A Group Model Building Process to Integrate Land Use, Transportation, and Air Quality Planning in Las Vegas, Nevada

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Abstract
This paper uses the framework proposed by Rouwette et al. (2002) to describe the group model building stage of a project to integrate land use, transportation and air quality planning in a rapidly growing metropolitan area. The paper has two purposes: compare this case with the findings of Rouwette et al. (2002), and test the framework for reporting about group model building interventions. Group modeling was used in this intervention for problem definition, causal diagramming, and quantification of "fuzzy" relationships between variables. Quantification was done "behind the scenes" by the consultants. Model development took 18 months. The case supports the findings of Rouwette et al. (2002) that show a strong connection between group model building and client learning about the problem. Consensus about the problem and commitment to the modeling approach also increased. The context–mechanism–outcome framework was useful for organizing information about the case, although some of the variables need to be defined more clearly.

Keywords
group model building, urban dynamics, urban growth, land use planning, public agencies

Introduction

One of the first decisions at the start of a system dynamics problem solving project is how, in general, to approach the project. Should a quantitative or a qualitative model be developed? How extensive should the data collection be? Should the model be developed primarily by the expert modelers, or should the clients be involved in model development? Each of these questions deserves its own paper; here we are concerned about what happens once you decide to proceed down the group model building path. As several authors have pointed out, we don't have a very good understanding of what makes group model building projects effective or not. The editors of special issue of the *System Dynamics Review* in 1997 (Volume 13, Number 2) described building models with client groups as "...still more art than science" (Vennix *et al.* 1997:103). Articles in the issue proposed both procedures for standardizing the practice of group model building and methods for extracting general principles from such exercises. More recently, Rouwette *et al.* (2002) conducted

a meta-analysis of 107 group model building cases. While they were able to make some preliminary general statements from the analysis, they concluded that the diversity in the way projects were described and evaluated made detailed conclusions difficult. They proposed a framework for reporting to help standardize knowledge in the field and improve our understanding of what factors contribute to the success or failure of such interventions.

In this paper, we use the proposed framework to examine an ongoing group model building intervention that began in early 2004 and will continue until early 2006. In part, this contribution is motivated by our own sense that we are still groping in the dark and proceeding by trial and error in our own group model building projects. We would have liked more guidance when we began, so we're hoping to help others in the same position with our experiences.

The case study

In early 2004, we began working with the Southern Nevada Regional Planning Coalition (SNRPC) on a two-year project to develop a system dynamics model to support integrated planning and build long-term capacity for interagency and intergovernmental collaboration. The purpose of the project is to improve the ability of resource managers in the Las Vegas metropolitan area to integrate land use, air quality and transportation management by developing and facilitating the use of a computer simulation model for decision-making.

The project was motivated by the SNRPC's charge to develop a regional policy plan for sustainable development and by noticeable decreases in quality of life indicators in the region. For the past couple of decades, annual growth has held steady at around 6.5 percent. Population doubled from just under 800,000 people in 1990 to just under 1.6 million people in 2004. In 2001, a new home was completed in Las Vegas every 15 minutes. The region is contending with worsening traffic congestion, increasing commute times, and visibly degraded air quality. In spite of these consequences, population growth is still seen as the engine that drives economic prosperity, so elected officials are wary of making policy suggestions that might slow population growth.

Two key obstacles to regional planning are a strong pressure for local autonomy and the lack of a mechanism for integrating resource management in the region. The Las Vegas metropolitan area consists of five governmental entities, each with its own planning staff and governance structure. In addition, regional services such as transportation, air quality, and water are managed by separate county-wide agencies, which are overseen by the governmental entities. There is no structure for integrating planning across agencies and limited coordination of land use planning among entities. In spite of, or perhaps because of this, it was the land use managers and resource managers who pushed for a system dynamics approach to regional planning.

The SNRPC is a body of elected officials from the five governmental entities. It was established in 1999 by State legislation requiring communities in the Las Vegas Valley to produce a regional policy plan. Based on a successful group modeling building project in 2001 with the transportation agency (Stave 2002), we were invited to help the SNRPC meet its charge. The SNRPC delegated planning

staff and agency experts to work with us. This became the Land Use, Transportation, and Air Quality (LUTAQ) working group.

A group model building approach was chosen because of the large number and diversity of stakeholders and because a key goal of the project was to build capacity for long-term collaboration among the participants.

The reporting framework

Rouwette *et al.* (2002) propose a framework of context–mechanism–outcome (based on Pawson and Tilley 1997) to describe a group model building intervention. Context describes factors largely outside the consultant's control such as characteristics of the organization and problem. Mechanism describes the characteristics of the intervention, and outcome describes its effects. They drew several preliminary insights from their analysis, but concluded that the diversity in the way projects were described and evaluated made detailed conclusions difficult. They proposed the following framework of context–mechanism–outcome to help standardize what is reported and allow better comparison of cases.

CONTEXT: factors outside consultant's control

Context includes geographical descriptors, characteristics of the organization, and characteristics of the problem.

In addition, the 107 cases they reviewed were divided into three broad types:
-- demonstration or training situations
-- situations involving conflict and intangibility of the problem
-- situations that are data rich with a more tangible problem

MECHANISM: characteristics of the intervention

Mechanism describes the participants, meetings, modeling team, type of process, and steps in the process.

The cases fell into four categories of mechanism:
-- those not aimed at implementation
-- qualitative models
-- small quantitative models (< 50 elements)
-- large quantitative models (> 50 elements)

OUTCOME: effects of the intervention

Outcomes were identified as:
-- Insight or learning about the problem
-- Commitment to implementing the results or continuing to use the method
-- Behavioral changes
-- Communication improvements among participants
-- Consensus
-- System changes
-- Implementation of results

Outcomes can be measured at the individual, group, organization, or method level.

Application of the framework to this case

CONTEXT: involves conflict and intangibility of problem

The SNRPC is a public sector organization with a network structure located in Las Vegas, NV. The SNRPC Board is composed of 11 elected officials who represent multiple government entities. While they acknowledge the importance of collaboration, they also prize their political autonomy and compete to some extent for a variety of resources. A group of 15 planning directors of the governmental entities and managers of resource agencies report to the SNRPC members, and, in turn, each supervise the staff of their own organizations. The 20 members of the modeling group – the LUTAQ working group -- were upper level staff members of the entity planning departments and agencies. Figure 1 shows the relationship of these three levels.

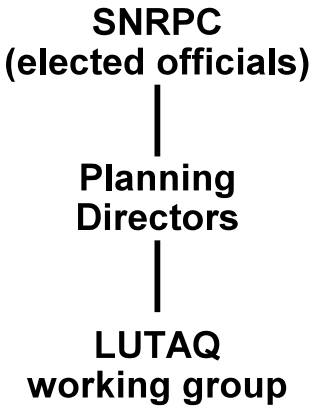


Figure 1. Hierarchy of client groups.

Although the context was politically charged, access to information for developing the model was not limited.

The consequences of not addressing the problem of traffic congestion and air quality degradation on a regional basis are potentially dire. However, the focus of elected officials has been primarily on economic growth. Public awareness and concern about traffic and air quality has been growing, but understanding of the connections between these factors and the economy is low.

MECHANISM: large quantitative model

The model development phase of this project took 18 months and relied heavily on client participation. As noted above, the 20 members of the LUTAQ working group were upper level staff members of the entity planning departments and agencies. They were drawn from different disciplines and included land use planners, air quality modelers, and transportation planners. Group model building was used for problem definition, causal loop diagramming, and quantification of certain "fuzzy" relationships between variables. Group members also contributed to model parameterization. Quantification was done "behind the scenes" by the consultants. A key feature of the process was that the working group developed the presentation of the model to the SNRPC Board.

Over the 18 months, the LUTAQ working group met 32 times. Each meeting lasted approximately 2 hours. The model development phase included:

5 months of facilitated discussions to elicit participant mental models of problem characteristics and project goal.
4 months developing causal loop diagrams refining the structure.
2 months "behind the scenes" for UNLV team to develop initial stock and flow structure.
3 months with group revising structure, setting parameters, developing lookup relationships
2 months using the model and discussing policy options
2 months facilitating group development of presentation for SNRPC board

18 months total

The model itself is classified as a large quantitative model according to Rouwette *et al.*'s (2002) guidelines. It has 10 sectors and 349 variables. Figure 2 shows the high-level causal structure, and Figure 3 shows the model's user interface.

Figure 2. High-Level Causal Structure

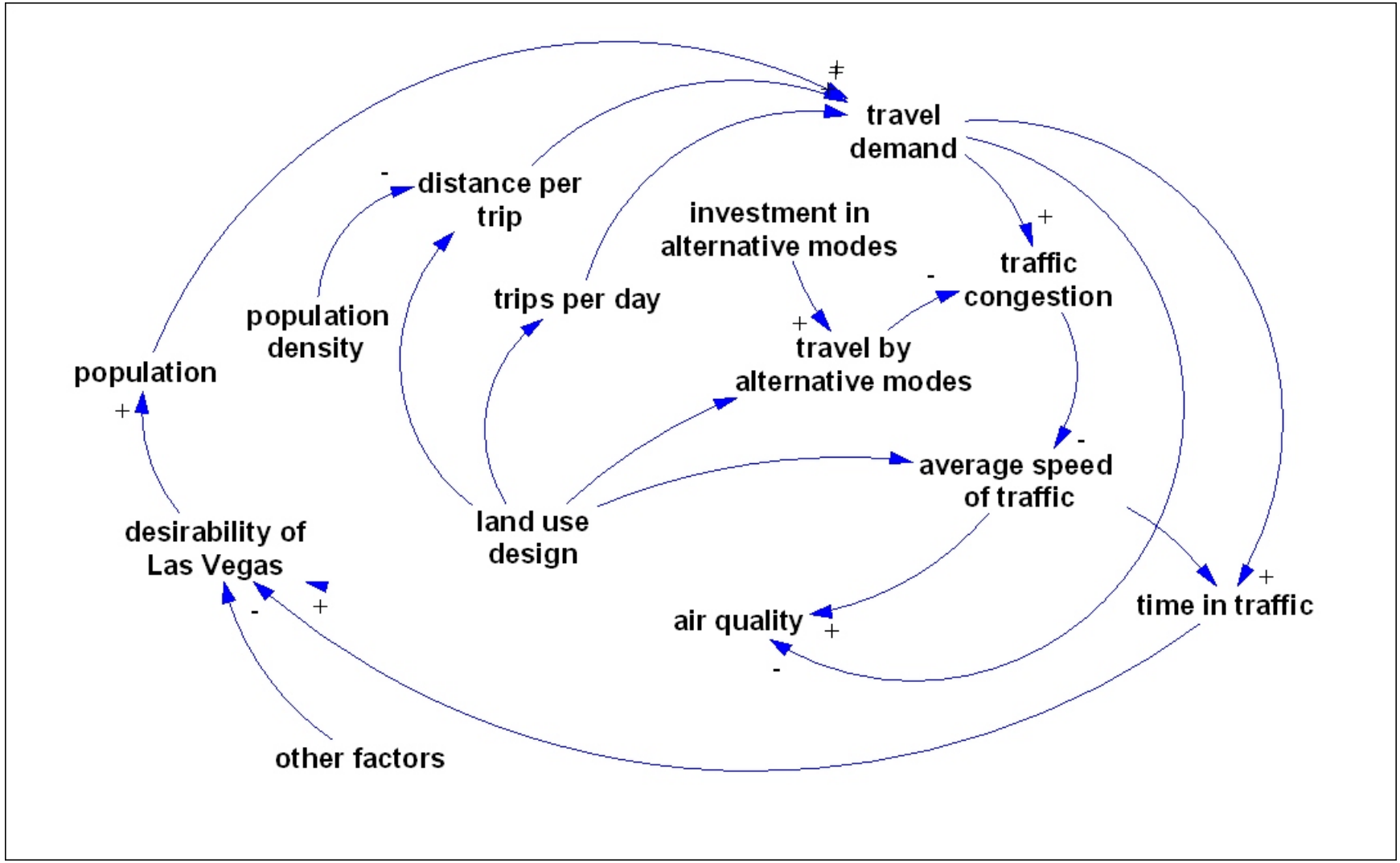
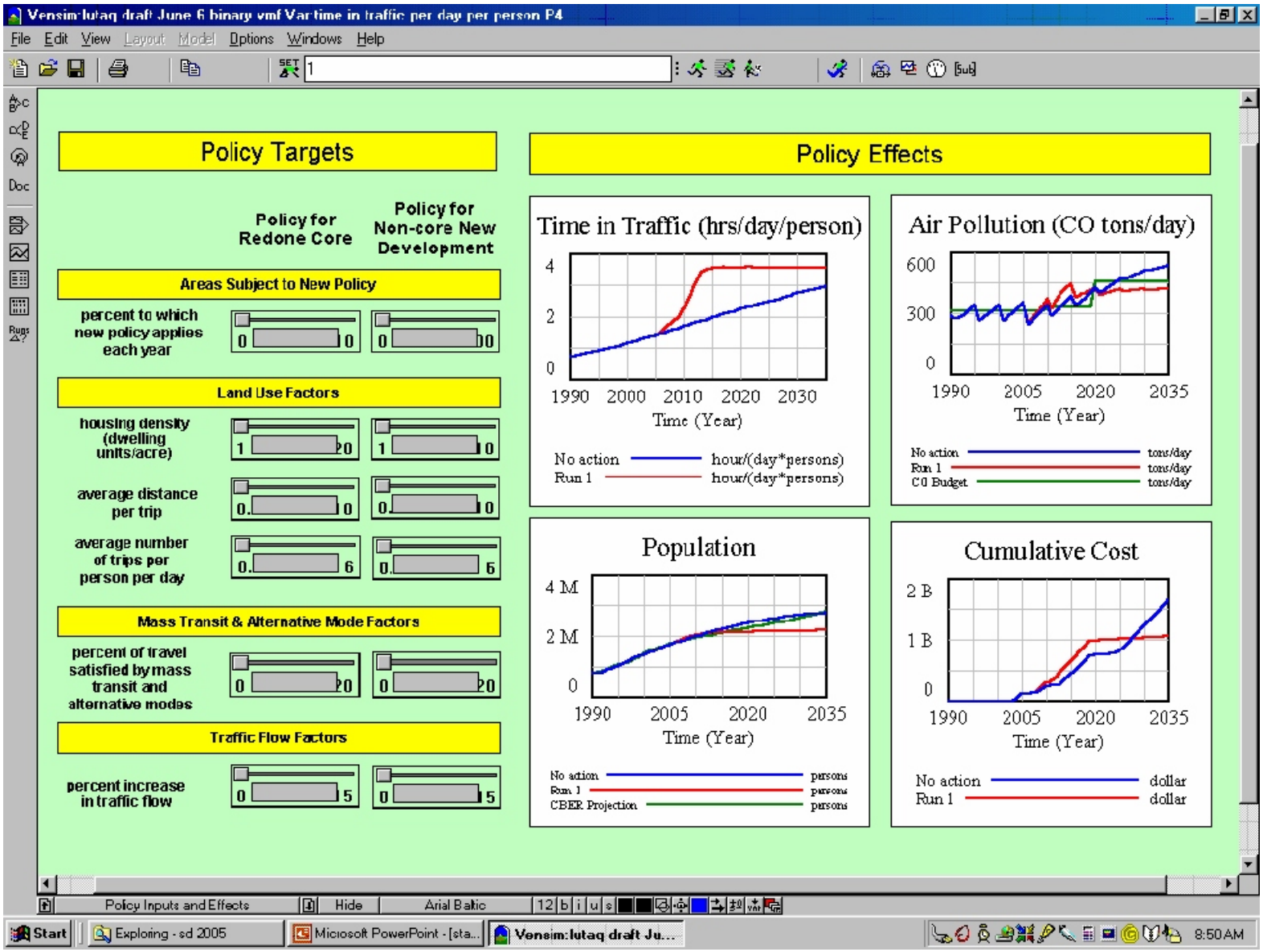


Figure 3. Model Interface



OUTCOME: insight, communication, consensus

The model has not yet been used by the SNRPC, the overall client for the project. However, the model and the modeling process has resulted in clear changes in perspective and new insights among working group members. Evidence of such changes include statements such as:

> "This shows that you can't simply do one thing, like increase residential density, and improve traffic congestion or air quality. You have to do a number of things all together."

> "This model is a worthwhile tool for communicating the issues to other people … and it's fun to use!"

In addition, the modeling project has led to two spin-off contracts from working group members for similar models to address more specific air quality issues. This suggests that the commitment of workgroup members to the modeling approach has increased. Finally, the workgroup has developed the presentation that will be used to deliver the model to the SNRPC Board. The presentation includes a description of system principles and an overview of the model structure, as well as preliminary insights about the system that are emerging from the use of the model. The workgroup took the lead in developing the presentation, demonstrating that they understand the principles of seeing the system as a whole and accounting for feedback. The case will be further analyzed for outcome after the next phase of the project, in which the model will be used for policy analysis.

Discussion

Rouwette *et al.* (2002) suggest that implementation of results and system improvement are primary goals of system dynamics interventions. In this project, however, even without implementation of the model, it is clear the workgroup members have developed a deeper understanding of the system and achieved some consensus about the problem and potential solutions. The case supports the findings that:

> -- there is a strong connection between group model building and learning
> -- it is hard to assess the effect of group model building on system change
> -- consensus and commitment of the group to the systems perspective increase

As Rouwette *et al.* (2002) found in their analysis, outcome is difficult to measure, and that is perhaps the area in which their proposed framework could be improved. We might consider developing some form of standardized questionnaires for evaluating changes in insight, commitment and consensus. In general, however, the context – mechanism – outcome framework provides a good structure for reporting about group model building interventions. Several details need to be strengthened, namely:

> -- we need clearer definitions of details about each of the variables
> -- we need more standardized ways to assess outcomes

-- we can't assume success is measured only by implementation of the results. The most lasting result may be a paradigm change

In addition, this case had two clients: the official client was the SNRPC and the unofficial client was the LUTAQ working group, representing the Planning Directors. That made it difficult to answer some of the questions or variables in the framework. One way to account for this would be to treat the entire project as two separate projects. The first would be the project to develop the model and the LUTAQ working group would be the client. The second would be the use of the model with the SNRPC being the client and LUTAQ members becoming part of the consultant modeling team.

Finally, compared with the previous group model building intervention with government advisory board in Las Vegas (Stave 2002), the model building group was much more removed from the ultimate client. Stave (2002:Table 1) shows the chronology of process and relationship of activities at the highest level of the client group, activities in the model building work group, and "behind the scenes". The chronology of this project was similar, but the relationship between the client group, the model building group and the "behind the scenes" work was different. This raises a question about whether recording the flow of events could be important, in addition to the suggested context-mechanism-outcome description.

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Appendix I
Applying the Framework to this Case

In this section, we attempted to use the variables suggested by Rouwette *et al.* (2002) to characterize this case. For variables we were not sure how to describe, we have marked our responses with (?). In addition to the variables suggested, we include a text description to expand on the characterization. We include this level of detail for illustration of the questions we had when trying to provide information for all suggested variables for the database.

Context

- **Geography**
  Continent: North America
  Country: United States
  City/State: Las Vegas, Nevada

- **Characteristics of the organization**

  Structure: (?) Network organization
  Type: governmental, regional planning
  Size: (?) SNRPC has 11 members, Planning Directors group has 20 members, LUTAQ working group has approximately 20 members, but all members represent much larger organizations affiliated with the project

This project has several client groups. Officially, the project client is the Southern Nevada Regional Planning Coalition (SNRPC), and the purpose of the intervention is to develop a regional planning strategy to address traffic congestion and air quality problems through land use policy. The SNRPC is made up primarily of elected officials. The SNRPC oversees the set of Planning Directors of each governmental entity in the region and the heads of each resource management agency. The members of the Planning Directors group are employees who are appointed by and answer to the city and county managers. For this project, the Planning Directors have assigned high-level members of their staffs to work with the modeling project. The LUTAQ working group members are the "group" participating directly in the group modeling.

In addition to supporting the work of the SNRPC, the LUTAQ working group members have their own goals for this project. LUTAQ members have commented often that they need a better way to communicate with elected officials, particularly about technical land use concepts.

- **Characteristics of the problem**

  Analytical:
  – Uniqueness of the situation
    (?) On the one hand, you could say the situation has never been confronted by the

organization because the SNRPC has not developed a regional plan before. On the other hand, you could say that the project purpose is the reason the organization exists.

– Consequentiality
  The consequences of not addressing the problems of growth on a regional basis in Las Vegas are potentially dire. However, it is not clear whether the clients, the SNRPC believe this to be true. Working group members do believe the consequences are great.
– Precursiveness
  The decision could potentially affect subsequent decisions to a great extent. Although the SNRPC does not have the authority to force government entities to conform to its policies, the members of the SNRPC have considerable political influence over the entities.
– Number and diversity of interests involved
  Types of interests: elected officials, planning managers, resource managers, planning staff
  Cross-cutting agendas: different jurisdictions
– Openness to alternatives
  While the decision has not already been made, per se, elected officials in Las Vegas are notoriously averse to doing anything that might reduce population growth.

Social:

– Pressure of influence
  (?) By whom, on whom?
– Intervention
  The external pressure that motivated this project is the pressure from the Nevada State Legislature to require Southern Nevada to develop a regional plan
– Imbalance
  The elected officials that comprise the SNRPC exert great influence over the Planning Directors and the LUTAQ working group members. Within the working group, however, influence appears to be balanced.
– Contention of objectives
  Working group members started out with different goals and problem perceptions based in the different jobs they do.

Mechanism

PRE-PROJECT ACTIVITIES

- **Initiation of contact**
  The client organization initiated contact.

- **Expectations and goals of project**
  Working group members started the project with very different expectations of what the model could and should do. Their expectations seemed to be correlated with their jobs and with their previous level of modeling experience. For example, the land use planners wanted the model to give a spatial output of how development should be done to meet transportation and air quality goals. Transportation and air quality modelers understood that the model would not be spatially distributed. In initial discussions, the majority of the group wanted the model to "show us what the best answer is". As the problem definition discussions progressed, the group became more unified around the idea that the model should "help us convince the elected officials to do the right thing." Thus the goals of the working group members were diverse at the beginning. After the first six months of problem definition, however, the goals of the group were unified around the goal of testing proposed land use strategies and policies. In this case "top management" can be considered in two ways. The managers of the LUTAQ workgroup were the Planning Directors and resource managers. They gave their full support to the group by assigning their staff to work on the work group. The true "top management" of this organization, however, is really the SNRPC. The SNRPC has given its support in the form of funding, but has largely remained outside the model development process.

- **Type of question addressed**
  The type of question is ostensibly an exploratory one: What will the effect of a given land use and transportation policy package be on transportation, air quality and other quality of life factors? However, some working group members have expressed an interest in a more prescriptive outcome, that is, that they would like the model to "show" the SNRPC what it should do.

- **Composition of participating (management) client modeling team**
  The LUTAQ working group is the client modeling team. It consists of approximately 20 members who are land use planners, and air quality and transportation modelers. Attendance at the workgroup meetings has varied from 5 members to 20 members. A core group of 5-6 people has attended almost every meeting.

- **Consultant modeling team**
  The consultant (UNLV) modeling team consists of two people, the authors of this paper. They have alternated roles throughout the process.

MODEL BUILDING MEETINGS

- **Meetings and time investment**

  Number and duration of meetings
  The workgroup met 32 times in the 18 months between February 2004 and August 2005. Meetings lasted an average of 2 hours each.

Total time investment by participants
Approximately 60 hours per participant.

Client participation
The workgroup participated fully in describing the reference modes, defining the problem, identifying input/decision variables and output variables, drawing causal loop diagrams, choosing output formats (graphs), describing ("quantifying") key lookup relationships, designing model input/output screen layouts from a template, testing draft versions of the model, and identifying revisions needed. Workgroup members developed scenarios to be used to demonstrate the model to the Planning Directors group. Representatives from the workgroup also took the lead in presenting the model to the Planning Directors group.

Some workgroup members participated partially in parameterizing the model. They provided data.

The workgroup did not participate in developing the stock and flow structure.

Work done off-site
In between the meetings, the UNLV team reviewed the notes and flipcharts from the previous meeting to summarize and organize the workgroup ideas in a way to make the next meeting most productive. UNLV provided minutes of the meeting to the group.

Causal loop diagrams produced in work group meetings were "cleaned up" by the UNLV team. All stock and flow modeling was done offsite by the UNLV team.

Total time span
18 months from initial work with the LUTAQ working group to presentation of the working model to the SNRPC Board of Directors.

- **Model and modeling procedure**
  After 18 months of working closely with the LUTAQ working group, we have developed a full working simulation model. The group took the first 5 months (February-July 2004) to agree on the key decision (input) and output variables, and while this seemed an extremely long time to the UNLV team, it also seemed necessary. The discussions allowed all the group members to present their perspectives on what they thought the problem was, what they thought the solution was, and what they thought the model should do. These meetings were loosely facilitated discussion to elicit participant mental models, using flip charts to record ideas and reflecting back ideas to the group both during the meeting, and in the typed minutes they received at the next meeting.
  The next 4 months (August-November 2004) were spent developing and refining causal loop diagrams. The UNLV team developed the first draft of the stock and flow model in 1.5 months "behind the scenes" and presented it to the group at the end of January 2005. In February through April the model was revised between each meeting and presented again to

the group for feedback. The model was refined between May and August and the presentation was developed.

Outcome

The outcome of the group model building portion of the project, the first 18 months, is a clear consensus among working group members about the definition of the problem and value of the model. The primary data used to assess the outcome are the detailed notes the UNLV team kept of working group discussions. The notes show the changes in positions taken on the purpose of the model and the definition of the problem by each group member throughout the process.