Using Dynamic Simulation for Resource Management Policy Design at the Minnesota Department of Transportation

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ABSTRACT:

This paper describes the application of systems thinking and system dynamics modeling for the development of improved resource management policies in the Minnesota Department of Transportation. The structure explored was that of one of twelve operating units responsible for maintenance of ~1600 miles of highway. Family testing has shown its applicability to the other operating units.

The paper identifies some of the policy insights and learning that occurred during model building and testing, as well as notes about process techniques. Insights included the effectiveness of hiring policies, side-effects of outsourcing strategies, effectiveness of training and cross-bargaining of human resources. Process techniques included group model testing, strategy and scenario building to frame model purpose and testing, the use of learning laboratories using a simulation model to engage the leadership of the organization, and a management flight simulator to disseminate the insights gained to the ranks in the organization.

BACKGROUND:

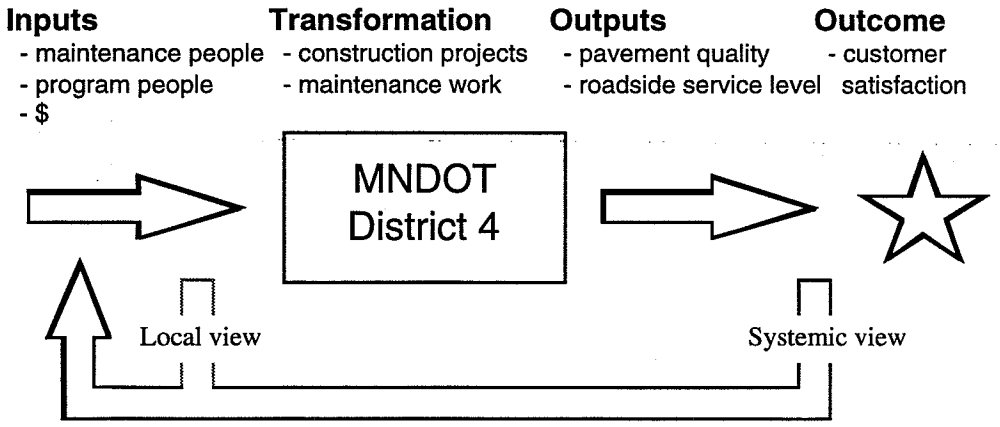
This organization has a deeply functional culture, and as many government agencies, faces some fiscal uncertainty. The project, sponsored by the district's top executive and other department managers, was intended to unfreeze and broaden the perspective of the management for more effective policy-making, and to leverage any learning throughout this district and across the wider organization. The clients were very involved in every aspect of building their model.

OVERVIEW OF POLICY INSIGHTS:

Effectiveness of hiring policies

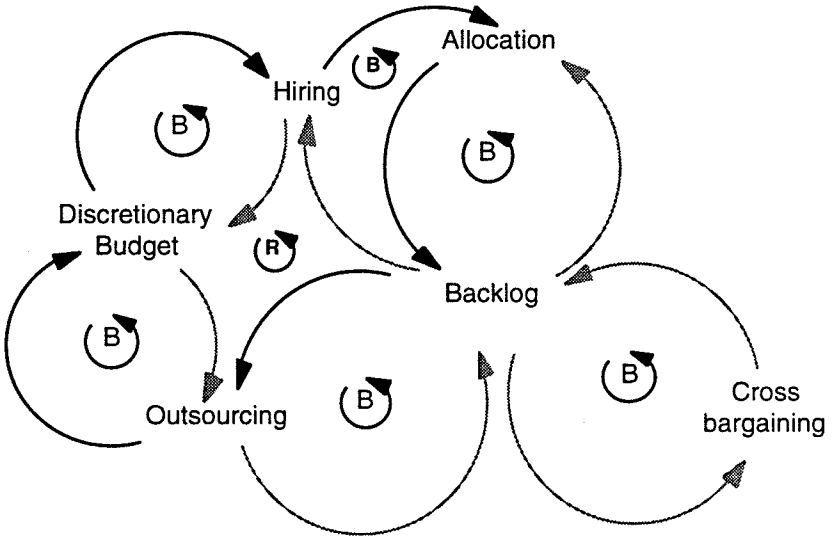
In the organization there is pressure to hire people whenever discretionary money is available. The organization is split into Construction workers and Maintenance workers. Managers of the two functions lobby vigorously to hire into their particular function, with a goal of maintaining headcount at the local level.

In the modeling process, the team posited a more systemic ways to determine how many people are needed. Specifically, the size of the backlogs of work which are driven by the performance measures were identified as key drivers.



Side-effects of outsourcing strategies

Outsourcing of maintenance work can be done on a short term basis to handle peaks in the workload. The backlog is decreased, and discretionary dollars are allocated to it. Because the backlog is reduced, the suggested staffing level is decreased slightly. Additionally, available discretionary funding is drawn down making longer term financial commitment to hiring permanent staff impossible. Because the financial hurdle to outsource this work is always lower than that to hire a permanent person, outsourcing can become a slippery slope.



The team realized that although outsourcing is significantly more cost effective than doing this work internally, and seems the obvious answer, choosing which work to outsource has long term strategic applications.

Diminishing returns of cross-bargaining of human resources

Cross-bargaining, or flexible workforce, is becoming a popular notion in the organization as a way to increase the efficiency of the organization. Through the testing of the model, the team noted that 20% cross-bargaining capability captured all the efficiency of a completely flexible workforce. The benefit was due largely to the out of phase seasonal peaks in the two kinds of work.

This result has implications for a plan to train the entire workforce to align the skill base with market salary levels. This policy would not have the intended benefits unless the organizational strategy involved increasing the amount of construction work or changing the balance of work.

Dynamic understanding of the effects of different reconstruction project types

The process of building the model helped to clarify the relationships between different types of construction projects and their effect on pavement quality. Although the organization has a management information system that recommends projects types for particular stretches of highway, the logic embedded in this system was not well understood. The different project types, each having different costs, delays in construction, and wear characteristics are effective in different situations.

The team also noted that if construction funds were increased substantially, it would cause the pavement quality to increase significantly, and overall spending, although higher in the short term, would be lower in the long term. This would result in large fluctuations in workforce levels, however, and require a shift in policies to prevent a long term oscillation.

Effects of fragmented budgets

Minnesota has been decreasing the amount of fragmentation in funding to the agency. This has increased the need to understand how best to allocate those resources.

The team's testing showed that even more flexibility in allocating both operating dollars and construction dollars could improve organizational efficiency even further. One underlying assumption for this conclusion is that management at the local levels has a dynamic understanding of their system and environment.

PROCESS TECHNIQUES:

The client team had much of the responsibility for testing, validating, and calibrating the model. There were six people on the core modeling team who were from different parts of the organization and at different levels of responsibility. The roles on this client team included the gate keeper, the internal modeler, and content experts. Consulting associates filled the facilitator and modeler/reflector roles. Stakeholders and other experts were included at many points in the process.

Group model testing for validation
The team invited the management staff of the organization to take part in testing the results and assumptions in the model. Team members had frequent dialogue checking particular assumptions with people in different areas of the organization.

Strategy and scenario planning to frame model purpose and testing
The team used classical scenario planning tools to develop coherent strategies for the organization. They also identified key uncertainties and developed scenarios from them. They were able to use the model to test the strategy scenario combinations to get a better understanding of their multiple possible futures.

Learning laboratories to engage leadership of organization
In order to determine whether the structural assumptions in the model were valid for other districts in the organization, the top executives from all the districts participated in a group model explanation and demonstration where they experimented, questioned assumptions, and validated the behavior. This meeting helped to build the confidence of these leaders, which will facilitate the roll-out to the wider organization.

Management flight simulator development to disseminate insights
The team learned a tremendous amount about their systems and environment. In order to leverage that learning to the rest of the district and the wider organization, a management flight simulator was developed to allow teams to experientially learn some of what the core modeling team learned during development.

REFERENCES

de Geus, A. P., "Modelling to predict or to learn?", European Journal of Operational Research 59(1992), pp. 1-5

Forrester, J. and Senge, P., "Tests for Building Confidence n System Dynamic Models," System Dynamics TIMS Studies in Management Science, Vol. 14, pp. 209-228, (1980)

Homer, Jack B., "Partial-model testing as a validation tool for system dynamics," Proceedings of 1983 International System Dynamics Conference, Boston, MA, pp. 919-931

Isaacs, William, Senge, Peter, "Overcoming limits to learning in computer-based learning environments," European Journal of Operational Research, 59(1), pp. 183-196

Lane, David C., "Modelling as Learning," European Journal of Operational Research, 59(1), pp. 64-84

Richardson, George P., Andersen, David F., "Teamwork in group model building," System Dynamics Review, Vol. 11, no. 2 (Summer 1995). pp. 113-137

Senge, P., Ross, R., Kleiner, A., Roberts, C., Smith, B., The Fifth Discipline Fieldbook: Strategies and Tools for Building A Learning Organization, Doubleday, 1994

Sterman, John D., "A behavioral model of the economic long wave," Journal of Economic Behavior and Organization, 1985, 6, pp. 17-53