions, and lifestyles coexisting at very close proximity.

No single actor or even groups of actors (corporate or public) appear to be capable of dealing satisfactorily with complexity emerging from this ever-changing mosaic. Moreover, EU citizens, workers and tax payers in particular, face increasing difficulties in participating in such processes.

It is relatively easy to find examples of suboptimal corporate plans or public policies (e.g. agricultural, educational, environmental, healthcare, industrial, labour, transport) at all levels of resolution: local, regional, national, and EU wide. As well as examples of the negative public responses they give rise to (e.g. strikes, protests, boycotts).

There may be a number of reasons for both types of difficulties (i.e. planning and participation), e.g. lack of resources, increased complexity, lack of motivation, corruption, opaque processes as well as several well tried ways of addressing them, e.g. regulation, opinion poles, referenda, citizens' advice bureaus.

These, besides being costly to administer, organise and co-ordinate, have so far only produced occasional and marginal improvements to the difficulties of planning and participation and could thus be seen as part of the problem rather than as part of its solution.

In this paper an alternative path is explored, *viz*. Anticipatory Rule Based Socio-Spatial Simulation Systems for participatory development, implementation, and evaluation of complex corporate and governmental plans and policies. That is, the question is raised in terms of the technologies (e.g. hard, soft, social) that could be employed to try and address the difficulties of planning and participation in large scale interdependent and evolving complex systems such as the EU.

Obviously there seems to be no shortage of 'hard' technological fixes. Equally however, each one seems to have its own fair share of difficulties. For example GIS although successful in describing and addressing geographical operational problems seem to be closed to participation and incapable of addressing strategic issues in some integrated manner (Holmberg, 1994, Asproth *et al*, 2003). Social simulation although producing insightful approximations and novel insights of the social world it often does so in landscapes devoid of any environmental features (*cf.* Squazzoni and Boero, 2002; Zhang, 2002, Fioretti, 2001; Brenner, 2001). Even when some parts of the environment are taken into consideration the system is closed to participation. Finally tele-, digital- and e- democracy and governance systems although useful for registering public opinion and/or facilitating discussion/debate do not allow the analytical exploration of alternatives (Kakabadse *et al*., 2003; Kinder, 2002).

The same goes for social technologies such as disciplines, religion and/or politics. As they tend to assume a monopoly of truth and/or true knowledge production; delineating problems so to suit established traditions and 'excluding' whatever cannot be made to fit the bill (e.g. awkward observations and/or voices). The criticisms and limitations of disciplinarity are well known (*cf.* Lunca, 1996; Kline 1996) and this is not the place to iterate them. Thus obviously what is proposed is a multi-, inter- or in the Lunca

(1995:145) parlance an undisciplinary research programme embracing all actors and technologies that could assist in its pursuit. ***In actual fact one of the motivations of writing this paper is to stimulate the interest of such actors.***
Having foregone the privilege of a single technology, discipline and the like one is robbed of the privilege of having (pre-selected, well defined, etc.) objects. What is one left with are research objectives or even better research questions.
This is the starting point of the proposed research programme and given the space limitations of any single paper they had to be prioritised. The following research questions will thus be explored in this paper:

1. What may be required from a participatory 'planning'[2] system for a complex system such as the EU?
2. What may be the building blocks be (e.g. fields, findings, approaches, actors) that could give the pursuit of such a research programme a 'head start' (e.g. sound basis, promising trajectories)?
3. In what way(s) may findings from such fields be combined?
4. What criteria could be used to evaluate their combinations?
5. How could the pursuit of such a research programme be made more rigorous and successful?

The first question is explored in §2, the second in §3, the third in §4, the fourth in §5, while an example is offered as an answer to the sixth question in §6.

2 The Mess and the Difficulties

As introduced the EU is far from a homogeneous area; quite the contrary i.e. a unique mosaic of "sticky places in a slippery space" (Markusen, 1996). At the same time the EU, at all levels of resolution (e.g. regional, national, as a whole), is under economic and technological competition from counterparts both inside and outside its boundaries.

Taking the region as a unit of analysis (i.e. NUTS1) for example one of the long standing challenges for the EU as well as for European national governments has been the development of policies for stimulating prosperous and harmonious regions. Still even within any single EU country, let along across the EU, there are for example substantial and persisting regional disparities at:

- The quality of life and standards of living
- Unemployment and migration

[2] Planning is used here as shorthand for policy making, problem solving, decision aiding, etc. support system. No vision of a centrally planned economy, state, etc. is stipulated. Quite the contrary; as the envisaged support system should provide the possibility of 'planning' for any combination of (view)points irrespective of their extent of (de/)centralisation.

- Education and skills
- Innovation and entrepreneurial activity
- Environmental protection and degradation
- Infrastructure and economic growth

The situation however is further perplexed due to the dynamic and systemic (e.g. evolving, interdependent, emergent) characteristics of the EU's regional problems giving rise to additional difficulties. Some major ones are listed below:

To start with, an action targeted at one region may have consequences in another due to systemic interdependencies and emergent properties. In other words, actions performed in one region may often have unintended and unforeseen side-effects to regions far away. This means that regions should be seen as grey boxes. Consequently, it is exceedingly difficult, if not impossible, to know beforehand with any precision the outcome of an action. Most importantly however, these unintended and unforeseen side-effects of action may be negative.

Given this systemic nature, it is exceedingly difficult to observe (let alone understand or predict) the actual system from the viewpoint of any observer/actor or group thereof (e.g. policy makers, citizens, managers). The system (if one is allowed to talk about it in the singular) consists of a range of inter-penetrating subsystems (Luhmann, 1995; Leydesdorff, 2001). For example transport, education, healthcare, environment, legal, taxation, labour, industrial, social. Today's aids to such observers/actors fail to adequately capture this complexity, are costly, do not allow participation, and are difficult to transfer (e.g. reuse across regions, by different actors).

In addressing such difficulties observers/actors have to make trade-offs between several criteria, i.e. they are confronted by Multi Criteria Decisions. It is also well know what happens to unaided or poorly aided actors when the number of issues facing them reaches the 'magical number 7 ± 2' (Miller, 1956). That is, the performed reduction, to bring the number of issues (e.g. criteria) to an actor's competence level can be haphazard.

In addition to the many criteria there are also many (and often competing) actors in the European or even in a national arena, i.e. there are also difficulties relating to Multi Actor and Multi Decider situations, each actor with his/her own specific values, goals, and priorities. As if this is not difficult enough often the 'games' they are involved in are treated as zero sum and worst of all they may be non-iterative (e.g. governments and governors change) making it extremely difficult to develop co-operation (Axlerod, 1984). The possibility to iterate such interaction (even in a simulated environment) could have far reaching and long lasting benefits.

Last but not least, every EU citizen and/or tax payer in particular, is a legitimate stakeholder in the planning and policy making process. Thus, they should be able to participate in such process. That is, being able to at least observe what the rest of the actors are (capable of) observing and having the right for its 'voice' to be observed by the rest of the actors. A PARBS4 should thus be of great benefit to that effect.

In the following section some building blocks upon which the pursuit of a PARBS4 could build upon are discussed.

3 Some Initial Building Blocks

From the so far discussion it should be clear that at least two broad paths and/or technologies are relevant to the pursuit of PARBS4 research programme. They could be referred to as the hard and soft, or the social and technological, humanistic and mechanistic. How one may refer to them however is not what matters; after all one can find hard in the soft and *vice versa*. What matters is their constitutive parts and especially those parts that could act as the building blocks to give the pursuit of such a research programme a 'head start' (e.g. sound basis, promising trajectories).

The table below (although far from complete) lists some of these building blocks:

Table 1: An incomplete list of some promising building blocks for PARBS4.

Anticipatory Modelling & Computation	Policy studies
Simulation	International Business & Relations
Digital Cartography& GIS	Economics & Regional Economics
Internet, Open-code & End-user Computing	Business & Management
Gaming and Human Computer Interaction	(Public) Administration & Governance
Systems Analysis and Design	Social & Economic Geography
Decision Support Systems	Sociology, Social psychology &
Management Information Systems	Anthropology/Ethnography
Environmental Information Systems	Learning & Education studies
Transport Information Systems	Evaluation studies
Computer Supported Collaborative Work	Environmental studies
Cybernetics & Complexity Sciences	(Community) Operational Research
Statistics & Mathematics	Sociodemographics & Ecodynamics

As it can be seen in Table 1, the list of building blocks although incomplete is already rather long. No single actor can obviously master all of these fields, let alone combine them in the pursuit of PARBS4. ***Thus another motivation for writing this paper is to invite contributions that add to this incomplete list as well as inviting actors with competences in these fields to come forward and join in the pursuit of the PARBS4 research programme.***

Given the impossibility of attempting an overview of the envisaged contributions of the above fields at any meaningful length, in the following section a pictorial overview is offered instead. It aims to help visualise the programme and its building blocks as well as guide the subsequent discussion of some of its building blocks.

3.1 Panting a Picture of PARBS4 and its Building Blocks

An overview of the current state of the PARBS4 research programme and its building blocks is provided below:

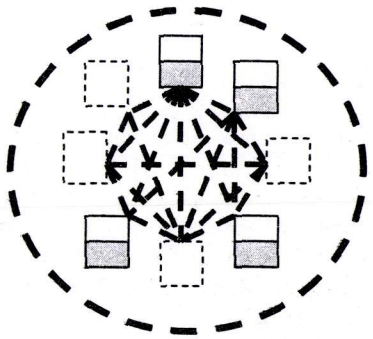

Figure 2: A Pictorial overview of PARBS4 and its building blocks.

The rectangles symbolise the different building blocks of the PARBS4 research programme. Some of them have been delineated and are 'filled' with relevant knowledge (grey areas) while others are yet to be delineated and/or filled (dotted rectangles).
The PARBS4 core, i.e. the dotted lines in the middle indicate that the building blocks so far are only loosely-coupled. Whereas the outer dotted circle indicates the programme's boundary and thus the formation of a proto-identity separating it from its environment. Moreover, the doted outer circle also indicates a permeable boundary inviting the exchange of contributions between PARBS4 and its environment.

In the remaining parts of this section some of those grey areas and their challenges will be touched upon, *viz.* those that appear to be more relevant to the anticipatory, computing, and wider systems community. This unavoidable prioritisation is solely due to the paper-size limitations and the nature of this paper's publication outlet. In forthcoming works of Holmberg and Tsagdis other grey areas and their challenges are intended to be addressed (e.g. relating to the simulation, business and policy communities).

3.2 Anticipatory Modelling and Computing

The anticipatory paradigm (Rosen, 1985) simply put advises to act in advance in order to have a better future. This may now seem to be a rather uncontroversial statement however, in terms of its antecedent and dominant reactive paradigm it constituted more or less a scientific revolution.

Successful anticipation presupposes both a value system, which makes it possible to evaluate and order different alternatives; as well as a prediction system, which makes it possible to perceive future states of the system in focus and its environment. Moreover, the prediction system may rely on a model, as in weak anticipation, or it may be intrinsic to the system, as in strong anticipation (Dubois, 2000).

In the case of PARBS4 the weak anticipation appears to be the most suited alternative. If that is to be the case the pursued anticipatory research programme is facing three main challenges according to eq. 1.

$$S(t+1) = F[S(t-I),..S(t-1), S(t), S^*(t+1),..S^*(t+j)] \quad (1)$$

First, the system state S is no longer a scalar variable in what Goertzel (1997) calls "toy iterations" but a vector holding enough elements to model complex real life situations in a relevant way. Moreover, as many stakeholders are expected to be involved, S will need to be expanded for example into a matrix with one row for each stakeholder group. Performing such an expansion will require striking a delicate balance between Klir's (1991) "Constraint Analysis" and (tradeoffs such as) relevance, complexity and uncertainty (Klir, 1996).

Second, it will be necessary to develop a model or probable models S*, which can replace S for time steps > t. Partial efforts of such anticipatory modelling of spatial entities may be found in (Asproth *et al*, 2001 and 2003; Holmberg, 2001; Asproth and Håkansson, 2002).

Third, in equation 1 there is no spatial dimension and no distribution; a shortcoming anticipation in this elementary form is sharing with System Dynamics (Meadows, 1980). On this point, however, the space hypothesis and the spatio-temporal fuzzy model (Holmberg, 1998) may form a first step toward a workable anticipatory methodology for spatial problems.

3.3 Systemic Evolution

Boulding's (1978) Ecodynamics is a work of systemic ideas in "General Systems Evolution", which touches upon several of the fundamental issues PARBS4 is grappling with, e.g. growth and decline in an inter regional setting. Unfortunately this work cannot be reviewed at any length in this paper. It will thus have to suffice stating that the PARSB4 research programme is informed by it.

What however may merit some space from his work under this heading is the distinction between dynamics and evolution. "Evolution itself evolves in a succession of patterns" whereas dynamics according to Boulding is just motion according to preset and fixed rules and laws in the way, for example, the moon is rotating around the earth.

Finally Boulding, among others, argued about the need to replace or extend traditional production factors (e.g. land, labour, capital) to those of know-how, energy, and material. Obviously, the adoption of a spatial perspective in PARBS4 is likely to involve a further enhancement of production factors by the addition of space, spatial distributions, and infrastructure. Such further enhanced production factors may be interwoven into a (spatial) nexus. This is likely to pose a challenge for factor substitution (in its strict classical sense).

3.4 Modelling, Simulating, and Learning

The modelling of geographical space and its ongoing economic, social, environmental, etc. processes will be a key prerequisite for PARSB4. Two main traditions to modelling and simulating, often portrayed as mutually exclusive, could be utilised. The older of the two, in the positivistic tradition's lineage, approaches modelling as a mechanical mapping of an independent and objective outer reality. Whereas the younger rival in the lineage of von Glasersfeld's (1998, 1999) radical constructivism and Le Moigne's (1995) systemic modelling, approaches modelling as a continuous and never ending learning process (Holmberg, 2002).

The beauty for PARBS4 is that it can be served by and serve both traditions. Thus the major challenge in this area appears to be how to integrate the alternative traditions in the delineated building blocks (e.g. in geography).

3.5 Monitoring, Assessing, and Evaluating

Masser (1984) and Holmberg (1994) suggested that monitoring is the continuous and real-time sensing and supervision/evaluation of a set of variables. Moreover, monitoring goes beyond the passive counting, observing, measuring, and recording of data. It also involves reacting and intervening in due time and taking the relevant variables into account. Although the principles of monitoring are well established the challenges involved in implementing monitoring systems especially across vast geographical areas and for a large population and wide range of variables[3] so to allow for regional comparisons is not for the faint hearted.

3.6 Designing, Deciding and Intervening

Banathy (1996) has paved the way to social systems design. One of the major (moral) challenges he identified was the inclusion in the design process of those served and affected by the system. Obviously, as often is the case, it is impractical, costly or even impossible to involve all those who are affected by a design, especially of the PARBS4 size. Still some help for dealing with this type of difficulty can be found in the works of Warfield (1990), Beer (1994) and Follet (1965).

3.7 Information and Communications Technologies

In order to accomplish the goals of PARBS4 some powerful and user friendly information and communication technologies (ICTs) will be required. Unfortunately

[3] Some of these variables will concern physical entities, well suited for positivist measurements. Others represent soft or human conditions, for which historic data may not be available, and may require innovative approaches to measurement.

space constraints only allow touching upon those posing some novel opportunities for PARBS4, *viz.* geographical information systems (GIS), transparent (pervasive, ubiquitous) computation (TC), next generation internet (NGI), and soft computation (SC).

GIS have reached a high degree of technical sophistication and versatility. From PARBS4 point of view however, the current GIS need to be improved in several aspects. To start with, the so far GIS have been focused on historic and current matters. What is needed in addition is a forward looking GIS capable of dealing with future events and states with equal fines; i.e. an anticipatory GIS (AGIS). AGIS however will not suffice. For PARBS4 one needs to go beyond description and into diagnosis and explanation. Further improvements will also be needed to migrate from visualising structures and other static features to handling dynamics and evolving entities, so that processes, flows and their participating/effected actors can also be represented, diagnosed, and explained.

Under the TC heading (aka ubiquitous or pervasive computation) a number of current ICT trends are encompassed. According to these, the computer will be marginalised as a discrete general purpose device while elements of it will migrate and become increasingly integrated into most tools and materials in our environment (Mattern, 2003).

The combination of TC with NGI, i.e. every ICT tool or device having its own IP-address and being able to spontaneously and autonomously communicate with other ICT devices, will open up novel possibilities. So far such possibilities have been underexploited in inter- and/or intra-regional planning. PARBS4 will be looking into the possibilities of harnessing of such technologies.

Finally SC is a collective name for fuzzy logic, artificial neural nets, and evolutionary computation with generic algorithms. What such computation methods share is inspiration by nature's way of solving problems. This is in contrast to the more traditional hard computation (HC) methods (e.g. based on formal two-valued logic). It remains to be seen how PARBS4 could integrate and exploit both types of computation in novel ways (e.g. SC for the more vague, multi-valued, and inter woven states and HC for 'bred and butter' programming).

4 Combining the building blocks

The building blocks discussed so far could be combined in a many-to-many (M:N) ways (as depicted in Fig. 3 and 4 below). In the former the core of the PARBS4 is formed by a synergetic research in: anticipatory computing (§4.2); systemic evolution (§4.3); modelling, simulating, and learning (§4.4); evaluation (§4.5); systems design, decision support and intervention (§4.6); and ICT (§4.7).

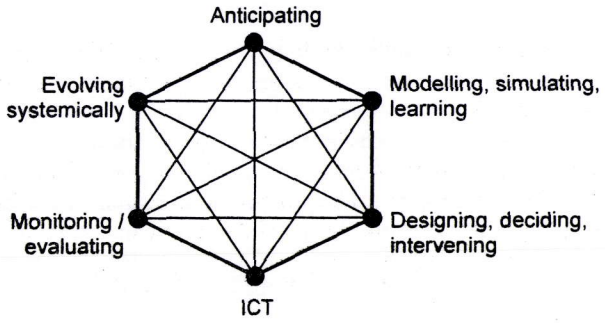

Figure 3: M:N ways of combining and researching the PARBS4 building blocks.

It is not, however, possible to tell everything in a complex situation with a single picture like figure 3. Hence with a process-oriented depiction of the PARBS4 activities and challenges, a bi-directional systems loop as in figure 4 below may give a complementary view.

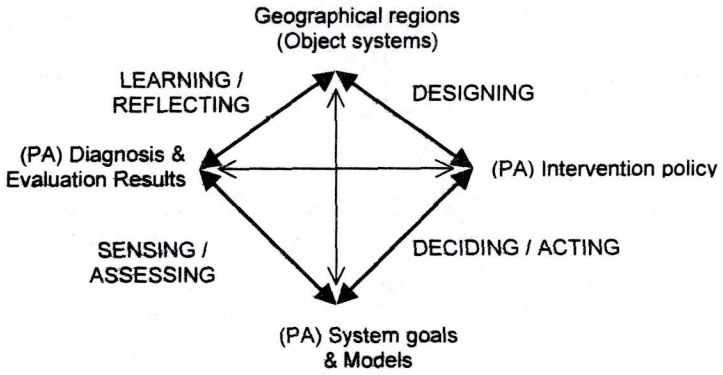

Figure 4: The spatial systems loop.

The object systems (e.g. EU regions) along with the participatory-anticipatory (PA) systems' goals and models, diagnosis and evaluation results, and last but not least intervention policy are positioned in the apexes of the loop. They are linked through sensing and evaluating, learning and reflecting, designing, deciding and acting contours. Obviously more apexes and contours can be added if and when necessary as what appears in Fig. 4 is more of a minimal illustration.
The way these and many more combinatorial possibilities can be evaluated is explored in the following section.

5 Evaluation

In order to evaluate the possible combinations and potential improvements of the proposed research programme and the existing research findings discussed so far, the Modelling Quality Star (MQS) is proposed as an initial robust and straightforward quality index. The MQS is inspired by Rander's (1980) "Star of model characteristics". In subsequent steps of the PARBS4 research programme this initial quality index may be refined and/or enhanced through the addition/modification of quality dimensions as well as with the amalgamation of other evaluation criteria and approaches. In the figure 5 the range of some initial criteria are depicted:

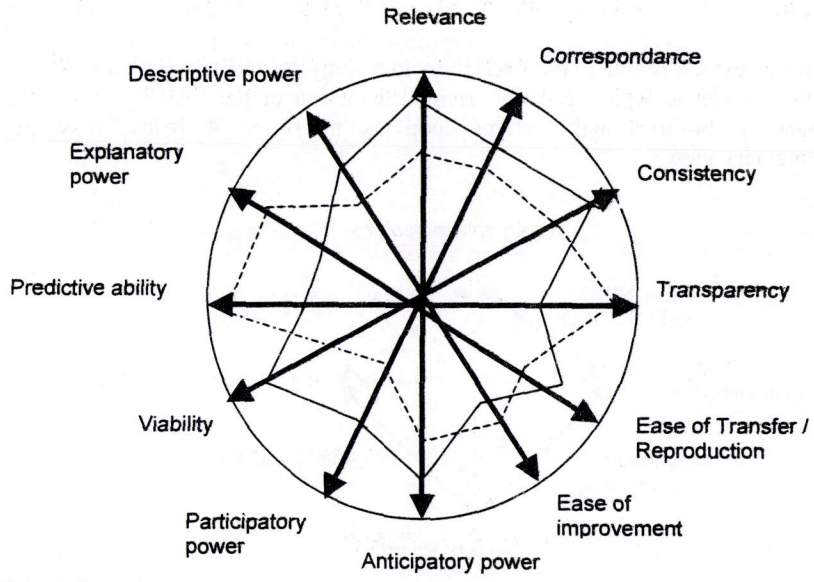

Figure 5: The model quality star (MQS).

As depicted in Figure 5 the quality of any combination/model is not a one-dimensional entity but consists of several dimensions. The centre of the figure represents the zero value while the circle represents a normalized value of one. Hence, for each dimension a model will acquire a value in the [0..1] interval. For example, the profiles of two different hypothetical combinations/models, *viz.* A and B are plotted in the figure.

The quality of a combination/model according to the MQS can be expressed as a vector by Eq. 2.

$$Q_i = [q_1, q_2, \ldots\ldots q_j] \quad (2)$$

Q_i, Quality vector of combination/model i.
q_l, Value in dimension l [1,, j]

An accumulated quality index (AQ) of a combination/model i with j quality properties can be calculated with help of Eq. 3.

$$AQ_i = \Sigma\, q_l / j \quad (3)$$

Whereas a relative quality index (RQ) between two combinations A and B respectively is given by Eq 4.

$$RQ_{AB} = AQ_A / AQ_B \quad (4)$$

Having overviewed the mess and its difficulties, some of the building blocks of PARBS4 and the way they could be combined and evaluated are explored in the form of an example in the next and penultimate section of this paper.

6 ERASE: one small step for PARSB4 a giant leap for...

In this section ERASE (European Regions Anticipatory Socio-Spatial participatory planning Environment) is explored as a possible European cooperative research and development project within the PARBS4 research programme. The ERASE project focuses on the goals of a future prosperous, democratic, and sustainable Europe while furthering the PARSB4 knowledge base, integrating disjoint areas, and filling knowledge gaps.

The main objective of ERASE is to make GIS and anticipatory spatial simulation accessible to new user groups, such as the common citizen and the non-technical professionals in business and local, regional, national and supranational government. This requires international multi-, inter- and un-disciplinary research competences, only possible to sustain within a European research framework.

6.1 Vision

The vision for the ERASE project is to develop an environment supporting European citizens and stakeholders in creating a shared future by actively participating in normative intra-, inter-, and supra-regional planning and policy, implementation and evaluation.

6.2 Objectives of ERASE

In order to obtain the main objectives and turn the vision into reality, ERASE will work with the following operational objectives:

O1) To establish a creative and synergetic development network of partners/contributors as well as appropriate working procedures and protocols.

O2) To develop anticipatory theory and techniques for multi-actor and criteria situations.

O3) To develop AGIS modelling and simulation.

O4) To develop methods, techniques and interfaces that allow access to ordinary citizens and different stakeholder groups.

O5) To design a (virtual) internet based participatory environment for intra- and inter-regional socio-spatial planning and policy, evaluation, and implementation.

O6) To develop techniques and methods for representing, visualising, diagnosing and explaining processes and flows in such an environment.

O7) To develop methods and techniques for increasing effectiveness in commercial and public activities with a geographic dimension.

O8) To test all of the above methods, techniques, interfaces and environments with pilot user groups in different regions and settings.

6.3 Organisation

The ERASE project is to be pursued by partners with different but complementary competencies. Partners will be invited to contribute specific competencies as well as trigger and act as catalysts for the others. This broad constellation is hoped to create a creative and evolutionary environment for the PARBS4 efforts.

6.4 Deliverables

A participatory European socio-spatial planning environment is envisaged to be the main deliverable of ERASE. Such an environment should make it possible for any European citizen and/or stakeholder to participate in intra- and inter-regional socio-spatial planning, policy making, evaluation, and implementation. The environment will be distributed and internet based with a gaming interface making it possible even for novice users to participate irrespective of their physical location.

7 Closure

PARBS4 is an international undisciplinary research programme in the making. In these early days it is difficult to draw any strong conclusions; besides its paramount importance for European planning and policy making, evaluation and implementation. Although challenging, the PARBS4 research programme is fortunate in having a number of solid and promising blocks to build upon. Still much remains to be accomplished.

An example of the things to come was provided in the form of ERASE as a European project aiming to accomplish a subset of the PARBS4 aims as well as integrate some of the aforementioned blocks and fill any knowledge gaps in a rigorous manner.

The authors would thus like to close this paper with a positive message and ***an invitation to ERASE the well known ills of today's planning systems and join us in contributing to the pursuit of PARBS4.***

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