TWO STAGE SIMULATION USE IN PROJECT VERIFICATION AND VALIDATION

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ABSTRACT
Using simulation solutions, policy planners can examine a variety of real-time solutions before their implementation as well as forecast the impact of potential decisions on the attainable goal in general (Silva et. al. 2009).

If the developed policy decision-making support system does not correspond to the requirements of the decision maker, funding will have been spent pointlessly. The basic task of the sociotechnical approach is to bring together the wishes of the decision maker with the technical possibilities of the developer, thereby promoting project clearness and giving the beneficiary an opportunity to validate the offered solutions and establish conceptual mistakes in the early stages of the software designing.

The article dealt with two step simulation use based on Zagreb Open Green Park application development.

Keywords: simulation, simulators architecture, policy modeling, agent-based models

1. INTRODUCTION
The development of suitable support tools for the previously mentioned requirements is rather complicated because a fundamentally important factor is product functionality and algorithm conformity to objective requirements e.g. political decision quality assurance. Political decision-making usually is implemented in the framework of a classic sociotechnical system where respect has to be shown for both technical and social aspects.

Each project has to be transparent otherwise the user cannot take part in the design, and the expected result mostly will not be acceptable to the user. Result visualization also has to correspond to guidelines accepted within the user's professional field. The simulator has to maintain a beneficiary's alphabet, which is a set of terms that the beneficiary encounters during his/her daily professional activities, to ensure user-friendly visualization. The simulator has to be open so it often can be integrated into goal system software. Policy decision makers i.e. policy, tourism, economy and other specialists could create simulation models, but then the design syntax have to be understandable by people without specific programming knowledge.

To enhance the use of simulation models by politicians for decision-making process such as policy design, it is essential to verify and validate (V&V) the simulation model (Sargent 1992, Burton 2003). While verification concerns whether the model is working as the modeller team expects it to, validation concerns whether the simulation is a good model of the target. Roughly speaking, a model is considered valid for a particular goal, if the results that can be obtained from the simulation have the same statistical properties and patterns as those obtained from the real system. However, in the area of sociotechnical system there are several aspects to be considered when comparing simulation results with a sample of the real system:

- Most social systems are characterized by its stochastic behaviour. Individual decisions strongly depend on human behaviour which is characterized by a diversity of options in front a particular choice problem, selecting a different choice even under similar circumstances. Thus, the simulation model considers also random factors to represent the stochastic process, which somehow justify a lack of rigorous correspondence between the results of a simulation run with respect to a sample. Comparisons between real data and simulation data usually is carried by statistical methods such as hypothesis test, which is a quite difficult problem to avoid accepting a false hypothesis or rejecting a true one, based always on modeller subjective considerations.

- Some simulation models are quite sensitive to the initial conditions dealing with drastic different results. Meanwhile the real system behaves in the same way, so the dynamics are highly dependent on the environmental conditions, the sensitivity of the model to the initial conditions is not a problem for explanatory targets validation, but it constraints its use for predictability purposes.

- Some social dynamics are quite dependent on time varying scenarios such as for example those urban policies which depend on seasonal weather conditions, or economic cycles. Consider the planning activities in a public green park for integration of autistic people with the neighbourhoods: affluence to the park and duration of the stance depends considerably on the weather conditions. Thus, even if the dynamics formalized is correct for certain boundaries conditions, they can lead to wrong results when the model is used for predictive purposes if the real scenario doesn't fulfil some of the boundary conditions.

To create trust and increase the credibility of the model and the simulation results delivered, it is essential to deal with a validation approach in which non-simulation trained end-users (ie. practitioners) could feel comfortable with the computer experimentation technique and trust the simulation model.

In this paper it is presented a two stage simulation framework, based on the model plausibility notion, also known as "conceptual validity" or "face validity", which expresses the conformity of the model with a priori knowledge about the process.

2. CONCEPT

The conception about simulator or goal system functionality will always differ between the policy decision maker and the developer because the decision maker is guided by specific functionality requirements, nuances and particular conditions only known to him, whereas the developer places importance on technical solutions, development time and potential costs. The complexity of simulators to be developed increases not only from a technical (territorially distributed systems, cloud computing, Future Internet architectures, semantic search etc.), but also from a functional standpoint (decision-making algorithms; fusion, mining and useable visualisation of complex data). This significantly complicates the development of suitable simulation software.

To achieve successful designing results it is reasonable to split goal system design in at least two steps: conceptual modelling and implementation. In each step simulation can be used as an active verification and validation method (see Figure 1) of provided ideas.

Assessment of model plausibility is tightly related to expert judgment of whether the model is good or not. The level of plausibility, or better said the expert opinion about it, is basically related to two features of the model:

- The first one considers the question whether the model "looks logical". This question concerns characteristics of the concept simulator.
- The second one is related to the question whether the model "behaves logically". This part concerns assessment of the reaction of the model outputs (dynamics, shape, etc.) to typical events (scenarios) on the inputs. If the model in different situation reacts in accordance with expectations of the experts, then the confidence about its validity is increased.

Concept simulator (V&V-1) is aimed to provided concept verification and validation to compare different potential possibilities of bottlenecks, conflicts and to determine border conditions. This first preliminary step is carried out to understand the trend instead of precise quantitative solution, because it is necessary to decide is it reasonable to continue the project if the forecasts are unpromising.

The V&V-1 simulation results are input for the second implementation stage. However also designing results are verified and validated on Implementation simulator (V&V-2). These simulations are oriented to detail testing of some preliminary results obtained, before launching design of real more expensive prototypes.

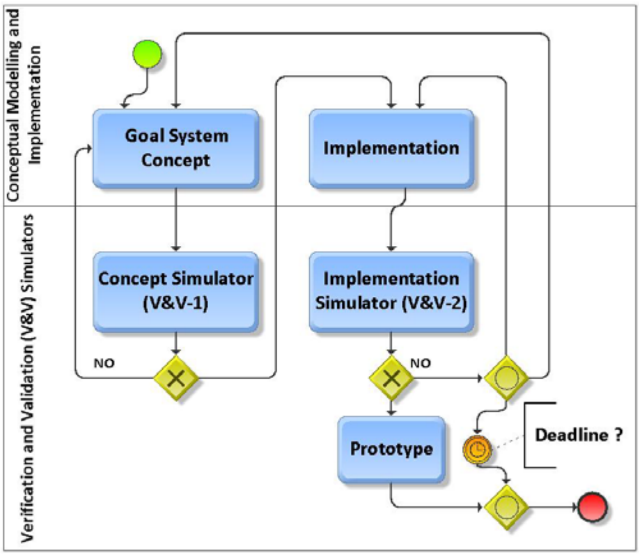

Figure 1: Two Stage Simulation BPMN2 Diagram of Project Verification and Validation

3. ZAGREB OPEN GREEN PARK SIMULATOR

One distinctive application of the above-mentioned approach is the FP7 FUPOL project No. 287119 "Future Policy Modeling" case related with designing of the Zagreb Open Green Park simulator (Ginters and Aizstrauts et.al. 2013; Piera and Buil et. al. 2013).

The territory of Zagreb Open Green Park is approximately 20,000 square meters. Autism Centre patients and visitors from other neighbourhoods are expected to visit the park. Zagreb municipality has statistical forecasts about the possible number of visitors on weekdays and weekends.

Zagreb Open Green Park simulator consists of two parts and is based on multi-agent simulation (MAS) designed in Repast Symphony and GUI implemented in Java environment (see Figure 2).

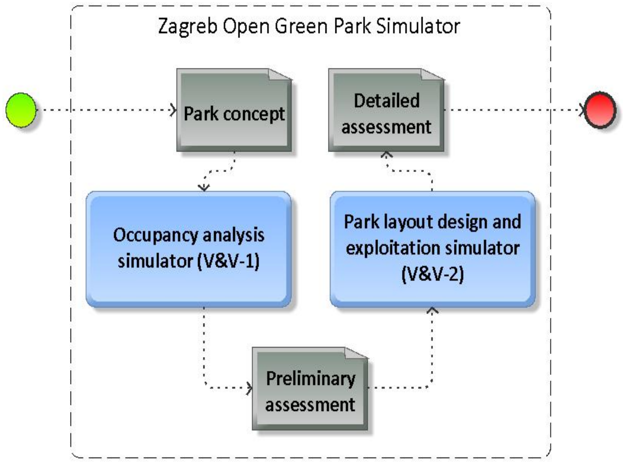

Figure 2: Zagreb Open Green Park Simulator Architecture

Despite, validation of multi-agent models can quickly become intractable (Batty et al., 2003), one of the advantages of MAS as a modelling technique is that it allows achieving an ontological correspondence between artificial and real agents. Thus, pre proposed two stage simulation framework proposed for V&V provides an innovative qualitative validation approach.

3.1. Concept Simulation

The aim of the simulator is the realisation of two related tasks: area breakdown general planning through potential occupancy analysis (stage 1) and park layout design, and exploitation (stage 2) (see Figure 1).

The Occupancy analysis part and the Layout design and exploitation part can be used together or separately. The Occupancy analysis simulation model is based on statistical data (typical visitor and accompanying person characteristics, time of arrival, list of desirable activities and probability of their choice), profile distribution on weekdays and weekends, as well as the minimal determined visitor comfort area. For each park visitor a corresponding profile is chosen according to recommendations of Zagreb municipality and Autism centre, and other statistical data. The set of activities have been determined to be implementable by visitors (see Figure 3).

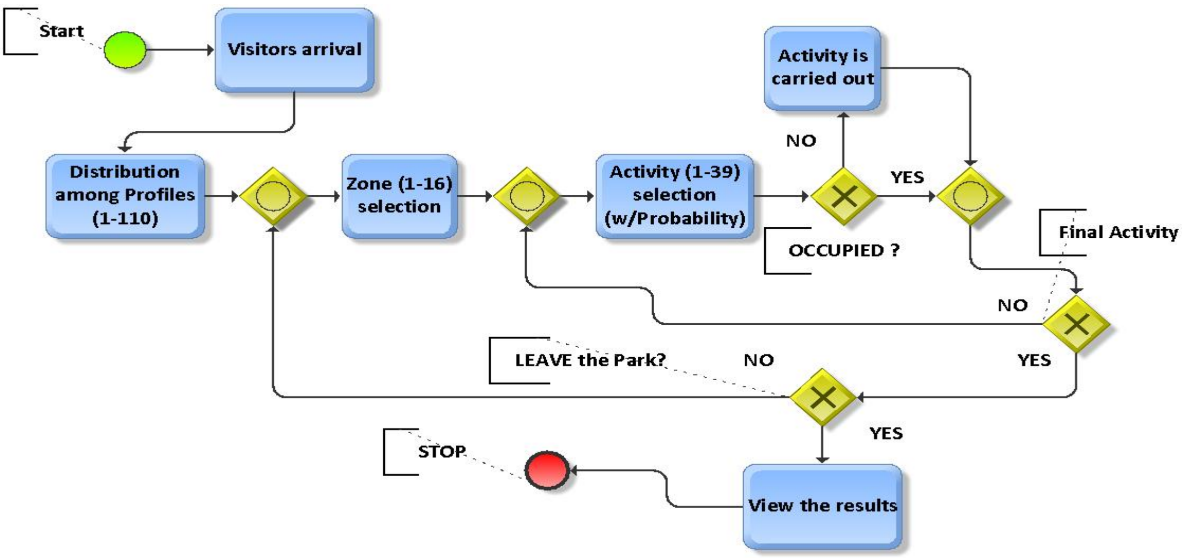

Figure 3: Zagreb Open Green Park Occupancy Analysis Simulation

Each profile has been appointed several most typical activities. These priority activities have been determined with a certain probability for each profile. The most likely time slot for visiting the park is provided for each profile. Simulation length determines result credibility because it anticipates the distribution of simulation results to conform to the normal distribution of probabilities. Result levelling can be observed visually but in keeping with statistical methods, it can be assumed that a 95% credible result can be achieved if the number of simulation cycles (days) exceed around 30. All activities are distributed over the park zones. The potential maximum number of visitors (comfort area for visitor is defined) determines the required minimum area of a zone. If the initially determined zone area is too small, the disappointed visitor goes to another priority activity or leaves the park. If the presence of people with autism as well as other visitors is detected within one activity, the possibility of contacts is predicted and registered. In order to facilitate the conceptual validation, all the agent behaviours are formalized by means of flowcharts to allow non-experts check if their previous knowledge about the socio-technical system is properly understood by the modeller.

Figure 4 illustrates by means of a flowchart the sequence of decisions implemented in the citizen agent model, each time a person with a parameterized profile enters in the park.

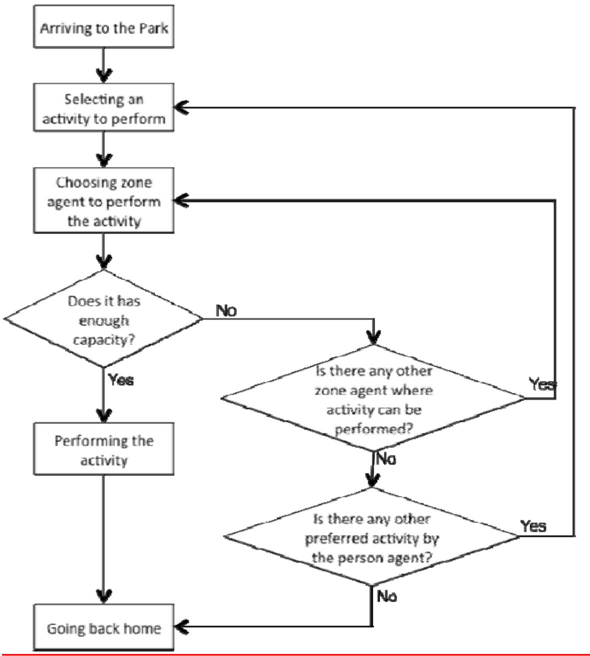

Figure 4: Citizen Behavior Arriving to the Park

In the Zagreb Open Green Park model, to succeed with the Concept Simulator (V&V-1), it has been necessary to formalize users affinity dynamics. It is well known that the original preferences of users are changed in order to satisfy different criteria, such as the possibility to meet some residents (ie. families with kids) while avoiding some other scenarios, such as overcapacity in certain zones. To deal with this important dynamic which is the result of several interdependencies between the different park users, it has been proposed a mechanism to evaluate the satisfaction of a park user considering the active agents in the zone.

Figure 5, summarizes using a flowchart the decision if the time scheduling preferences of a user of the park are updated to have the possibility to match users with similar affinities in the next visit to the park. The right parameters used to obtain a stable behaviour are tuned at the implementation model.

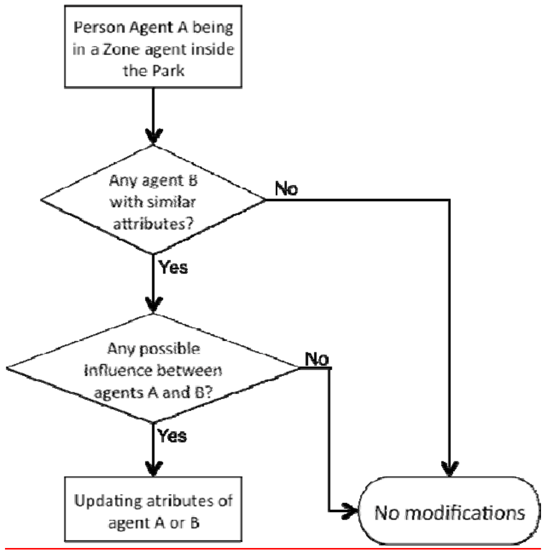

Figure 5: Citizen Affinity Flowchart

The simulation allows creating a rough and hypothetical breakdown of park zoning. It is possible to ascertain the number of visitors in each zone in the simulated time slot, as well as determine the number of rejected visitors if the particular zone/activity was fully occupied.

However, the above-mentioned project assessment stage does not take into account the locations and square size of activities/facilities and reasonable distances between intermediary activities.

Such preliminary park concept evaluation would be recommended before implementation phase.

Important question would be how to recognize that simulation model of the concept is right and valid. Because the park does not exist it is possible to identify the trend only. Therefore social networks are used comparing discussions and opinions with concept simulation results.

3.2. Implementation

The Zagreb Open Green Park Layout design and exploitation part can use the operational data from a preliminary park zone area conceptual assessment provided by first simulation stage and allows park layout interactive design using spatial graphical information (see Figure 6).

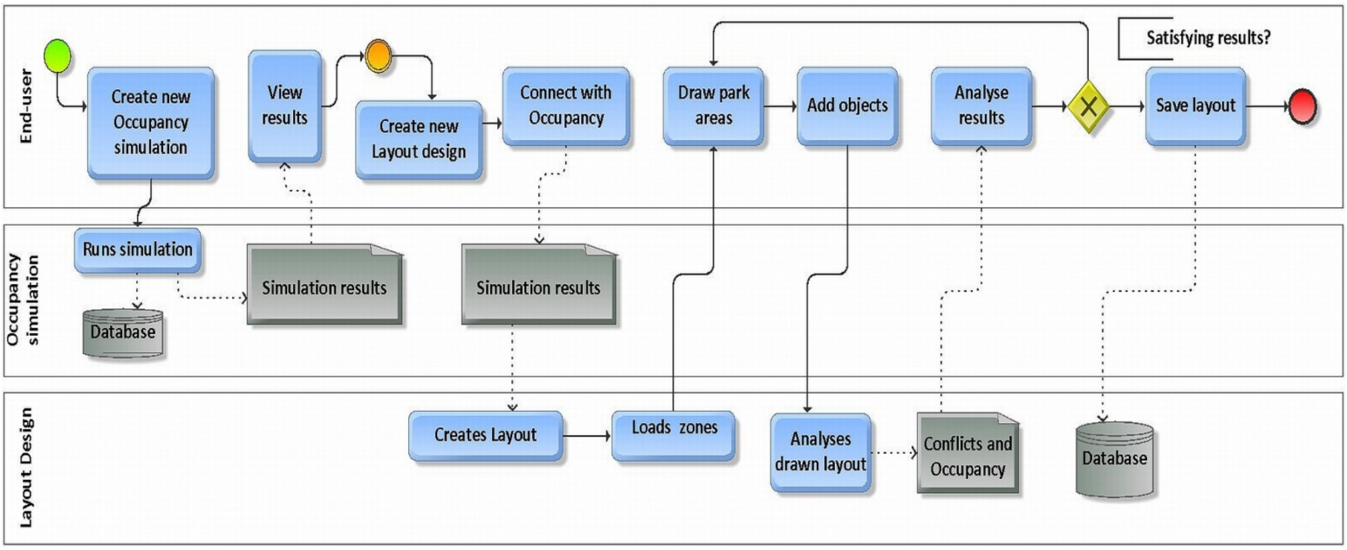

Figure 6: Zagreb Open Green Park Layout Design Diagram

Diagram shows processes of connecting Occupancy Analysis simulation results with Layout Design and modifying a Layout.

The process is distributed among three pools:

- End-user – this pool represents the user of a system, who is working with Zagreb-Open Green park simulation software and wants to receive the results of a simulation and Layout Design;
- Occupancy Analysis – first part of Zagreb-Open Green park simulation software that runs simulation and provides results regarding park zone sizes and overall visitor attendance;
- Layout Design – second part of Zagreb-Open Green park simulation software that can be connected with first part simulation. Layout Design provides options for planning a park layout including zone and park objects' disposition.

To connect an Occupancy simulation with a Layout Design user has to create one. He can do that by choosing new Occupancy simulation at the home page and inputting necessary initial data for simulation including data about the number of total visitors per day, preferred zones, its' sizes and performable activities in the park etc.

Software runs a simulation and provides results for the user. Simulation results show how big should the park zone sizes be, according to the total size and initial values, as well as total park occupancy at each hour point of simulation (that simulates two week period).

After seeing the results the first part is done and intermediate point is reached.

End user returns to home page to create a Layout Design. While creating new Layout project user specifies Occupancy simulation to connect with the new Layout Design.

Chosen simulation's results are taken from the database to help creating a start for new park layout, loading only those resources (zones and park objects for each zone), that were chosen for the simulation. Additionally, Layout Design shows proposed zone sizes that should be drawn (also taken from simulation results).

Layout Design includes park zone division in areas that can placed anywhere on the map showing its' real sizes. Each park area can be filled with park objects – activities and facilities (see Figure 7).

After any creation/modification of the layout, software calculates the situation and provides results on the map for the layout including conflicts between park objects and occupancy per hour for each object.

If the user is satisfied with the layout and provided results, he can finish the work by saving the project or continue modifying until decent layout is created. Layout can also be saved at any point of creation and work can be continued from the last saved point.

The second stage provides an opportunity to create a more accurate breakdown and zoning distribution, because it is based on layout visualization providing designers with an extra capacity to deploy the zones considering the maximum number of simultaneous visitors for a certain activity and also respect allowed distances among different activities.

The development of the Zagreb Open Green real planning and realization can be continued if both steps have given promising results.

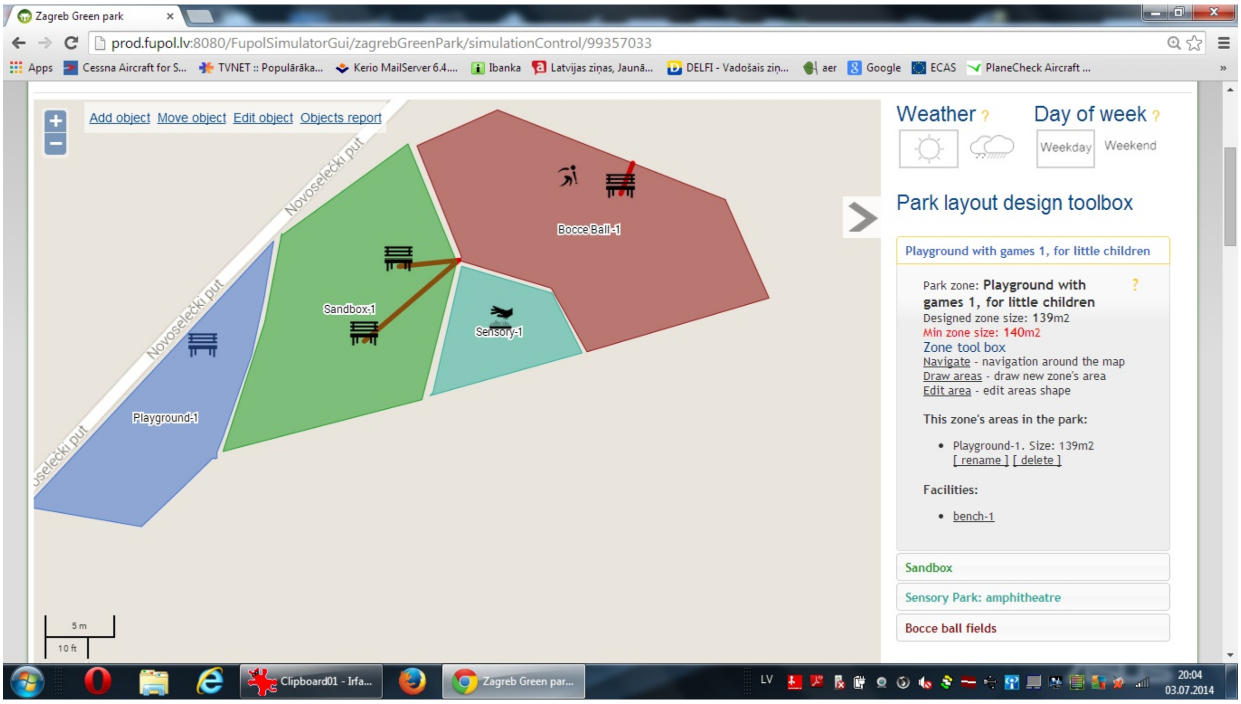

Figure 7: Zagreb Open Green Park Layout Design Desktop

4. CONCLUSIONS

The designing of support tools for planning and making political decisions is an almost impossible mission because in politics, agriculture and medicine everyone is an expert. Voluntary and unsubstantiated decisions are made as a result and the losses, as usual, are covered by the tax payer. Analytical modelling methods are usually not applicable as they are too complex and cases have a significant number of important stochastic factors.

To ensure at least some possibility to evaluate potential project solutions before investing significant financial resources the authors propose performing an initial conception simulation that would allow determining trends and ascertaining whether further implementation of the project is expedient.

The proposed framework supports an efficient try-and-error approach, which is one of the bases of the simulation techniques, since errors or misleading functionalities can be detected at early stages of the concept simulation. Simulation users with different profiles can be involved at the V&V-1, minimizing the risk of developing a complex simulation model that could not satisfy end-users expectations.

This approach is demonstrated on the basis of the Zagreb Open Green Park designing project.

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REFERENCES

Batty, M., Desyllas, J., Duxbury, E., 2003. *Safety in numbers?* Modelling crowds and designing control for the Notting Hill Carnival. Urban Studies, 40, 1573–1590.

Burton R., 2003. Computational Laboratories for Organization Science: Questions,Validity and Docking. *Computational & Mathematical Organization Theory*, 9(2): 91- 108.

Ginters, E., Aizstrauts, A., et. al., 2013. Deliverable 4.4: FUPOL Simulator Software Prototype (Zagreb Open Green Park), 324.Ahmed, A., Greensmith, J., Aickelin, U., 2012. Variance in system dynamics and agent-based modelling using the SIR model of infectious disease. *Proceedings 26th European Conference on Modelling and Simulation.* K. G. Troitzsch, M. Möhring, U. Lotzmann, eds. ISBN: 978-0-9564944-4-3.

Piera, M-A., Buil, R., Ginters, E., 2013. Validation of Agent-Based Urban Policy Models by Means of State Space Analysis. *Proceedings 8th EUROSIM 2013 Congress on Modelling and Simulation*. In: K. Al-Begain et.al., eds. Wales, United Kingdom, 10-13 September 2013, IEEE, ISBN 978-0-7695-5073-2, 403-409.

Sargent, R., 1992. Validation and Verification of Simulation Models. In *1992 Winter Simulation Conference*, Piscataway, New Jersey, Institute of Electrical and Electronics Engineers.

Silva, S., Fidalgo, J. N., Dalila, B. M. F., 2009. *A simulation based decision aid tool for setting regulation of energy grids with distributed generation*. ISSN 1109-2858 (Print), 1866-1505 (Online). Springer Berlin: Heidelberg.

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