

# Study on Project Planning and Management System of New Transit Construction Based on Systems Approach

Ritsumeikan University  
Ritsumeikan University

○Xuepeng QIAN<sup>\*1</sup>  
Mamoru HARUNA<sup>\*2</sup>

The Otsu-Konan Region in the Shiga-prefecture has been a remarkably developed region in Japan during the last decades, since the accessibility is well provided where the trunk lines are concentrated in the region. However, the feeder transportation network has been poor in connecting terminals of trunk lines and the suburban areas where the large residential districts, lots of factories and universities produce large transportation demand. Based on the understandings above stated on the urbanizing situation, such a project of new transit system can evoke more attractive development in this region as is analyzed in following study. In the article, the project planning and management system of the new transit construction is proposed, which is concluded based on systems approach. Corresponding to the research flow, the system includes survey, land use, concept of management system for activation, forecasting and behavior analysis, simulation of social behaviors, planning setting, experiment of behavior simulation, formula of the planning problems, risk analysis and the feasibility study and financial evaluation in order. Hybrid analysis is also embedded in the system to search the optimal design. Through the case study, the system has shown the effectiveness and efficiency in supporting the initial stage of the new transit construction project.

*Keywords: Planning, Management system, Systems Approach*

## 1. Background

Kusatsu City and Otsu City are located in Shiga Prefecture, with a total population of about 460 thousand, and yearly visitors over 1.5 million. The region has been one of the remarkably developed regions in Japan during the last decades, since the accessibility is well provided where the trunk lines are concentrated there. However, the feeder transportation network has been poor in connecting terminals of trunk lines and the suburban areas where the large residential districts, lots of factories and universities produce large transportation demand. Based on the understandings above stated on the urbanizing situation, such a project of new transit system can evoke more attractive development in this region. To operate the project effectively and efficiently, the construction management system must be well prepared, which includes from the

planning to construction and even the operation process.

## 2. Literature Review

Systems approach, in its broadest sense, is the interdisciplinary study of organization within the context of a definitive system. More specifically, it is a framework by which one can analyze and/or describe any group of objects that work in concert to produce some result. This could be a single organism, any organization or society, or any electro-mechanical, or informational artifact. While systems concepts had long been used in sociology and the area is often associated with cybernetics, systems approach as a technical and general academic area of study predominantly refers to the science of systems that resulted from Bertalanffy's General System Theory (GST)<sup>1)</sup>.

Evidently, there are many types of systems that can be analyzed both quantitatively and qualitatively. For example, with an analysis of urban systems dynamics, Steiss (1967)<sup>2)</sup> defines five intersecting systems, including the physical subsystem and behavioral system.

<sup>\*1</sup>Graduate School of Science and Engineering,  
Ritsumeikan University Tel: 077-561-2736

<sup>\*2</sup>Department of Environmental System Engineering,  
Ritsumeikan University Tel: 077-561-2736

Important distinctions have been made between hard and soft systems. Hard systems are associated with areas such as systems engineering, operations research and quantitative systems analysis. Soft systems are commonly associated with concepts developed by Checkland through Soft Systems Methodology (SSM) involving methods such as behavior research and emphasizing participatory designs. Where hard systems might be identified as more "scientific," the distinction between them is actually often hard to define. The systems approach integrates the analytic and the synthetic method, encompassing both holism and reductionism. The systems approach is a problem-solving method which helps to:

1. Define the problem as clearly as possible.
2. Analyse the problem and identify alternative solutions.
3. Select from the alternatives and develop the most viable solution mix.
4. Implement and test the solution.
5. Evaluate the effectiveness and worth of the solution.

The following study focuses the establishment of the planning and management system of the new transit construction project based on systems approach.

### 3. Project Planning and Management System

The planning starts from analyzing the conditions, including social-economical, natural condition and so on. Besides those intuitionistic data, it is becoming more and more important to grasp the characteristics of people's behaviors and their needs through marketing skills and even the social psychology application. Secondly, simulation of the current condition is regarded as one of the requirements to utilize systems approach, which should represent the phenomena rationally. After that, the planning can be forwarded to the planning stage: to define the subject, object, reasonable aims, to prepare the alternatives and so on. The last stage is to evaluate the planning alternatives. Feedback is necessary to improve and attain the final plan. The flow is shown in Figure 1.

Corresponding to the flow, the framework of planning and management system is shown in the breakdown tree figure of Figure 2, and includes survey, land use, concept of management system for activation, forecasting and behavior analysis, simulation of social behaviors, planning setting, experiment of behavior simulation, formula of the

planning problems, risk analysis and the feasibility study and financial evaluation in order.

In the first part of the study, social needs of inhabitants and communities were analyzed by introducing social psychological analysis approach. Daily behaviors such as person trips are surveyed to build up the passengers' behavior simulation model. In the second part designs and planning of the new transit system are studied mainly focusing from the functional planning aspects in relation with visiting and consuming behaviors in the experiments of "passengers' behavior simulation". In the third part based on output information from these experiments, forecasting model and new transit project financial model are combined into one planning system through the project designs. This hybrid planning analysis is applied to obtain the optimal project design which can maximize the passengers' satisfaction which is measured by utility function to each passenger under the constraints for attaining the feasibility of the new transit project. In the research, verification studies to confirm the effectiveness and efficiency of systems approach method developed here are implemented for the new transit construction project which is proposed in this region.

### 4. Embedded Hybrid Analysis and Case Study

Generally speaking, planning is a process of searching optimal solution in response to the requirements. In most cases of planning problems, several alternatives are given and evaluated to choose the best as the proposal. And design of experiment is applied widely in design the combination of limited planning variables of several levels. However, those methods lack of the continuous operation of searching. Hybrid planning analysis is promoted to improve this situation and it is also embedded in the planning and management system proposed in the study.

In the past study, the effective and practical hybrid model analysis method for planning and designing traffic facility was developed by Yamada, K. & Haruna, M.<sup>3)</sup> and Haruna, M. etc.<sup>4)</sup> to release the traffic congestion caused by visitors to large scale shopping center in the district around the shopping center. The effect of each planning alternatives in each stage will be simulated and they will be feedback to the optimization model to tell us how to modify the plan. The simulation model and optimization model, or evaluation model can be incorporated into such a hybrid and cycle mechanism.

In this study, the hybrid planning analysis is applied to search and realize the optimal project design of the new transit construction (see Figure 3), which is the advanced study of Qian X. and Haruna M. (2006)<sup>4)</sup>. The hybrid analysis realizes the feedback function of the research flow. The hybrid planning system combines the passenger forecasting and the financial simulation model. It has some characteristics:

Firstly, hybrid planning system is a group of connected models or sub-systems, where information can be smoothly cycled inside and communicated with outside.

Secondly, the system is a dynamic system, where elements inside the system are interactive and one change will cause the changes in series. The change of project design will cause the change in both sub systems.

In this study, when the initial project planning is decided, the number of new transit passengers is calculated. And in the searching process, the initial project design will be changed and the new output of the number of passengers is to be recorded. If the number increases, that proves the modification of project design is positive. Following the direction, the next modification will be done and the change of the number of passengers will be observed. The step-wise searching will stop when the number of passengers starts to decrease, or when the constraints can not be satisfied.

In this model, the objective of the plan is to maximize the utility functions of new transit mode. The utility functions are concluded based on the preference of passengers, can be regarded as the measurement of passengers' satisfaction when they use new transit. The maximization of the utility can be regarded the satisfaction of passengers.

The utility functions are also used in the multinomial logit model to forecast the number of the passengers. The assumption is that the attributes of other transportation modes do not change with the change of new transit project design. So the maximization of the utility of new transit mode is the same as the maximization of the proportion of new transit mode. Then the number of passengers reaches the peak point.

The financial simulation model shows the capital and cash flow in construction, maintenance, management and operation and the refund process. Since the income from tickets contributes about 95% of the income of new transit project, which will be influenced greatly by the number of

the passengers concluded in the forecasting model. The project planning will change the number of passengers, and at the same time, change the financial situation. The interactive mechanism provides more information in searching the optimal project design. Finally the station construction, as the physical factors in construction and the fare system, as the soft factors in management are concluded by the system.

## 5. Conclusion

The project planning and management system based on systems approach is described in the article through the case study of the new transit construction project. The system is to be improved in several aspects. Firstly, as the project goes on, the system can get more information about the construction, which helps to enhance the accuracy of the system, especially the simulation models. Secondly, more factors can be involved in the hybrid analysis besides the financial factors, such as construction limitation and so on. Finally, there is still a lot of work about the optimization and its algorithms, which can show the advantage of the systems approach methods.

## Reference

- 1) Bertalanffy, L. von.: "An Outline of General Systems Theory." *British Journal for the Philosophy of Science*, Vol. 1, No. 2., 1950
- 2) Steiss, A.W.: *Urban Systems Dynamics*. Toronto: Lexington Books, 1967
- 3) Yamada, K. & Haruna, M.: *A Hybrid Planning Model Analysis for Traffic Facility Planning and Design Method*, Civil and Environmental Engineering Conference Volume4 , The Asian Institute of Technology, pp.V47-V56, 1999
- 4) Haruna, M., Takebayashi, M., Yamada, K., Nakagawa, H.: *A Study on Systems Approach to Transportation Management Problem for Desirable Urban Development Applying Hybrid Planning Model Analysis*. *Proceedings of Infrastructure Planning JSCE*, p.305-308, 2000
- 5) Qian, X. and Haruna, M.: *Planning Analysis of New Transit System Project in Local Cities to Realize Transit-Oriented Development*, *The Proceedings of the 24rd Annual Forum on Construction Management Issues*, CD-ROM, 2006

Appendix: Figures

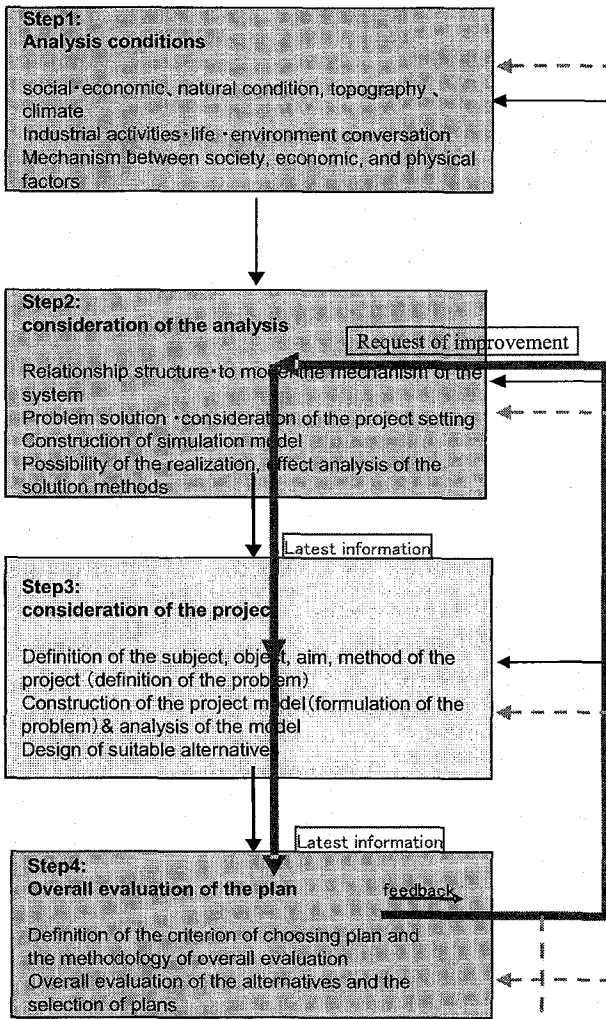


Figure 1 Step-wise Planning Flow

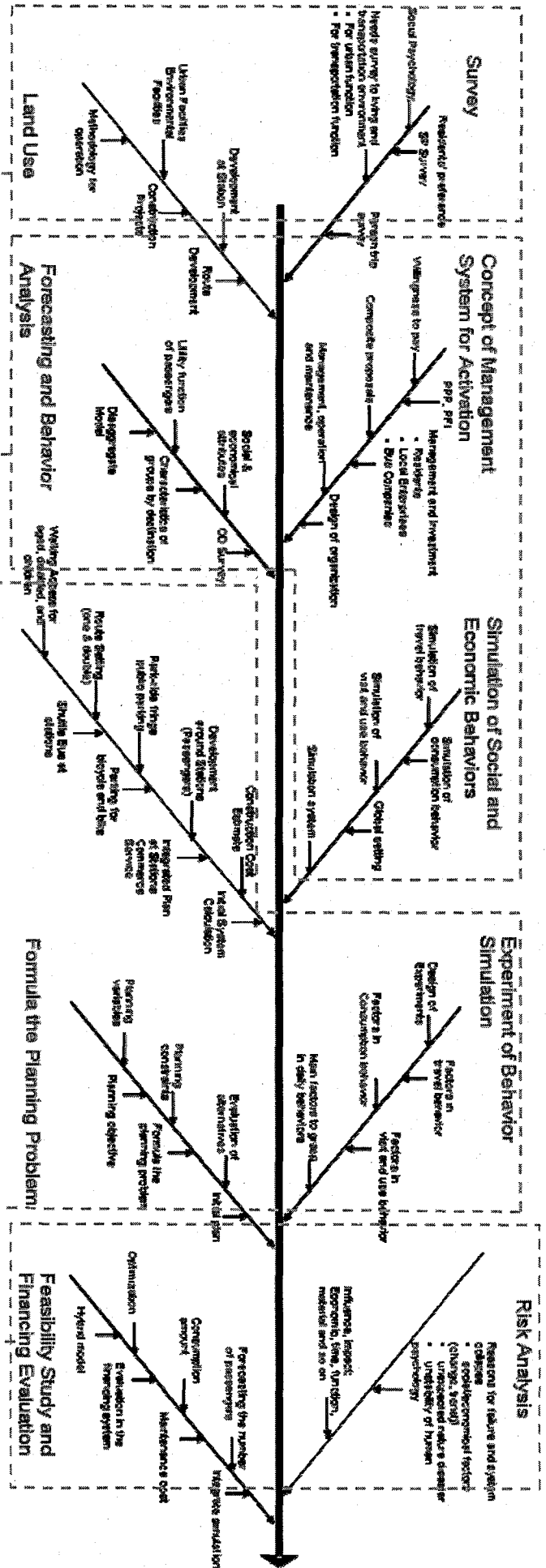


Figure 2 Breakdown Tree Figure of the System

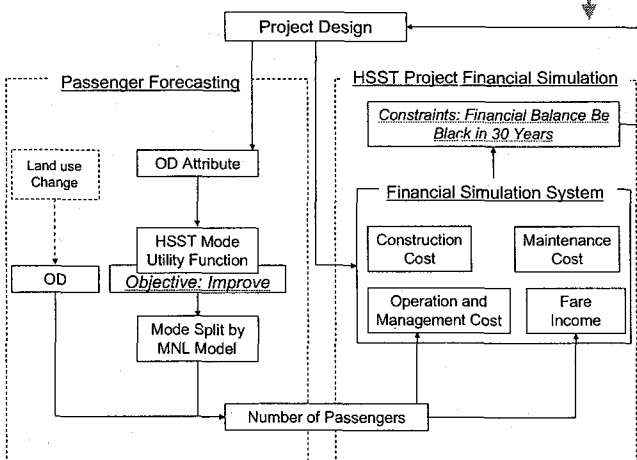


Figure 3 Hybrid Analysis in the Case Study