The planning process and logical framework approach in road evacuation: a coherent vision

F. Russo & C. Rindone
Università degli Studi Mediterranea di Reggio Calabria,
DIMET - Dipartimento di Informatica, Matematica,
Elettronica e Trasporti, Italy

Abstract

In this paper the Internal Planning Process (IPP) and Logical Framework Approach (LFA) are analyzed with a view to proposing a coherent vision between the two processes. Elements representing processes and mutual interactions are defined. The Internal Planning Process is represented in explicit form by means of production functions (from resources to products and services), demand-supply interaction models (from products and services to direct effects) and impact functions (from direct to indirect effects). The Logical Framework Approach is explicitly represented by means of exogenous activities (from inputs to outputs) usually considered in the current literature. We introduce endogenous activities (from outputs to outcomes and from outcomes to goals), that are normally activated as processes evolve but are generally not considered. Coherent IPP and LFA vision for evacuation of a school is illustrated.
Keywords: planning process, evacuation plan, logical framework approach.

1 Introduction

Construction and management of transport infrastructures and services have to be the result of a comprehensive planning and design process. Transportation planning should be carried out to design and then build infrastructures. After construction, continuous monitoring has to be carried out. Throughout their life cycle, infrastructures and services have to undergo periodic maintenance interventions that have to planned, designed and performed.

WIT Transactions on the Built Environment, Vol 117, © 2011 WIT Press
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/SAFE110361

In this paper we focus on the planning process. Transportation planning can be defined as a set of processes that generates different products, resulting from interactions among subjects involved in the processes. The planning process is represented by [1] planning dimensions (area, time, study-in-depth) by means of which the generic product-plan is defined; the pattern of interactions among subjects involved is represented by the evolution among different planning dimensions (internal dynamic process, external dynamic process).

Although transportation planning concerns both ordinary and emergency conditions, here we consider the internal transportation planning process in emergency conditions. Transportation planning in emergency conditions aims to specify interventions to reduce risk. Risk has three main components: occurrence, in terms of event probability or frequency; vulnerability, related only to the resistance of the infrastructures when the event has occurred; exposure, that is an equivalent homogeneous weighted value of people, goods and infrastructures affected during and after the event. The main measure to reduce exposure is evacuation, which consists in reducing the number of users and goods that can experience negative effects when emergency events occur [2].

In this paper the focus is on evacuation planning, considering the safety of users in road evacuation. To develop evacuation planning, an Internal Planning Process (IPP) is needed. A possible approach to representing IPP is proposed in Russo and Rindone [3]. In recent years, at international level for the same process, Logical Framework Approach (LFA) is adopted [4–6]. The main aim of this paper is to propose a coherent vision to represent the IPP, integrating LFA elements for transportation planning. By adopting this integration the IPP can be represented with LFA standards.

The paper is organized as follows. The main elements of IPP and LFA are recalled in section 2, including common components. In section 3 the proposed coherent vision is presented. In section 4 an exemplification of a coherent IPP and LFA vision for evacuation planning is illustrated.

2 General framework

2.1 Internal planning process

The product-plan is the result of the internal transportation planning process. The process is affected by objectives to pursue with implementation of strategies respecting constraints. Objectives and constraints derive from interaction among stakeholders. Based on objectives and constraints, technical groups develop suitable studies: starting from analysis of the present situation, they identify a set of strategies to adopt for pursuing their objectives, respecting constraints.

Adoption of different strategies generates alternative scenarios. Effects of scenarios can be simulated and evaluated by systems of models. Technicians represent plan effects with indicators that can be compared with objectives and constraints prior to implementation of planned interventions (ex ante evaluations). Results from technical groups support the following phase to choose the best scenario by political bodies. These results partly constitute objectives of interactions among authorities and other public groups. At the end of such interactions the plan-product is adopted. If the plan is implemented a future situation is generated.

2.2 Logical framework approach

The Logical Framework Approach is a method to represent planning process components and mutual interactions; the components are [7]:

- *inputs (constraints)*, or resources needed to implement the plan; inputs depend on levels of goals to be pursued with the plan;
- *activities (strategies)*, or interventions included in the plan;
- *outputs*, or products and services to carry out activities under the plan;
- *outcomes*, or purposes, to pursue, in the medium term, after implementation of the plan;
- *goals (objectives)*, or general objectives, to pursue, in the long term, after implementation of the plan; goals are connected with *need*s resulting from analysis of the present situation.

All components are connected by a cause-effect rationale (plan description): starting from available inputs, if activities are implemented then outputs will be delivered, if these outputs are delivered then outcomes will be achieved, and if outcomes are achieved then goals will be pursued.

2.3 Common components

Indicators

Each plan's component is measured directly or indirectly by indicators that have to be SMART (Specific, Measurable, Accurate, Realistic and Time-bound). For each indicator, a specific target may be assumed. Means of verification to estimate and validate values of each indicator have to be indicated. Individual components of the plan may be influenced by external factors that comprise events, conditions and decisions that can be verified independently by the planner.

Indicators (*performance measures*) allow plan components to be measured. Measures can be quantitative, qualitative, direct or indirect (proxy variables). Indicators are functions to elaborate available information. Indicators have to be defined for each plan component.

Once a set of indicators has been adopted, a set of targets can be specified. Targets represent reference values that are desired values for each plan component. They refer to: classes of involved subjects (*for whom*); quantity (*how much*); quality (*how well*); time horizon (*by when*); and space horizon (*where*).

Indicators and relative targets represent tools to support monitoring and evaluation. Specific works have been developed to compare modelling and Decision Support Systems that are at the disposal of the technicians and analysts in planning road evacuation [8–11]. The same plan must be evaluated ex post, adopting a monitoring system that allows the same ex ante indicators to be re-calculated ex post.

Performance criteria

- *relevance*, to evaluate how pertinent the objectives are to problems to be solved in physical and institutional context in which it operates; this performance criterion measures quality of planning in terms of coherence among general objectives (*goals*) and initial needs resulting from analysis of the current situation;
- *efficiency*, to evaluate capacity to allocate available resources; this performance is measured by means of output to input ratios;
- *effectiveness*, to evaluate capacity to pursue plan objectives; this performance is measured by the outcomes to outputs ratio;
- *impact*, to evaluate capacity to modify the planned context; this performance is measured by the goals to outcomes ratio;
- *sustainability*, to evaluate capacity to maintain social, economic and environmental benefits produced for stakeholders after the financing and execution phases.

3 Coherent vision

To represent IPP and LFA with a coherent vision, to the following may be associated in only one set:

- objectives and goals (starting and final); this set comprises the final results that have to be obtained with plan implementation;
- constraints and inputs; this set includes available (material and non-material) resources to plan a set of products and services; in some cases, resources represent constraints in the planning, design and execution process; inputs correspond to constraints when they are constant; in the project phase, when resources have to be determined, input can be variables; sometimes the constraints are the subset of the input;
- strategies and activities; this set includes actions required to plan a set of products and services; actions of all stakeholders (political, technical and public organs); the time interval in which activities are carried out is defined from the instant at which the first action connected to the intervention proposal starts to the instant at which the last action is undertaken to make planned, designed and realised products and services (output) operative; from this instant, the output is available and operative;
- alternative scenario and set of outputs to simulate; this set comprises products and services that are available at the end of activities; outputs are operative when all activities are completed; outputs can be simulated by applying a quantitative model; if the production function is known, a parametric method can be applied; if the production function is not known, a non-parametric method can be applied [12];
- IPP indicators and LFA outcomes and goals; this set includes:
  - indicators to measure the set of (direct) effects occurring after the start of operating outputs (simulated outcomes); these effects are shown from the instant at which outputs operate; outcomes can be estimated by

applying a set of simulation models or measured by applying a monitoring system; for transportation systems, ex ante evaluations of these indicators are obtained as a result by applying demand-supply interaction models, considering some parameters that represent external factors; simulated outcomes are verified and selected in identifying the final alternative scenario;

- indicators to measure the set of (indirect) effects occurring after the outcomes; the plan could contribute to pursuing goals; goals can be estimated by applying a set of impact functions or measured by applying a monitoring system (simulated goals); simulated goals are verified and selected in identifying the final alternative scenario.

To obtain a coherent vision between IPP and LFA two classes of activities are introduced: *exogenous activities and endogenous activities* (not explicit in LFA). *Exogenous activities* correspond to explicit LFA activities. They are a set of actions that transform inputs into outputs. These actions are performed exogenously to the planned system; for instance, in a transportation system, exogenous activities comprise the set of actions to plan and design a road infrastructure, in simulation phase, and a specific intervention (new road, new bus line, …) in its operative phase. Exogenous activities can be represented by means of production functions. Available inputs are associated to sets of variables (inputs to simulate) that feed production functions. Application of these functions, given external factors represented by a set of parameters, generates a set of variables that represent simulated outputs. These outputs are verified and selected to obtain final outputs. The set of final outputs constitutes the final planned scenario.

Endogenous activities correspond to the activities that the system develops internally to shift from one equilibrium point to another. The LFA method does not explicitly consider internal system evolution after modification to a specific element. LFA is conceived and implemented generally to construct and manage individual schemes, often in less developed areas, such as schools and wells. In the case proposed in this paper, we consider the realisation of more than one intervention. The entire system is thus modified and a linear relationship between outputs and outcomes is not available. Hence we need to adopt a specific model to examine activities connected to the modification of the system: we define *endogenous activities* as the classes of activities that are produced in the system as a chain reaction. It is possible to distinguish:

- endogenous activities connected to system evolution from outputs to outcomes; in this set we can include internal interactions that, considering relative external factors, include a set of factors that condition system evolution from the instant when products and services (outputs) are available at the end of exogenous activities and from which internal effects are generated (outcomes); for instance, in transportation system, such endogenous activities include the set of factors that influence mode choice after construction of a new road network or, quite simply, a route of a new bus line;

- endogenous activities connected to system evolution from outcomes to goals; this set includes activities that influence system evolution after the manifestation of internal effects (outcomes) until external effects are shown (goals); for instance, in a transportation system, these endogenous activities include the set of factors that influence impacts on the environment after road infrastructure travel choices or bus service users.

The proposed scheme (Figure 1) is similar to the LFA scheme, with explicit introduction of endogenous activities.

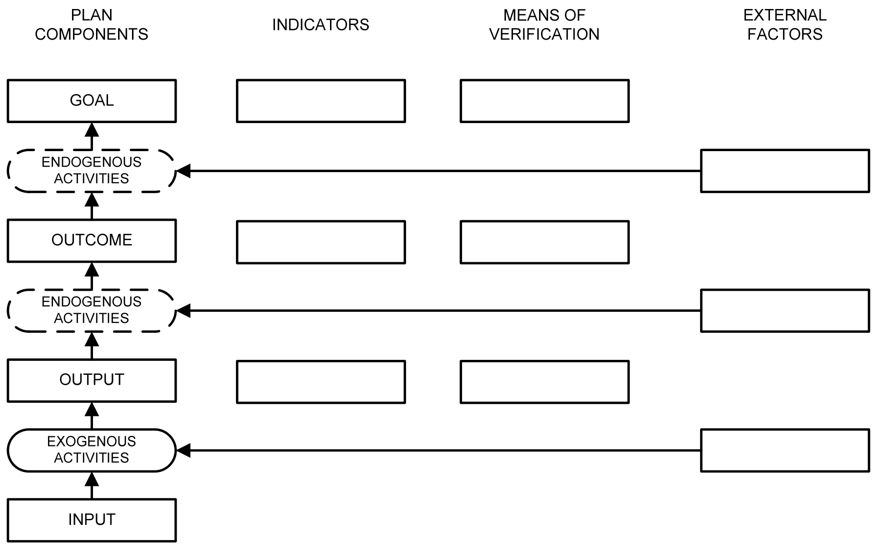

Figure 1: LFA process with explicit introduction of activities

Endogenous activities, from outputs to outcomes, in transportation planning can be analysed by means of demand-supply interaction models. Final outputs are associated to a set of variables (outputs to simulate) that feed interaction models. Application of these models, considering external factors, represented by a set of parameters, generates a set of results that represent simulated outcomes. For instance, in evacuation planning a set of models can be applied to simulate transportation system evolution in emergency conditions [13–15], with specific advances vis-à-vis different models [16–20]. These outcomes are subjected to a set of verification procedures which, if satisfied, generate final outcomes.

Endogenous activities, from outcomes to goals, in transportation planning can be identified through impact function models. Final outcomes are associated to a set of variables (outcomes to simulate) that feed impact functions. Application of these models, considering external factors represented by a set of parameters, generates simulated goals. These goals are subjected to a set of verification procedures which, if satisfied, generate final goals. In Figure 2 a coherent vision of IPP and LFA is represented. The proposed scheme is similar to IPP with the introduction of outputs, goals and external factors.

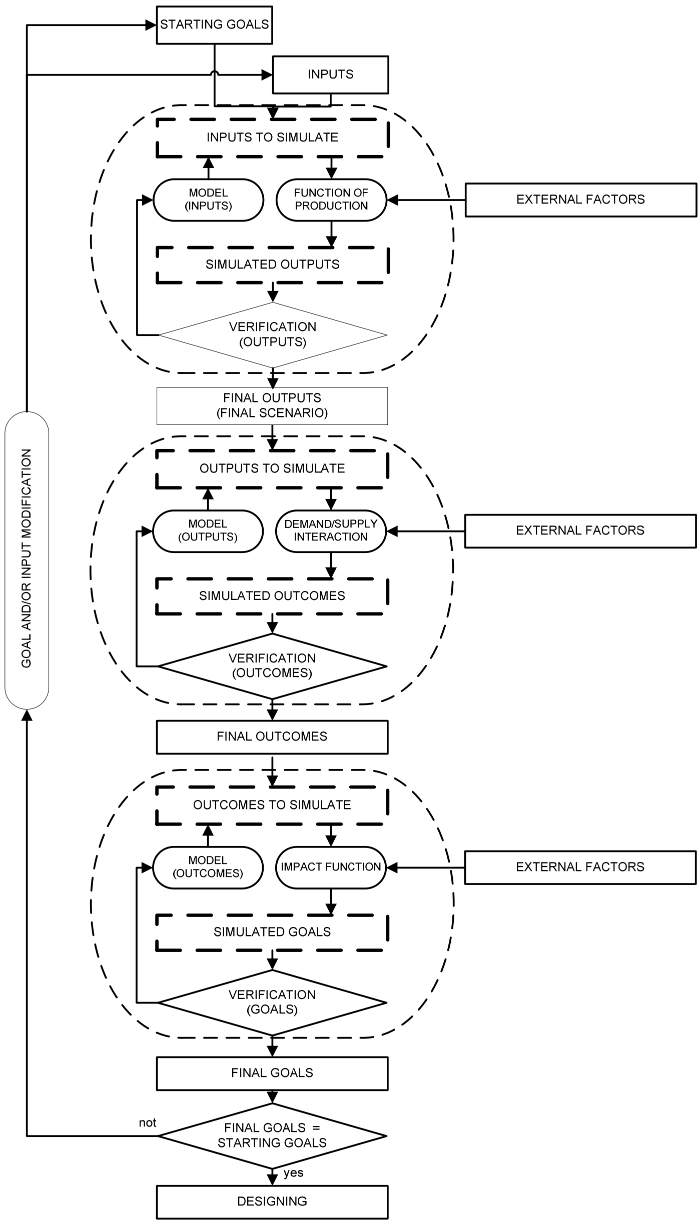

Figure 2: IPP process with explicit introduction of LFA elements.

4 Exemplification of IPP and LFA coherent vision

The coherent vision of IPP and LFA can be represented by referring to a real case: an evacuation plan of a school, with regard to transportation activities of students from school buildings to a safe area.

The following hypotheses are introduced: only one bus is available; there is only one alternative route for the bus line itinerary; the number of students to evacuate is obtained by applying a demand model specified and calibrated for an urban area in evacuation conditions [17, 21], equal to D = 100 users; a useful time interval to complete evacuation, measured from the instant at which the first run starts until the start of disastrous effects, is 50 minutes.

Plan elements are:

- *initial goals* corresponding to conclusion of evacuation in the useful time interval; time is measured from the instant in which the first run starts ($t_0 = 0$) until the instant when evacuation has to be concluded ($t_f = 50$ minutes);
- *inputs (resources)* consist of only one available bus with a capacity (C) of 30 seats and only one driver;
- *exogenous activities* are,
  - definition of the itinerary from school buildings to refuge area and relative operative variables (frequency, φ; round trip time, T_g); round trip time is assumed about 15 minutes and service is regular. Hence the formula:

$$\varphi = 1 / T_g = 4 \text{ runs / hour}$$

  - measures the number of runs to transfer all students; neglecting operative costs, the number of runs (R) needed can be obtained:

$$R = \text{int}\,(D/C + 0.5)$$

  - training for drivers as well as teaching and non-teaching staff to support evacuation operations,
  - training for students concerning rules for behaviour during evacuation,
  - definition of procedures for information exchange between the control centre and drivers and staff,

- *outputs,* considering constraints, can be measured in terms of maximum feasible number of runs (R) and maximum number of passengers (D_{max}),

$$R = 4 \text{ runs}$$
$$D_{max} = \varphi * C = 120 \text{ users / hour}$$

- *endogenous activities* for the evolving system from outputs to outcomes can be represented by applying a supply-demand interaction which, in this case, is deterministic; from application of the model, run flows can be obtained (f_1, f_2, f_3, f_4); to represent in a disaggregate form transport service performance in evacuation conditions, specific models can be applied [18, 22]; to consider interaction with private cars and the need to introduce signal settings at the intersections other specific models are required [19, 20];

- *outcomes* are measured by the number of users in each run (f_1 = 30, f_2 = 30, f_3 = 30, f_4 = 10); in the considered case the first three runs transfer 90 students ($f_1 + f_2 + f_3$), the last run transfers the remaining 10 students (f_4);
- *endogenous activities* for the evolving system from outcomes to outputs can be represented by applying a discrete exposure function, that is defined in terms of the number of students to evacuate at the end of each run (E_1, E_2, E_3, E_4);
- *goals* are measured by the reduction in exposure; in our case, exposure is measured in terms of students to evacuate:

$$E_i = E_{i-1} - f_i \qquad i = 1, \ldots 4$$

where

E_i is the number of students being evacuated at the end of each generic run i;

f_i is the number of students evacuated by generic run i.

For the first run $E_0 = D$

Goal indicators are summarised in tab. 1.

Table 1: Summary of goal indicator values.

t_i	f_i	E_i
$t_0 = 0$	-	$E_0 = 100$
$t_1 = 15$	$f_1 = 30$	$E_1 = E_0 - f_1 = 70$
$t_2 = 30$	$f_2 = 30$	$E_2 = E_1 - f_2 = 40$
$t_3 = 45$	$f_3 = 30$	$E_3 = E_2 - f_3 = 10$
$t_4 = 60$	$f_4 = 10$	$E_4 = E_3 - f_4 = 0$

With the available resources, the time needed to perform the four runs is greater than the useful time interval to complete evacuation. In particular, the students to evacuate from instant t_3 and instant t_4 could be affected by the effects of the disastrous event. Final goals are thus different from initial goals. Another bus and another driver have to be acquired. Indeed, if the available resources are doubled, the frequency and time required to complete evacuation are halved.

5 Final considerations

In the literature the Internal Planning Process is represented in various forms. LFA allows processes to be represented in standard form. In this paper we proposed a coherent vision to represent IPP and LFA in a standard version. Hence several elements were explicitly represented: some IPP elements by means of production functions (from resources to products and services), supply-demand interaction models (from products and services to direct effects) and impact functions (from direct effects to indirect effects); some LFA elements by introducing exogenous and endogenous activities.

www.witpress.com, ISSN 1743-3509 (on-line)

Using this coherent approach it is possible to represent, ex ante, all plan elements in a standard way. Planning variables can be controlled during implementation and, ex post, can be verified after planning actions have become operative. The approach allows comparison between alternative scenarios of the same plan or different plans referring to various area contexts. Future developments in this research topic will concern analysis and representation of stakeholders and mutual interactions.

References

[1] Russo F. & Rindone C., Safety of users in road evacuation: planning internal processes and guidelines. *Proc. of Urban Transport XIII, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 825-834, 2007.

[2] Russo F. & Vitetta A., Risk evaluation in a transportation system. *International Journal of Sustainable Development and Planning*, 1 (2), pp. 170-191, 2006.

[3] Russo F. & Rindone C., Safety of users in road evacuation: planning internal processes and guidelines, *Urban Transport: Safety of Users in Road Evacuation*, Russo F. (ed.), WIT Press, 2007.

[4] White House, Office of Management and Budget (1993), "Government Performance Results Act of 1993", http:// www.whitehouse.gov/ omb/ mgmt-gpra/ gplaw2m.html#h1 (October 2007).

[5] European Commission (2004), "Project Cycle Management" http://ec.europa.eu/europeaid/multimedia/publications/publications/manuals-tools/t101_en.htm (February 2009).

[6] Australian Government – AusAID (2005) "AusGuide – A Guide to Program Management" http://www.ausaid.gov.au/ausguide/ (October 2007).

[7] Russo F. & Rindone C., Safety of users in road evacuation: the logical framework approach in evacuation planning. *Proc. of Urban Transport XIV, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 751-760, 2008.

[8] Russo F. & Rindone C., Safety of users in road evacuation: Modelling and DSS for LFA in the planning process. *Proc. of Sustainable Development and Planning IV, vol.1*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 453-464, 2009.

[9] Russo F. & Chilà G., Safety of users in road evacuation: Modelling and DSS for demand. *Proc. of Sustainable Development and Planning IV, vol.1*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 465-474, 2009.

[10] Vitetta A., Musolino G. & Marcianò F.A., Safety of users in road evacuation: Modelling and DSS for transport supply and supply-demand interaction. *Proc. of Sustainable Development and Planning IV, vol.1*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 475-484, 2009.

[11] Vitetta A., Quattrone A. & Polimeni A., Safety of users in road evacuation: Modelling and DSS for paths design of emergency vehicles, *Proc. of*

Sustainable Development and Planning IV, vol.1, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 485-495, 2009.

[12] Russo F. & Rindone C., Evaluation methods for evacuation planning. *Proc. of Urban Transport XVI, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 335-343, 2010.

[13] Russo F. & Chilà G., Safety of users in road evacuation: demand models. *Proc. of Urban Transport XIII, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 773-782, 2007.

[14] Vitetta A., Musolino G. & Marcianò F.A., Safety of users in road evacuation: Supply and demand-supply interaction models for users. *Proc. of Urban Transport XIII, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 783-792, 2007.

[15] Vitetta A., Quattrone A. & Polimeni A., Safety of users in road evacuation: design of path choice models for emergency vehicles. *Proc. of Urban Transport XIII, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 803-812, 2007.

[16] Russo F. & Chilà G., Safety of users in road evacuation: RP vs. SP surveys in demand analysis. *Proc. of Urban Transport XIV, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 703-713, 2008.

[17] Vitetta A., Musolino G. & Marcianò F. A., Safety of users in road evacuation: calibration of cost functions and simulation. *Proc. of Urban Transport XIV, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 715-725, 2008.

[18] Vitetta A., Quattrone A. & Polimeni A., Safety of users in road evacuation: algorithms for path design of emergency vehicles, *Proc. of Urban Transport XIV, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 727-737, 2008.

[19] Vitetta A., Musolino G. & Marcianò F. A., A system of models for signal setting design of a signalized road network in evacuation conditions. *Proc. of Urban Transport XVI, Urban Transport and the Environment in the 21st century*, Brebbia C.A. (ed.), WIT Press, Southampton, pp. 313-323, 2010.

[20] Marcianò F.A., Musolino G. & Vitetta A., Signal setting design on a road network: application of a system of models in evacuation conditions. *Proc. of Seventh International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation*, Brebbia C.A. (ed.), WIT Press, Southampton, 2010.

[21] Russo F. & Chilà G., A sequential dynamic choice model to simulate demand evacuation. *Proc. of Seventh International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation*, Brebbia C.A. (ed.), WIT Press, Southampton, 2010.

[22] Polimeni A., Quattrone A. & Vitetta A., An approach to design vehicle routes in evacuation conditions, *Proc. of Seventh International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation*, Brebbia C.A. (ed.), WIT Press, Southampton, 2010.