Concept Models

George P. Richardson[1]
Rockefeller College of Public Affairs and Policy
University at Albany, State University of New York

Abstract
Working with groups unfamiliar with system dynamics, modelers need a quick way to introduce the iconography of the approach and some of its framing assumptions. In the early exploratory days of group model building interventions at the University at Albany, we settled on the use of sequences of tiny models for this purpose, which we call "concept" models. The intent is to begin with a sequence of simulatable pictures so simple and self-explanatory, in the domain and language of the group's problem, that the group is quickly and naturally drawn into the system dynamics approach.

Previous papers have sketched in passing the notion of concept models as we have used them. Here we provide a number of illustrative examples and describe in detail the ways we use these little models, the assumptions behind them, some design principles that have matured over time as our experience has grown, and a discussion of possible problems with the approach.

Background
Working with groups unfamiliar with system dynamics, modelers need a quick way to introduce the iconography of the approach and some of its framing assumptions. In the early exploratory days of group model building interventions at the University at Albany, we settled on the use of sequences of tiny models for this purpose, which we call "concept models." The term reflects the conceptual nature of these little models in two senses. The models introduce concepts, iconography, and points of view of the system dynamics approach. In addition, the models are designed to try to approach the group's own concepts of its problem in its systemic context.

Our intent is to begin with a sequence of simulatable pictures so simple and self-explanatory, in the domain and language of the group's problem, that the group is quickly and naturally drawn into the system dynamics approach. Within thirty minutes or less, we'd like to working with the group on

[1] Although this paper happens to be the work of a single author, who was the author of the concept models described in it, it is essential to understand that projects in which these models were used were highly integrated team efforts. The welfare reform work in which the first concept model discussed below appears was initiated by John Rohrbaugh, facilitated by David Andersen, and supported significantly by Tsuey Ping Lee and Aldo Zagonel. The second concept model discussed in this paper appeared in two workshops organized by Jose Gonzales, led and facilitated by David Andersen, and supported extensively by Eliot Rich. The third concept model appeared in an intervention led and facilitated by David Andersen in which Charles Finn contributed significantly with stakeholder analyses and other facilitation support. I am grateful to these colleagues for the many ways they contributed in the background to this paper and to the ideas it contains.

their problem in their terms, listening hard to what they have to say, facilitating their conversations, and structuring their views of the problem.

Previous papers have sketched in passing our notions and use of concept models (Richardson et al. 1992, Richardson and Andersen 1995, Andersen and Richardson 1997). Here we present a number of examples illustrating a range of possibilities and describe in detail the assumptions behind the idea of concept models, some design principles that have matured over time as our experience has grown, and a discussion of possible problems with the approach.[2]

An Archetypical Example from Welfare Reform

In the late 1990s, the United States Congress passed sweeping welfare reform legislation that changed the Federal government's role and responsibilities in providing support for the nation's poor. The legislation put an end to programs that began in the depths of the Great Depression providing the potential of lifetime federal support for an indigent family, and replaced it with Temporary Assistance to Needy Families. A needy family now has up to five years of Federal TANF support, cumulative over the lifetime of the parent. The rest, if any, would have to come from states and counties. The frightening prospect that families could begin timing out of Federal support as early as 2002 caused a number of New York State counties to want a systems view over time of likely or potential scenarios (Zagonel et al. 2004).

We began the group modeling phase of the project with a sequence of three concept models, which we will develop here in detail to show the process. The sequence is chosen

- to introduce the iconography of stocks, flows and feedback loops,
- to initiate understandings that dynamic behavior is a consequence of such system structure,
- and to motivate discussion on the group's problem.

We began with the structure shown in Figure 1.

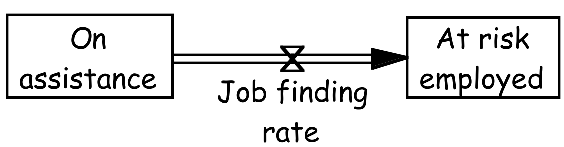

Figure 1: First stage of the Welfare Reform concept model sequence.

The picture was hand-drawn on a white board (we think that is important), first the labeled boxes, then the flow. In explaining what the boxes and the pipe mean, we usually draw an old-fashioned tub showing wavy water inside, with a faucet pouring water in and a drain pouring water out, spilling out over the floor in concentric ripples. People in these boxes, we explain, are being

[2] This work falls within the growing body of work on group model building in the system dynamics community. The system dynamics bibliography (version 2006a) lists at least 64 works referring to group model building. None focus specifically on models and methods of the sort discussed here. The general works in the field include Vennix (1996), Vennix et al. (1997), and Zagonel (2002, 2004).

thought of as flows and pools of water, rather than as individuals.

Acknowledging that the picture is inadequate because it leaves out the possible flow back to needing assistance, we added that recidivism flow to the picture, as in Figure 2.

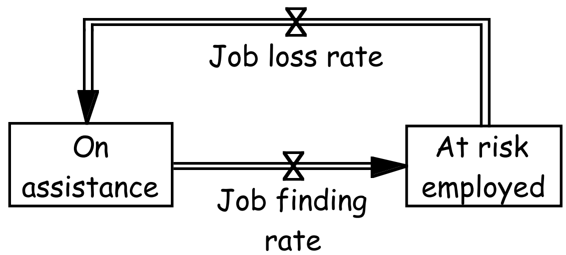

Figure 2: Second stage of the first Welfare Reform concept model.

We then argue that we'd like to create some simple algebra for the two flows so that we can move toward quantifying this picture. That motivates drawing, one at a time, the structures determining the two flows showing in Figure 3. We take pains to be sure that the group sees there is no magic here, just simple arithmetic, with the diagram showing the quantities that come together to determine each flow. We don't write the equations, just state them verbally to keep the tone conversational; we do, however, note that arithmetic guarantees that the units of both flows are "people per year," as units appear to be helpful to everyone's understanding.

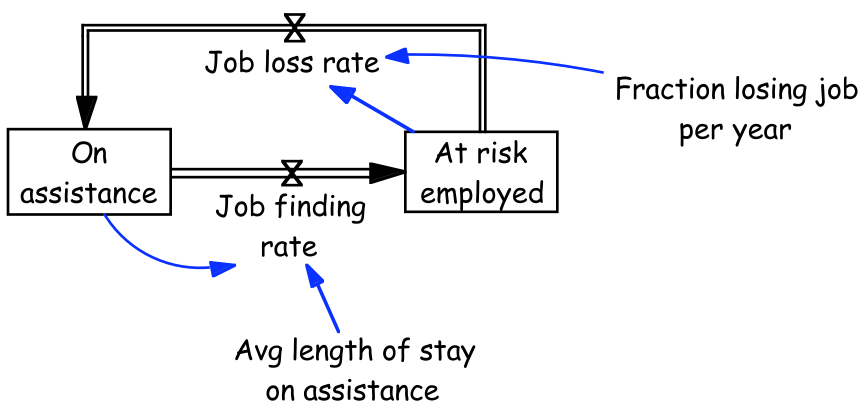

Figure 3: Final stage in the first Welfare Reform concept model, showing the structure of the algebra determining the flows.

At this point, we turn on the LCD projector and display the model in its modeling environment (we use Vensim, but began years ago with STELLA/iThink). It is crucial at this moment for everyone to see that the software picture is identical to the hand-drawn picture. We then simulate the model in a carefully chosen scenario designed to connect to the group's problem. In this case, we begin the simulation in equilibrium and step down the Average Length of Stay on Assistance, motivating that scenario as a likely or intended effect of the welfare reform legislation. This result is show in

Figure 4.

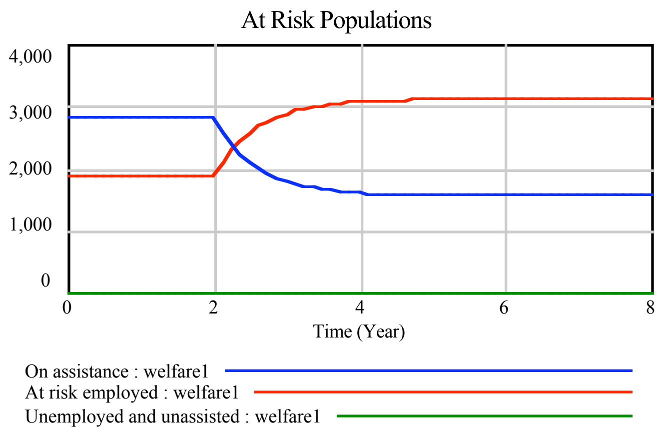

Figure 4: Dynamics of the structure in Figure 3 disturbed from equilibrium by a step down in the Average Length of Stay on Assistance.

The result is portrayed as reasonable to the group, probably not requiring simulation to see. With families spending on average less time on assistance, more are finding jobs. The On Assistance population declines over time, and the Employed (though still at risk) population rises.

At this point the group has seen an example of the diagrams we will use and has some understanding of the icons, and the use of simulation to play out the implications of the model's assumptions. But they would see little need here for simulation, as they could probably predict the model's behavior from simply simulating their mental model of this structure.

The next step is crucially important. We return to the hand-drawn picture on the white board and modify it, ostensibly to make it more realistic, closer to elements in the group's problem. In this case we added a ratio of the At Risk Employed to a fixed number of Jobs available, and an influence of that saturation ratio on the fraction of At Risk Employed losing their jobs per year. That influence converts the Fraction Losing Job per Year from a constant in the first model, to a variable.

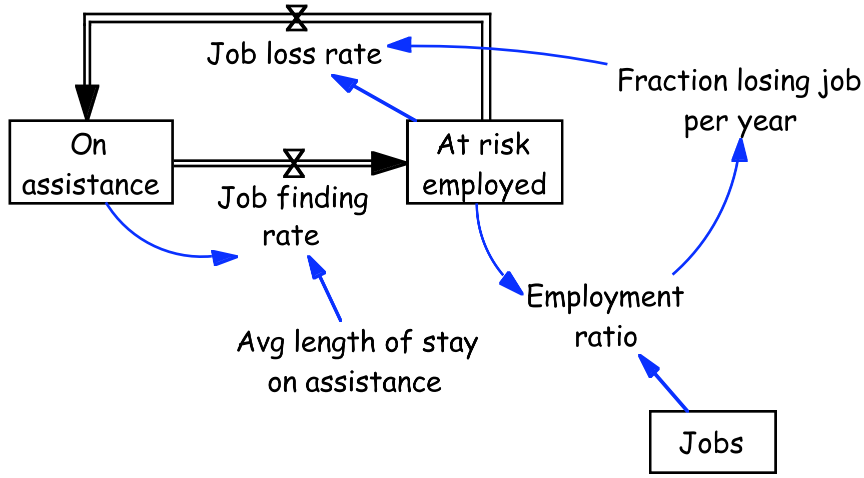

Figure 5: The second Welfare Reform concept model, building on the structure of the first by adding job availability.

Turning again to the computer, this second model is displayed, and we make certain the group sees it is the same as the hand-drawn version. Simulation produces the behavior shown in Figure 6.

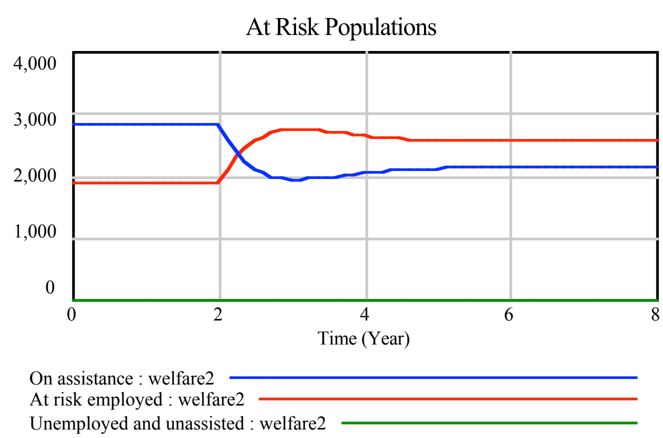

Figure 6: Behavior of the second Welfare Reform concept model, showing that the change in structure has alternated the behavior of the model somewhat

Participants notice, and we emphasize, that the dynamic behavior is somewhat different. The At Risk Employed still increase after the simulated initiation of welfare reform (the step decrease in Average Length of Stay on Assistance), but they then decline somewhat, while the At Risk Employed begin to increase. The difference is slight, but significant; it paves the way for the remarkable difference the next structural change brings.

Returning to the hand-drawn model for the final time, we observe that the model does not include the crucial element of the welfare reform legislation, that families have a limited eligibility for Federal assistance. So we draw in the structure shown in Figure 7, explaining as we go.

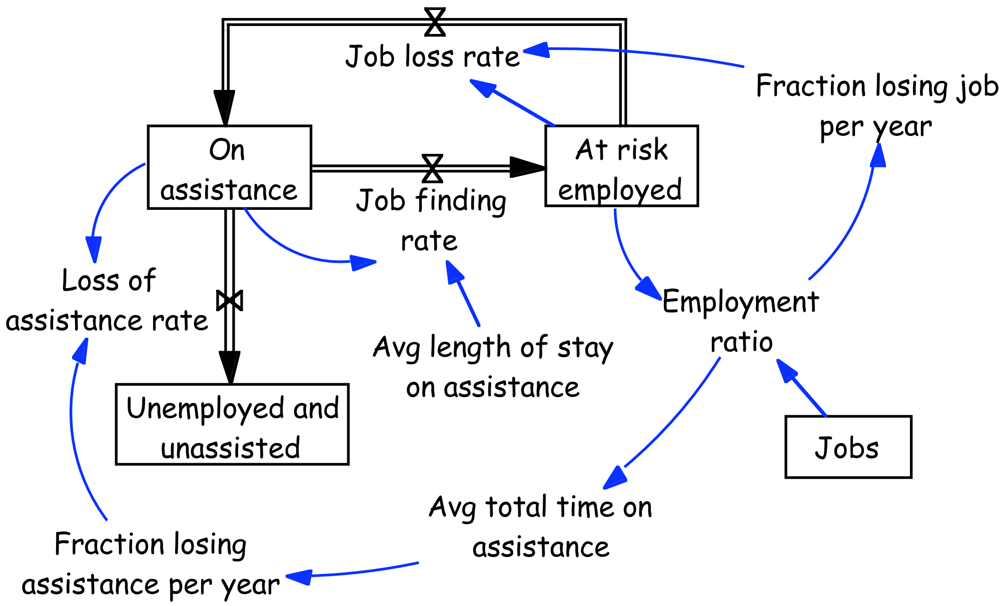

Figure 7: The final Welfare Reform concept model, showing the addition of structure for families timing out of the system and becoming ineligible for Federal assistance

Once again returning to the computer to simulate the model, participants see the dramatic results shown in Figure 8.

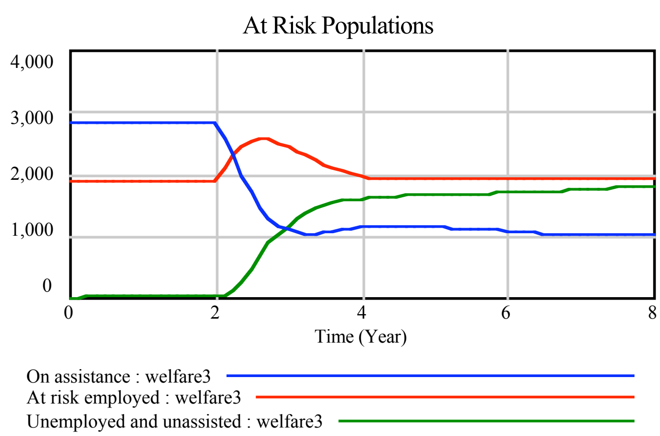

Figure 8: Dynamic behavior of the third Welfare Reform concept model, sowing the rise of an Unemployed and Unassisted population and a return of the At Risk Employed population to its original value.

In this scenario, the On Assistance population declines as before, and as intended by the welfare reform legislation, but the At Risk Employed population experiences only a temporary rise, eventually declining to something like its original value. Now the new population in the model, the Unemployed and Unassisted, begins to rise after the initiation of simulated welfare reform (the step change in Average Length of Stay on Assistance).

This sequence of concept models shows just the sort of behavior with which a modeling team would love to start a group discussion. The behavior of the first model is the expressed intent of the welfare reform legislation: get people off assistance and into jobs. The behavior of the second model starts to cast a little doubt on that scenario, and the third completely contradicts it. The third model looks like a nightmare of advocates for the poor: the legislation, this third scenario suggests, will not improve people's employment prospects, but rather will simply reduce the Federal government's financial responsibility and shift it to the states and counties. Needless to say, the group was ready to talk about the structure and future of welfare as they saw it!

The sequence of concepts models here did its job extremely well.

- The iconography of system dynamics structure was introduced and became familiar;
- The use of simulation to play out behavior over time became clear;
- The dynamic behavior of the system, initially obvious, became less so with each structural addition, making simulation seem more and more necessary;
- The behavioral changes were so dramatic as to move from one end of the political advocacy spectrum to the other, creating irresistible motivations within the group to talk about what's wrong with these little pictures of what they know to be a very complex welfare support system;
- The entire development, from white board drawings to the final simulation, took less than thirty minutes.

Observations on the Archetypical Example

The concept models used in the welfare reform group modeling sessions were very simple, starting with just two stocks (actually a first-order system since the stocks are not independent), and ending up eventually with just three stocks and three flows. Three stocks is probably an optimal goal. Creating such a compelling a sequence of concept models as this one with no more than three stocks gets the conversation off to an informed and highly motivated start with a minimum chance of confusing or losing people.

To all the experts in the room, and to those of us on the modeling team, these concept models were wrong. Reflecting a long line of wise reflection in science in general and the system dynamics field in particular, Sterman assures us that all models are wrong (Sterman 2000, pp. 846ff)[3] , so we should not be surprised that the welfare reform concept models are wrong. But these models are wronger than most! And they are for some very good reasons.

- First, the models are tiny -- little imitations only hinting at the structural and dynamic complexity of the Federal, state and local welfare system(s). When we begin a group

[3] The often-repeated statement to the effect that "All models are wrong, but some models are useful" appears as a heading in a chapter of Box (1979). It seems quitely likely to me that there are earlier sources of this famous shibboleth, but I am not aware of them.

modeling intervention, we know more than we put into the concept models that get the discussions started. The models have to be tiny to serve our introductory purposes.

- Second, the models are constructed and sequenced to get across very particular aspects of the system dynamics approach, including the idea (initially obvious, then questionable, finally repeatedly affirmed in practice) that dynamic behavior is a consequence of system structure. Paying attention to getting those ideas across often necessarily draws attention away from the real system and toward a representation of it that will serve our concept model purposes. In particular, illustrating dramatically that behavior is a consequence of structure may require less robust or unrealistic structural formulations such as open integrators or other omitted feedback loops.
- Thirdly, concept models should have simple, even obvious, algebraic structure; that requirement of simplicity may force leaving out structure essential for coming close to realism. One reason for requiring simple algebraic (or nonlinear graphical) equations is in case a participant asks to see an actual equation. In our experience, that almost never happens -- people seem content to get a gradual introduction and are anxious to get to the complexities they came to discuss -- but the concept model should be ready to be investigated a bit, nonetheless.
- In this spirit of avoiding mathematical ugliness and striving for simple algebraic structure, concept models should always embed graphical functions within a variable (as STELLA/iThink always does and as Vensim can do). The focus should be as much as possible not on software or mathematical elements, but rather on the structure and dynamics of the group's problem. It is expecially true for concept models that "mathematics should be on tap, never on top."[4]

All these design principles can push in varying degrees toward formulations that one might not put forward as best practice in the field.

A Recent Example

To illustrate variations and extensions on these themes, we turn now to a recent intervention about cybersecurity. An energy client group was dealing with potential security risks on ocean oil platforms as day-to-day operations were shifted to remote (onshore) internet-based electronic control. There were two workshops, separated by a summer and involving a somewhat different cast of characters each time. We needed concept models to start both group modeling building workshops, but could not really start from scratch in the second workshop. Here's the sequence of three concept models that began the first workshop.

[4] Attributed to General Motors engineer Charlie Wilson in MacCorduck (1979, 388).

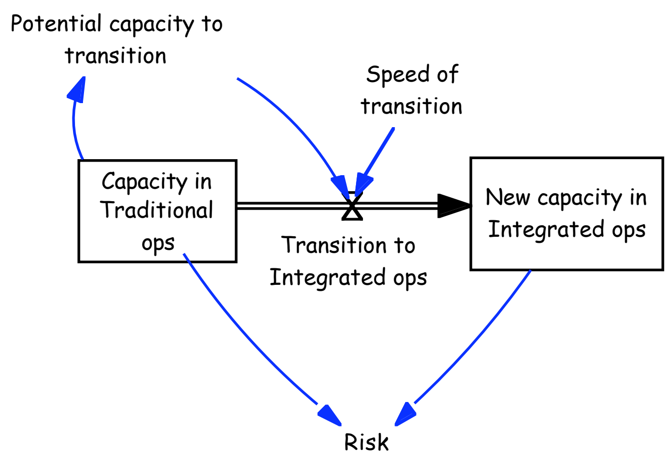

Figure 9: The first concept model in group model building to study a transition to integrated, remote e-operations on ocean oil platforms.

Following the procedures laid out above, the model was first drawn on a white board, one element at a time, explaining the meaning of icons and quantities as we went. Turning to simulation, we showed the model

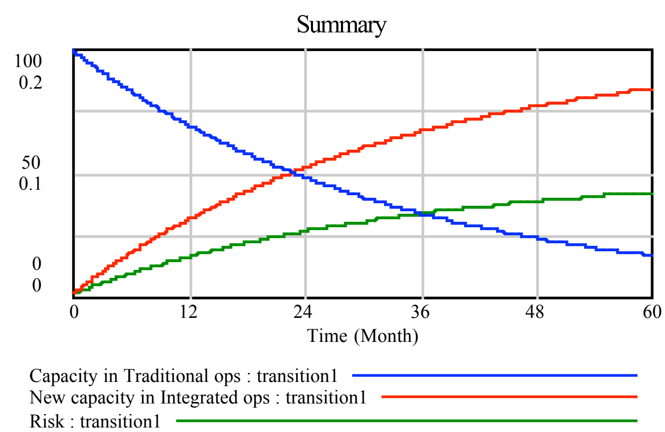

Figure 10: Behavior of the first concept model in the oil platform study

The second concept model added feedback structure contributing to the speed of the transition to new work processes in integrated e-operations.

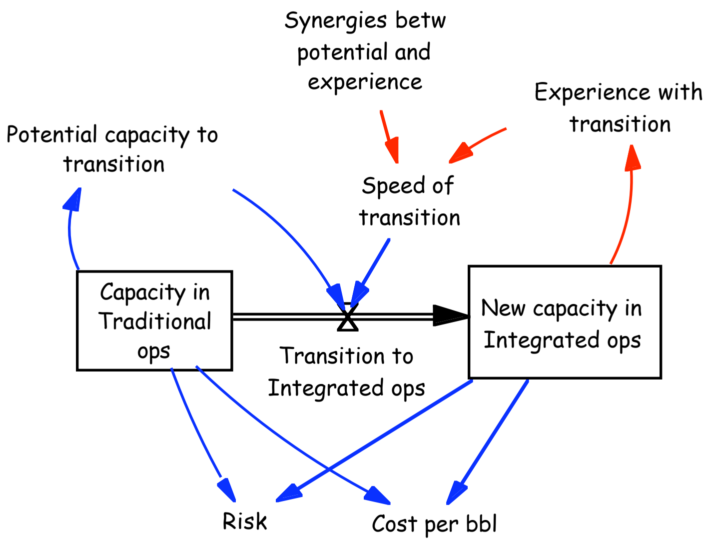

Figure 11: The second concept model in the oil platform study, showing an epidemic-like reinforcing loop helping to speed the transition to integrated e-operations

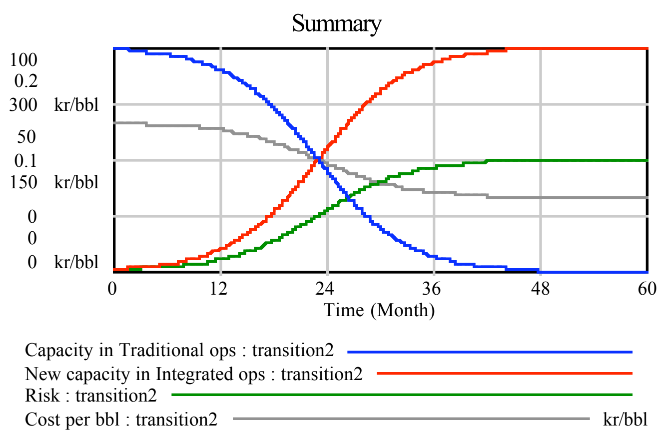

Figure 12: Behavior of the second oil platform concept model, showing a dramatic shift from simple goal-seeking behavior of the first model to s-shaped growth and decline.

This second model shows the declining production cost per barrel of oil, a variable of major interest and the reason for migrating oil platforms to cheaper integrated remote e-operations. But it appears to show that the risk in this transformation rises throughout the run. That observation leads to the addition of a third stock in the system, which we labeled Mature Capacity in Integrated Ops, as shown in Figures 13, 14, and 15.

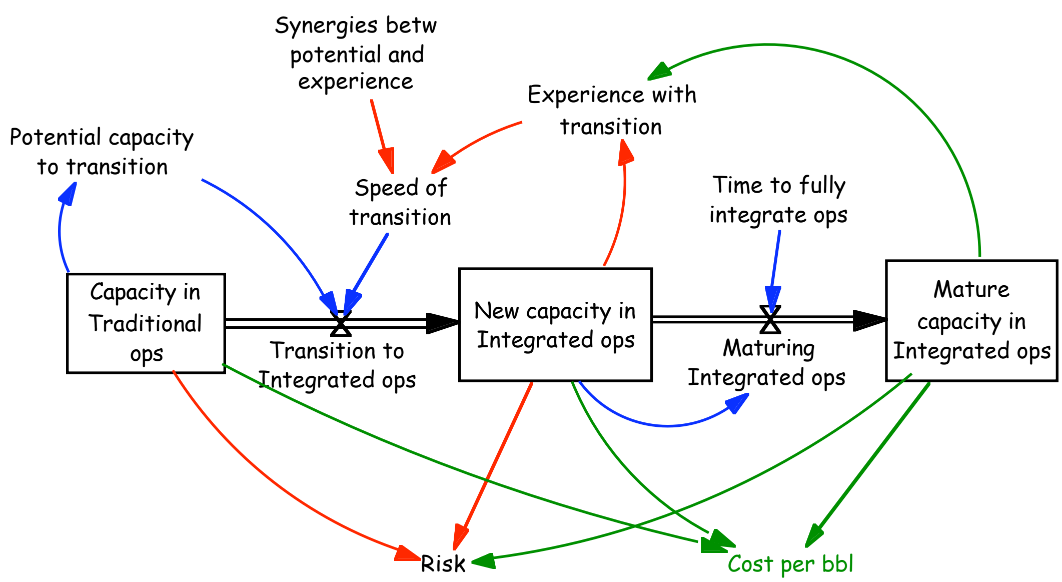

Figure 13: Structure of the third and final concept model in the oil platform sequence showing more complexity in the assumptions about Cost and Risk and the speed of the transition.

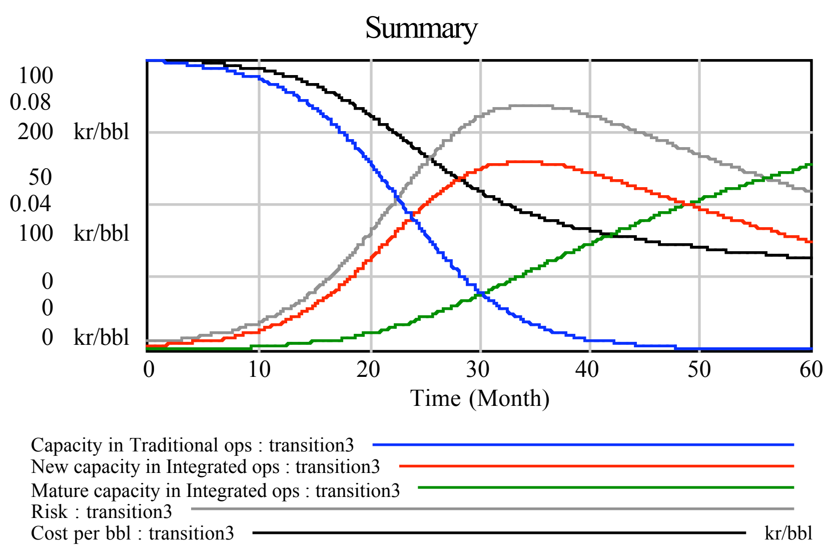

Figure 14: Behavior of the third oil platform concept model, showing new behavior in New Capacity (rising to a peak and declining). Risk follows the same pattern.

To facilitate comparisons of the behavior of these models, we showed comparative graphs of Risks and Costs per Barrel shown in Figure 15. The comparison shows vividly that each structural change brought about changes in the behavior of the system. One could argue, as we did when we added bits of structure, that we were getting closer to something that looked like the actual nature of this dynamic system, but no one was fooled into thinking this was an adequate representation of the complexities of the transition the group needed to understand.

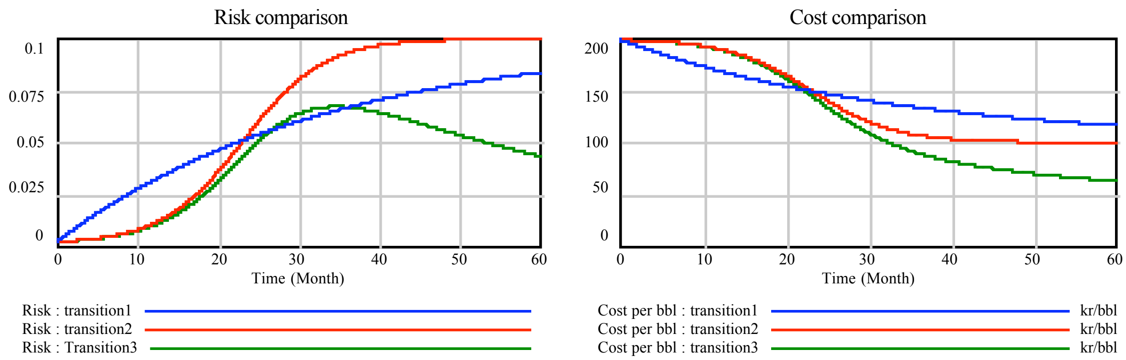

Figure 15: Comparisons of Risks and Costs per Barrel in the three oil platform concept models, illustrating the principle that behavior is to some degree a consequence of structure.

Observations on this Recent Example

Modelers will observe that there must be some unusual things going on in these models focusing on a transition to integrated e-operations on oil platforms. There appear to be some omitted elements and unusual naming conventions. How, for example, is the variable Potential Capacity to Transition formulated in the three models? How is the variable Experience with the Transition formulated in the second and third models? And mathematically, what do we mean by the Speed of Transition or Synergies Between Potential and Experience?

First, the modeler's unvarnished truth:

- In all three models the variable Potential Capacity to transition was simply set equal to the stock of Capacity in Traditional Ops.
- In the first model, the Speed of the Transition was a constant, the fraction of traditional capacity transferring each month (0.03).
- In the second and third models, the Speed of the Transition was the product of Synergies times Experience.
- In the second and third models Synergies was now the constant, the fraction of Traditional Capacity transferring each month (0.002, smaller now because Experience is in the product).
- Finally, in the second model Experience with Transition was simply set equal to New Capacity in Integrated Ops, and in the third model Experience was set equal to the sum of the new and mature capacities.

What was the modeler thinking about here?! Why were these decisions made?

Taking the bullet points in order, the first question can be interpreted as asking why the variable Potential Capacity to Transition is in the model at all if it is just equal to the Traditional Capacity. We felt including that wording told a story about making changes in traditional operations that the client group would identify with. Some operations could be turned into integrated e-operations and maybe some could not. One might think a better way to formulate this story could be to set Potential Capacity to Transition equal to a fraction of the traditional capacity, so as to leave some traditional capacity as permanently not transformable. But this sort of formulation does not do what it intends, and the proper formulation is a good deal more complex and not particularly intuitive[5] so we chose to leave it as we wrote it.

The second bullet could be interpreted as asking why we didn't name the constant as the "Fraction of Traditional Operations Transferred per month." Why the "Speed of Transition"? We thought that "speed of transition" communicated the real-world significance of the parameter, while a name with "fraction per month" in it would focus attention on the mathematics rather than the real-world significance. It's a debatable point: Richmond held that variables should always be named with the most descriptive mathematical terminology, to avoid any ambiguity in the meaning of the formulation. But these models are *concept* models, so conceptual names seem more appropriate.

The same issue pops up with the constant called Synergies Between Potential and Experience. The name we chose hides the fact that this variable is a fraction (0.002). But naming it as we did communicates the concept that if there are more synergies between traditional operations and our experience with the transition to new integrated e-operations, the transition should happen faster, and we thought that to be the desirable focus. We also stayed away from naming the Synergies parameter a fraction of some sort because, like all such parameters in this Bass model-like structure, it has dreadfully complicated units (something like 1/capacity units/experience units/month) which are not at all intuitive. We thought it better to leave the name at the intuitive level.

These observations lead to the disturbing modeler's truth revealed above, that Experience was simply set equal to capacities. Why not some converter constant times capacity? In fact, it could have been formulated like that, and would make a modeler feel better if it had been so because the units could be made to make sense. But then to keep the structure clean and simple looking, we probably would have hidden the constant anyway. So we chose to simply leave it out. It appears that in explaining these structures as they are developed on the board, the audience puts the missing constant in mentally, or ignores it, or doesn't know it should be there -- and in any of these cases we do better leaving it out rather than putting it in and raising the ugly specter (in this particular structure) of dimensional consistency.

These thoughts suggest the following principles about concept models used for group model building:

[5] The "fraction" formulation does not leave something in the traditional stock; all would be transferred eventually to capacity in new integrated operations, just at a lower pace. The formulation such thoughts really aim toward is a fraction of the *total* of capacity that is transformalble, with the potential capacity to transition set equal to that total transferable capcity minus the amount already transferred. The complexity of this paragraph illustrates why we chose to sidestep all of these thoughts and just set the Potential Capacity to Transtion equal to the Traditional Capacity.

- Concept models and the ways we use them with a group should minimize attention to the software and model mathematics. Instead, our work with concept models should maximize the group's attention to concepts in the real system and the model as a representation of the real system. That can mean using variable names that sound less like mathematics and more like real system structure. It can sometimes even mean hiding or embedding some constants if they aren't going to be focused on or changed.
- In this spirit of hiding unnecessary software or mathematical ugliness, concept models should always embed graphical functions within a variable (as STELLA/iThink always does and as Vensim can do).
- Finally, it is a reasonable extension of this principle about minimizing attention to the software and model mathematics to suggest that mouse moves on the computer screen should be kept to a minimum. Pull down menus should be avoided if keyboard shortcuts exist.

The theme of these observations is that participants' thoughts about concept models should not be about mathematics or software, but about the system structure and behavior of their problem.

An Extended Example that Breaks More Rules and Suggests More Principles

Our final example (Griffen et al. 2000) comes from work done a number of years ago with a state agency that spends its time and resources each a year equalizing tax burdens across school district and county lines. The agency would be for the most part unnecessary if localities assessed all properties every year and set tax rates based on full assessed value. Unfortunately, New York State constitutionally can not require localities to assess and tax like that. Furthermore, localities are under a wide variety of forces that tend to push them away from assessing every year, or even every five or ten years, and to set tax rates based on some fraction of full assessed value. So the state agency steps in to assure that people who own similar houses or business properties in different taxing regions have essential the same tax burden.

We were brought in to get a systems view of this problem, working with people from the state tax equalizing agency and its visionary leader, together with various tax and assessment professionals at the county and local levels: a disparate group with multiple agendas. After beginning with a series of strategic planning exercises to get the problem well-defined and the group ready to tackle it (Griffen et al. 2000), we introduced, in the fashion described above for welfare reform, the concept model shown in Figure 16.

The reader will note immediately that this first concept model looks more complex than the first concept models for welfare reform and cybersecurity on oil platforms. There are five stocks and flows, two more than past experience suggests is wise practice. But we reasoned that the concepts in the structure would look very familiar to the participants and that familiarity would carry over to make the entire diagram seem reasonable. Both assumptions proved correct. Also enabling this structure to be the first system dynamics map and model the participants had every seen is the simple arithmetic governing the flows. The first-order formulations are obvious from the picture, even for non-modelers. One does not need to see the equations to see that each flow is some number of towns moving per year from one category to the next. Even the units (towns/year) are discernible from the arrows pointing to the flows and made sense to the participants.

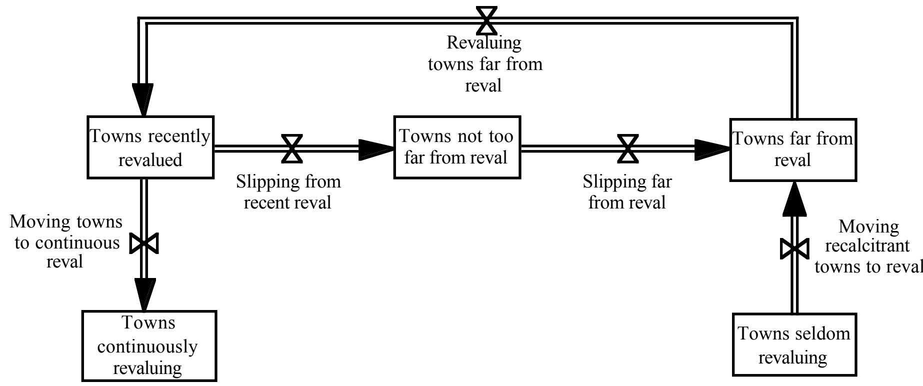

Figure 16: Initial view of the local tax assessment concept model, drawn at first by hand, one stock and flow at a time, showing pools of towns in five assessment categories and how they can move between categories. [“Reval” is the state’s shorthand for reassessment.]

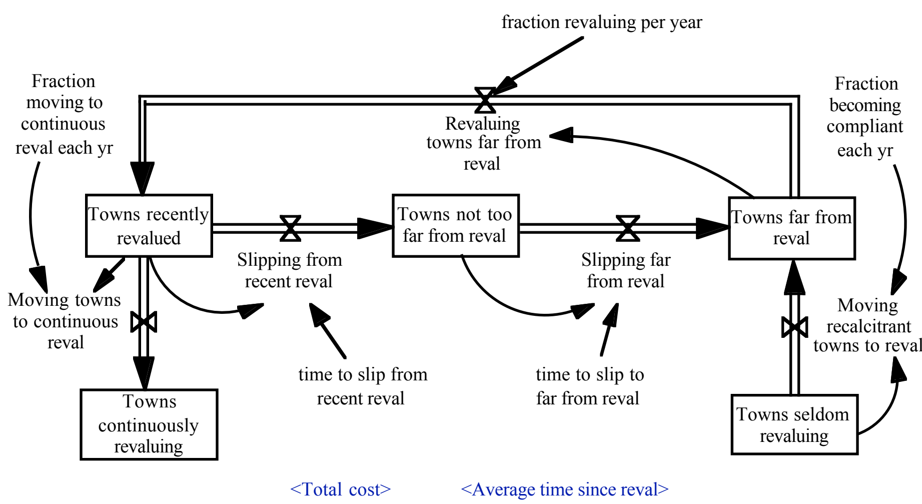

Figure 17: Second view of the local tax assessment concept model, showing the simple arithmetic governing the movement of towns among the categories.

Hidden in Figure 17 is the fact that all the constants in the model were formulated as graphical functions of time, as shown in Figure 18. That technique is extremely useful if, as in this case, the modeling team wants to simulate different scenarios. The base simulation of the model was in equilibrium. Simulating different scenarios, such as increasing the frequency of revaluations shown in Figure 18, enables the model to begin in its original equilibrium and transition through the simulated scenario. Participants would be puzzled to see the variable Time involved in each of these ‘constants,’ so Time is hidden from their view.

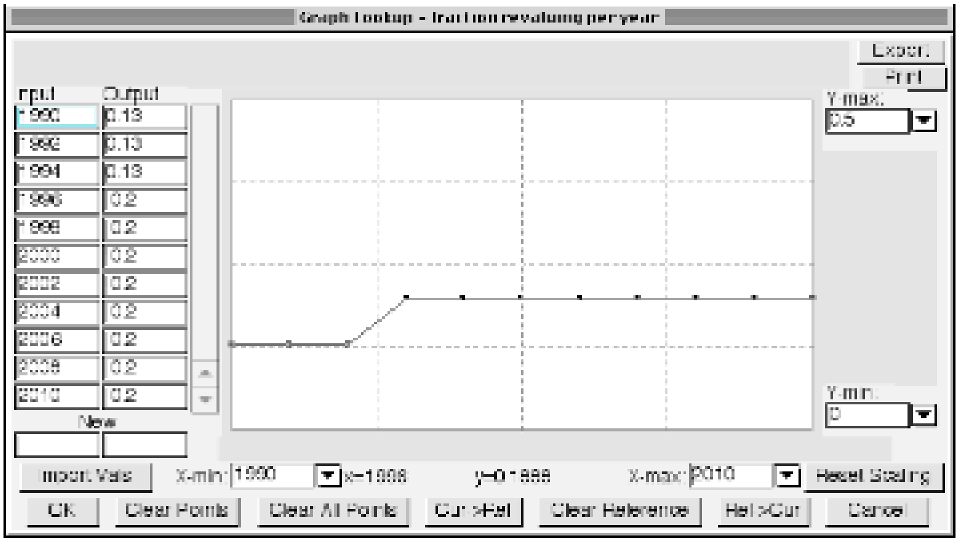

Figure 18: The ‘constant’ Fraction Revaluing per Year formulated as a graphical function of time to facilitate simulating different scenarios, in this case almost doubling the frequency of revaluations.

However, noticeable in Figure 17 are two quantities disconnected in this view from the chain of towns: Total Cost and Average Time Since Reval. These two quantities are computed in three other screens in the concept model (see Figure 19 for costs, for example), which we alluded to in the workshop but did not bother to show. Participants were content that the concept model could compute from average values the total annual cost of equalizing tax burdens among towns with different assessment policies and the cost of moving towns from one assessment category to another, that is, the cost of assessments. Costs figured prominently in what we did with this concept model, as we shall see below, and the average time since revaluation generated an unanticipated insight among the participants, so we know that these concepts were easy for them. Had we shown the arithmetic in Figure 18 to the participants we probably would have obfuscated much more than we clarified, so we purposely hid these “spreadsheet” calculations.[6]

[6] The computation of the Average Time Since Reval should have involved a coflow structure to keep track of time as towns aged through the system or reassessed. However, such a computation would have looked terrible to participants if someone asked to see it, so we opted for a less accurate but adequate algebraic formulation involving weighted averages of time constants.

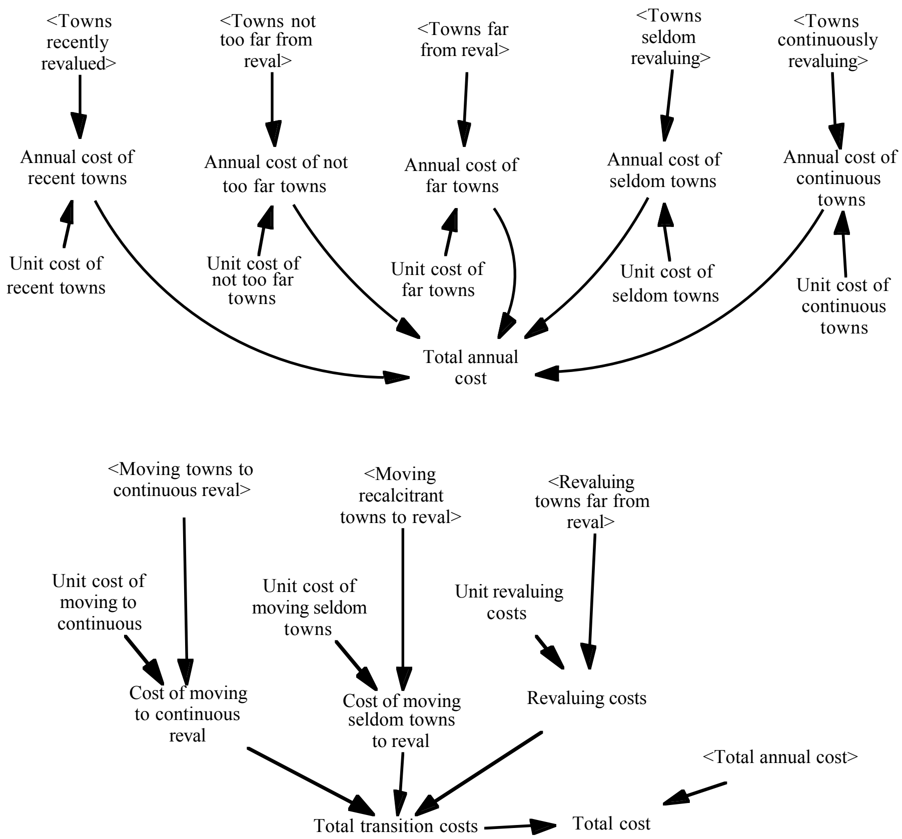

Figure 19: Computing costs (dollars per year) in the local tax assessment concept model, from the annual costs of equalizing tax burdens across assessment categories (top of the figure) to the costs of assessing towns and thereby changing their assessment categories (bottom of the figure).

Several things may be observed already with this concept model:

- It contains more than the usually recommended three stocks.
- It contains a lot of 'spreadsheet calculations' that must be hidden from view or risk bowling over participants with model complexity.
- It starts with the modelers' view of the problem of this agency wished to talk about, at a level of aggregation selected by the modelers, not the clients.
- It is apparently not designed to show changes in behavior as structure is added, but rather as parameters (like the Fraction Revaluing per Year) are changed.
    - By implication, the model is not intended to help build the insight that "behavior is a consequence of structure."
    - A second implication is that participants would not get a sense of changing model structure as a part of the concept model phase of the group model building process.
    - A third implication is that this concept model could anchor, perhaps inappropriately, the group's perceptions and discussions. (More about that below.)

This concept model was designed as a tool for engaging participants in thinking about different revaluation scenarios and to track their costs. It may come as something of a surprise that the process we used to get there began with simulating the model with deliberately and outrageously fictitious cost parameters. The annual costs of towns in the various revaluation categories were (left to right in the top of Figure 19): $.50, $2, $3, $5, and $.50 per year. The costs of moving towns were (left to right at the bottom of Figure 19) $50, $30, and $15 per town.

The process we followed with the model was to develop it slowly with the group, stock by stock and flow by flow. We then projected the model and simulated it, showing equilibrium behavior. Then we illustrated a series of simulations in which we increased the Fraction Revaluing per Year, the Fraction Becoming Compliant per Year, and the Fraction moving to Continuous Reval per Year. We showed the graphs of various quantities, e.g., Figure 20.

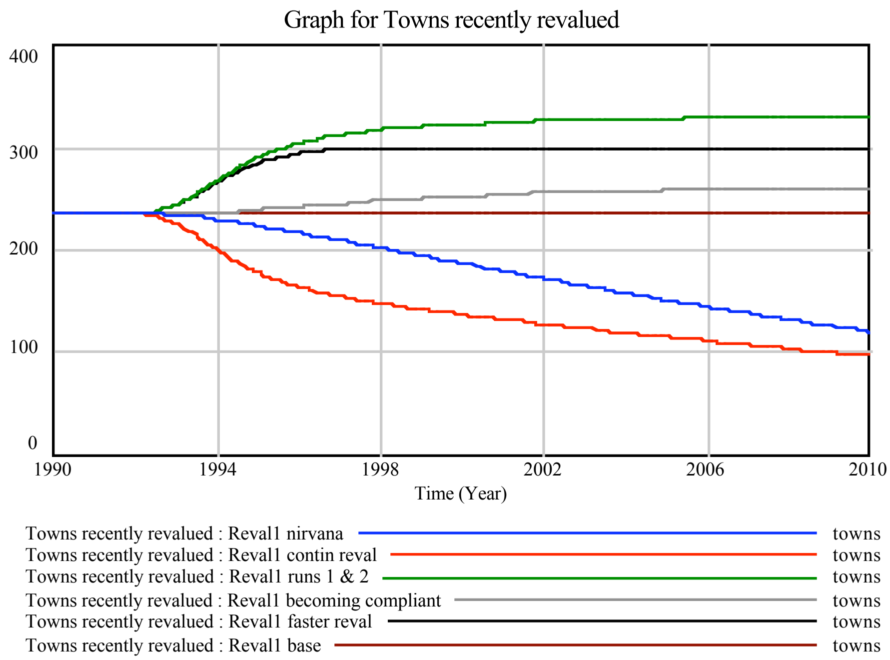

Figure 20: Towns Recently Revalued under six different scenarios in the concept model with fictitious cost parameters.

Although the cost parameters were fictitious (silly, actually), participants saw the logic of the concept model and these scenario experiments. They were motivated to engage in the exercise we were working toward, eliciting realistic values for all the parameters in the model, particularly the cost figures. We had prepared a worksheet containing all the parameters and gave the group the task of estimating and reporting realistic parameters. The director of the agency became intensely interested and took a major role in getting the group to settle on consensus values.

The model was then revised in real time as the workshop turned to another task, with structure added at the request of the participants to capture the breakdown of costs in the state share and the local share, costs. Then we repeated the scenario simulations, this time asking the participants for the parameter changes they wanted to test (for more frequent revaluations and the like) and the names of the scenarios they invented. Some of the results are shown in Figure 21.

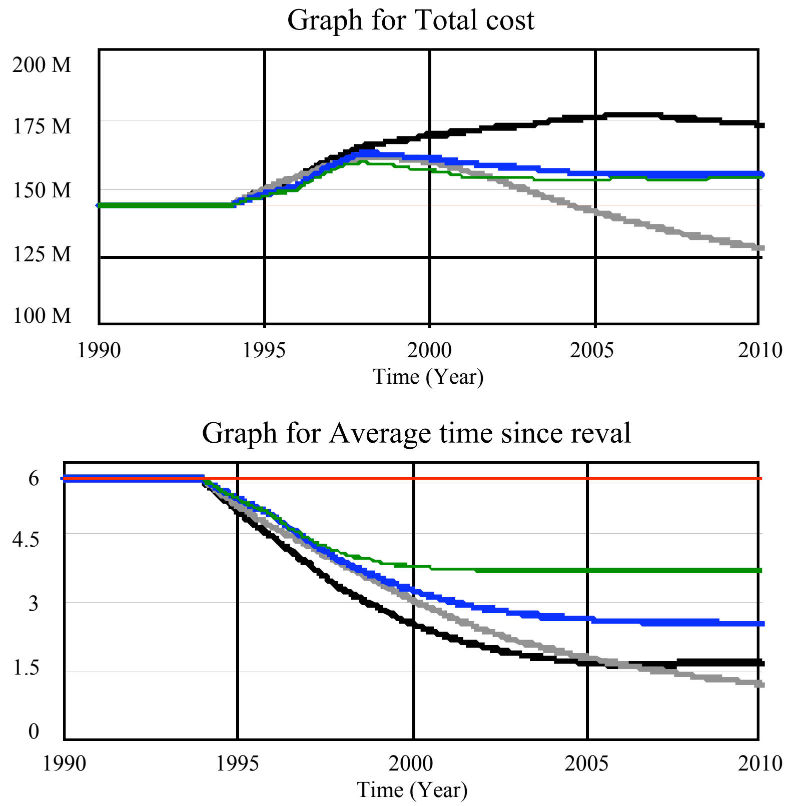

Figure 21: Total Cost and Average Time Since Reval shown in five difference scenarios suggested by the participants using accurate cost and share parameters in the concept model.

The impact of these results were, at the same time, expected and stunning. The simulations showed that attempts to improve the state/local assessment process did indeed shorten the average times since revaluation, but always cost more, except in one simulation. If towns could be moved to a process of "continuous revaluation" (actually, annual evaluations of statistical samples of property), the cost would rise in the short run, as in all the other simulations, but eventually decline: classic worse-before-better behavior. The concept model behavior reinforced what they had sensed, that the only way to improve the system and eventually lower costs would be to move toward a system of continuous revaluations. The very simple concept model, introduced initially with obviously fictitious parameters became the medium for the disparate group of property assessment professionals to come together around a substantive conclusion that formed the focus of their work for the next several years.

There was an unexpected insight here, which the director of the agency continued to talk about years after this intervention. We needed a representation in the model for the fairness or equity of assessments. The extreme high level of aggregation of the concept model and the need to keep it extremely simple for this gathering did not allow for the formulation of anything like a real measure of fairness or equity. So the modeler settled on the Average Time Since Revaluation as a stand-in or proxy for that concept, formulated as a weighted average of the various times since revaluation of the town categories in the model (see footnote 2). That approximation came to the participants, particularly the director of the agency, as a great insight, which apparently gave them a handle or perspective on equity that they had not had before.

That's the good news. There was some bad news in this concept model and the ways it was used in the workshop. Most prominently, it did not lead to the focused grouped model building effort that we thought it would. The group essentially stopped with the concept model with accurate parameters, when we thought that would have been just the beginning.

Our plan was to use the rich conversations around the concept model to build motivation for a careful study of what keeps towns from revaluing properties frequently. What keeps some towns from revaluing at all, maintaining housing assessed values around $8,000 for houses worth $300,000 in the current housing market? We thought that the ease of changing the Fraction Becoming Compliant (the fraction of towns seldom revaluing which decide to move each year to at least occasional revaluation) would stand in stark contrast in their minds with the extreme difficulty of bringing about that change in reality. Participants, we thought, would see this stark contrast and be highly motivated to move to a careful systems view of the forces and dynamics of "recalcitrant towns." We were unable to make that move in the workshop.

The story contains hints of what we believe in retrospect to be the reasons behind our failure to make the transition from these experiences with this concept model to a study focused on recalcitrant towns:

First, like all concept models, the model here was "owned" by the modeling team, not by the participants. But unlike our usual work with concept models, the model structure was never changed in front of the group. The group never got the idea that they could structure the model as they saw the world. We never gave them "permission," and they never asked for it. Instead, the group got the idea that their job was to make the parameters in a fixed model accurate, and the model would be have accurately. The group owned the parameters, not the model.

Second, the model was "too good." Certainly, from the point of view of a professional modeler, the assessment model was trivially simple – linear, with exogenous time series for scenario parameters, essentially open loop, no rich feedback structure, no compensating feedback for policy initiatives, and so on. But the model looked right and behaved right to the participants, particularly after good parameter estimates were introduced. Unlike our usual concept models, it did not have rather glaring simplifications or inaccuracies. It did not cry out to be fixed. It did not provide the drive toward rich give-and-take conversation among the participants, facilitated by the modeling team, trying to get a systems view of the tough assessment problem. In fact, it may have looked like it "solved" the problems.

Third, the model became an anchor. The group had no interest in developing a rich dynamic systems view of the structure recalcitrant towns and forces that keep them from revaluing. The concept model told the story they wanted to focus on. It turned out to be a pretty good anchor, but it was an anchor nonetheless, which inhibited the group's ability and willingness to move beyond it.

Fourth, the model tended to reinforce an exogenous view of system behavior rather than an endogenous view. The scenario parameters were captured as functions of time. While we still believe that that modeling choice for the scenario paraters was just right here, there is no denying the fact that the model's behavior traces directly to changes in these scenario parameters. It contained no interesting stock-and-flow / feedback structure generating intriguing, unexpected behavior. One could say, perhaps, that it exhibited "fixes that fail," since speeding the frequency of revaluations only got at part of the problem and probably would help to mask the real problem of uncompliant towns. But there were no shifts in loop dominance from nonlinearities, no real compensating feedback to puzzle policy makers. The concept model itself, and the ways we used it, inadvertantly reinforced the idea that change comes from outside the system.

We went on in this intervention to be of substantial help to this agency, so we overcame some of the shortcomings listed here. Most significantly, the work helped the organization move toward its director's vision to try to change from being a watchdog agency keeping towns in line with state procedures to being a consulting agency helping towns acquire the capabilities to move to continuous revaluation. The concept model undoubtedly helped. But it did not lead in the exact path we thought it would.

Summary and Conclusions

The preceding discussions of concept models in three widely differing interventions contain lessons for their use in group model building, and perhaps lessons for other kinds of modeling with clients as well. The most crucial lessons learned from our experiences with concept models include:

- Choose very carefully the scenario to simulate in a sequence of concept models. It must...
    - be realistically related to the group's problem,
    - be simple (and obvious) to implement in the simulation model,
    - not be "too good," so plausible as to fail to stimulate conversation,
    - and not weaken the endogenous point of view.
- Use simple algebra or obvious nonlinear effects that are as close as possible to being understandable or intuitable from the picture.
- If there must be a tradeoff between good modeling practice and understandable simplicity, always choose the latter. The point is not a good model, but a good start to a conversation.

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