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Emergence of the Governance Structure for Information Integration across Governmental Agencies: A System Dynamics Approach[1]

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Abstract

The purpose of this paper is to describe a dynamic theory of the socio-technical processes involved in the definition of an Integration Information problem in New York State (NYS). In April 2003, the Criminal Justice Information Technology (CJIT) group of NYS was tasked with developing a framework to fulfill the goal of giving users of criminal justice data and information systems "one-stop shopping" access to the information needed to accomplish their mission. The research team of the Center for Technology in

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Government[2] (CTG) collaborated with the CJIT group for an eight-month period during 2003 to accomplish this task. The CJIT-CTG team went through a series of conversations to specify the business problem and its context, and to identify feasible solutions and alternatives. This paper reports on a system dynamics model for understanding the dynamics of the socio-technical processes that took place during this project. This model building effort is looking for the development of a theory of interorganizational collaboration. The model is being developed in facilitated group model building (GMB) sessions with the team at CTG. Although the model presented in this paper is still preliminary, the model is capable to generate interesting scenarios with reasonable changes in the initial values of some parameters. Moreover, the model illustrates a powerful way to use group model building and simulation as theory-building tools.

Key Words
Group Model Building, System Dynamics Modeling, Theory Building, Information Integration.

I. The Problem: Dynamic Implementation of Inter-Agency Information Intensive Projects

The purpose of this paper is to describe a dynamic theory of the socio-technical processes involved in the definition of an information integration problem in New York State (NYS). Information is one of the most valuable resources in government. "Information is a major input in government programs. Information is, in fact, a primary product of government activity. Collecting, housing, protecting, and using it well are fundamental responsibilities of the public sector" (Andersen and Dawes, 1991:14). There is an observed trend to make government information readily accessible to the public inside and outside government. These trends respond partially to the interest of government administration to improve internal efficiency (Dawes *et al.*, 2004), but also respond to a more general trend in government towards managing for results and improving customer satisfaction (Bardach, 1998).

Many programs oriented to improve government services require from two or more agencies to integrate and share their information resources in order to accomplish their objectives through the use of Information Technology (Dawes, 1996). Information integration in multi-organizational government settings involves complex interactions within social and technological contexts. "Organizations must establish and maintain collaborative relationships in which knowledge sharing is critical to resolving numerous issues relating to data definitions and structures, diverse database designs, highly variable data quality, and incompatible network infrastructure. These integration processes often involve new work processes and significant organizational change. They are also

[2] The Center for Technology in Government at the University at Albany develops applied research and partnership projects to foster innovative ways to improve government services through the understanding of the management, policy, and technology dimensions of information use in the public sector (http://www.ctg.albany.edu).

embedded in larger political and institutional environments which shape their goals and circumscribe their choices" (CTG, 2002).

Information technology (IT) initiatives fail year after year. Of a study of 8,000 projects in 1995, the Standish group found that 30% of them were canceled before completion, and 70% failed to deliver the expected features (Stallinger and Grünbacher, 2001). Managing IT projects in multi-organizational settings is a complex task for several reasons (Van Lamsweerde, 2000):

- The scope ranges from a world of human organizations to a technical artifact that must be integrated in it.
- There exist multiple parties involved -- customers, commissioners, domain experts, requirement engineers, users, programmers, etc.
- Each group of stakeholders holds multiple (sometimes conflicting) concerns, such as safety, security or usability.
- Errors during early stages in the project have an important impact in further stages of development.
- Projects involve multiple, intertwined activities -- domain analysis, elicitation, negotiation and agreement, specification, documentation, and evolution.

There is a growing group of researchers interested in understanding IT initiatives from both social and technical perspectives (Kling and Schacchi, 1982; Anderson, 1994; Berg, 1998; Doherty and King, 1998; Doherty and King, 1998; Mumford, 2000; Cresswell and Pardo, 2001; Davidson, 2002; Suchman, 2002; Arnold, 2003; Pardo et al, 2004). However, experiences from the field have revealed the need of getting a better understanding of both, the technology and the collaborative processes involved in its use, developing models to explain the interactions between social and technical factors, and to guide practice (Dawes and Pardo, 2003). The development of such models is a difficult task given that IT initiatives are complex phenomena involving the interactions around a particular technology "characterized by ongoing sensemaking among stakeholders, and it can be chaotic, nonlinear, and continuous" (Davidson, 2002:329).

II. A Multi-Method Research Approach

The model reported here is an integral part of a two-year research program that concentrates on integration activities in two critical policy areas: justice and public health since they include a full range of functions across all three levels of government. These are also areas in which significant integration initiatives are underway and available for study. Federal and state government agencies are collaborating in the research, as are organizations of government professionals concerned with information technology.

Understanding and supporting information integration is a multidisciplinary undertaking. The project therefore combines perspectives from organizational behavior, computer and information science, and political science. Two forms of modeling are being used: system dynamics modeling that emphasizes the continuous and non-linear feedback aspects of the process, and social process modeling that emphasizes the way collaboration and shared meanings are developed. These methods build on prior work of the investigators in interorganizational knowledge sharing, collaboration, and government technology innovation.

The research is being conducted in three overlapping phases. Phase one includes two intensive integration projects: one with the New York State Criminal Justice Information Technology Group (CJIT), which is comprised of seven New York State criminal justice agencies and the New York State Office of Technology; and one with the New York State Department of Health and related agencies involved in integrating information about the West Nile Virus. Phase two includes six field visits to other states to observe ongoing integration initiatives and to interview key actors. Phase three includes a survey designed to test the models of integration developed based on the results of phases one and two. Data is being collected throughout the three phases through individual and event observations, interviews, group decision conferences, and document analysis.

The model presented in this paper captures the dynamics of the work developed by CJIT during 2003 (see Figure 1). In April 2003, the Criminal Justice Information Technology (CJIT) group of New York State (NYS) was tasked with developing a framework to fulfill the goal of giving users of criminal justice data and information systems "one-stop shopping" access to the information needed to accomplish their mission. The action research team of the Center for Technology in Government (CTG) collaborated for an eight-month period during 2003 with the CJIT group to accomplish this task.

Following CTG's approach, the CJIT-CTG team went through a series of conversations to specify the business problem and its context, and to identify feasible solutions and alternatives (Dawes *et al.*, 2003). As a result, the formation of an Integrated Justice Advisory Board was seen as a critical first step in the establishment of the governance process necessary to achieve the goals of NYS Integrated Justice.

The final result of the team's work was a set of recommendations relating to the formation and operations of a NYS Integrated Justice Advisory Board. Although ambiguity and a diversity of views characterized the initial working meetings, the team was able to effectively share their understanding of "NYS Integrated Justice", and to develop a shared vision of the problem, alternative solutions, and strategic priorities.

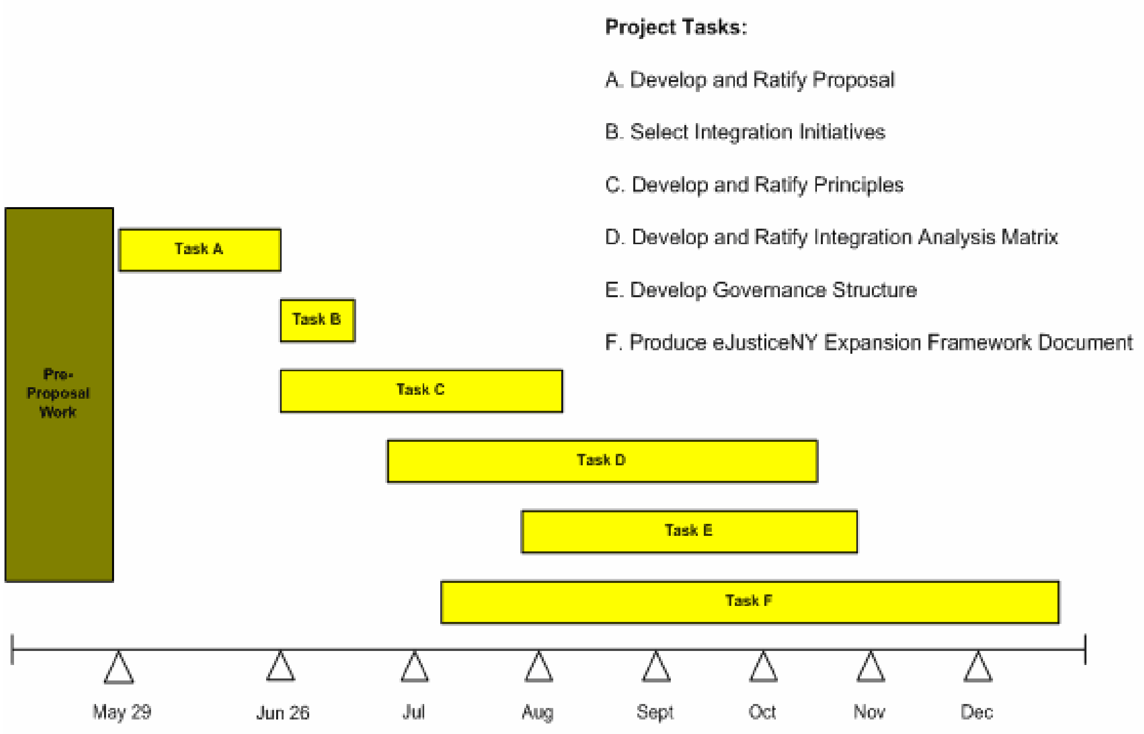

Figure 1. CJIT Project timeline.

The system dynamics model reported in this paper was built using the group model building (GMB) techniques developed by the group at the University at Albany (Richardson and Andersen, 1995; Andersen and Richardson, 1997; Rohrbaugh, 2000). A distinctive characteristic of these GMB sessions was their use as a theory-building method instead of a method to help groups of managers to tackle complex problems. The particular scripts used in this process are documented elsewhere in these proceedings (Luna-Reyes *et al.*, 2004).

System dynamics has proven useful in theory building efforts (Patrick, 1995; Black *et al.*, 2001; Repenning, 2002). Similarly to other qualitative theory-building approaches (Glaser and Strauss, 1967; Walsham, 1995; Eisenhardt, 2002), "a formal model is constructed by inferring from data and theoretical statements some hypotheses about causal relationships that generate a particular pattern of behavior over time observed in the case. Model-building proceeds iteratively by representing the hypotheses in a mathematical form, simulating, comparing the model output with observed behaviors, and returning to the observations and theories to refine the hypotheses represented in the model by changing its structure. In this sense, a formal model is a nontextual, mathematical expression of a theory of the cause-and-effect relationships that systematically produce the patterns of behavior observed in the field" (Black, 2002:120).

The basic building blocks of the model are stocks (accumulations), rates (activities explaining how the stocks change) and feedback structures (closed causal relationships). As pointed out by Black (Black, 2002:36-40) these building blocks are consistent with elements from sociological theory such as Weick's concept of activities (1979), Bourdieu's concept of accumulations (1990), and Giddens' concept of recursive interaction (1984). The modeling technique is also consistent with current research in information technology (DeSanctis and Poole, 1994; Orlikowski, 2000; Sarker, 2000; Fountain, 2001).

The mathematical nature of the method forces the analyst to be "quite exact and specific in attempting to specify causal dynamics that accomplish a satisfactory translation between verbal theory and empirical observations" (Hanneman and Patrick, 1997:457). Dynamic simulation helps to get a better understanding of verbal theories and any unexpected outcome obtained from them, with the potential to inform or improve the activities of both theorists and empirical analysts (Patrick, 1995).

III. A Generic Dynamic Theory of Inter-Agency Information Integration (III)

Modeling interagency collaboration is a line of work that emerged from the partnership between the System Dynamics Group at the University at Albany, and the Center for Technology in Government since 2001. Consistent with theory development on collaboration and innovation dynamics (Black, 2002; Repenning, 2002), the partnership has yielded a series of papers and models oriented to increase understanding of collaboration in the intergovernmental settings (Cresswell *et al.*, 2002; Black *et al.*, 2003; Luna-Reyes, 2004; Luna-Reyes *et al.*, 2004).

Using data gathered through the action research approach to information systems research (Baskerville, 1999), the approach combines the strengths for theory development of case studies (Benbastat *et al.*, 1987; Lee, 1989), and system dynamics modeling with groups (Richardson and Andersen, 1995; Vennix, 1996; Andersen and Richardson, 1997; Rouwette, 2003).

One of the initial conceptual efforts that the theory building effort yielded reflected the general process that many groups face when they get together for the first time to solve a problem or to develop a project (Gray, 1989; De Reuck *et al.*, 1999). At the beginning of this specific process, members of the CJIT had different, fuzzy conceptions of the task at hand; its objectives, goals, and the power structure inside and outside the group (see Figure 2). As the group got immersed in the social process associated with the work on the problem, the group got clarity on the problem definition, developing a shared vision and common understanding of Integrated Justice in NYS.

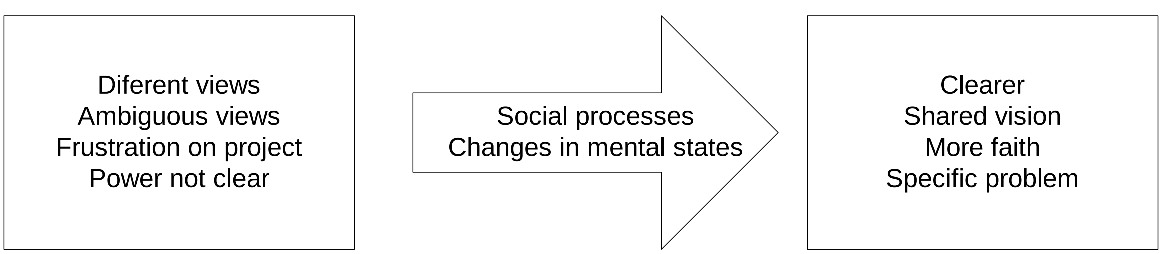

Figure 2. Preliminary Conceptual Icon.

Several pieces of stock-and-flow and feedback structures emerged from the group conversations as the main building blocks of the generic theory of the socio-technical process involved on the clarification of the meaning of Integrated Justice. Figure 3 shows the simplest of them, implying that group activity *created* several kinds of *artifacts* along the process. Moreover, the activity of *creating* artifacts was the result of a certain amount of *effort*, and some *effectiveness* associated with that effort. This common structure used in system dynamics practice helped the group to differentiate among different variables affecting the *creating* capacity of CJIT. Some of them could increase (or decrease) this capacity through motivating an increase (or decrease) in the amount of *effort*, and others could improve (or limit) the group *effectiveness*. The accumulation of artifacts could in turn affect some other variables in the process.

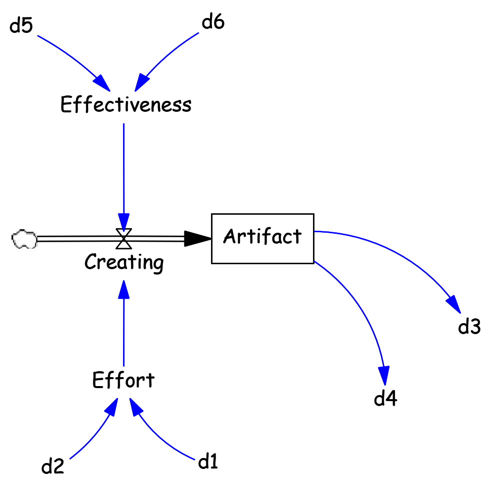

Figure 3. Creating artifacts results from effort and effectiveness.

A second set of generic insights about the process of defining Integrated Justice NY was associated with the idea that CJIT produced not only one kind of artifact, but several of them. Furthermore, these artifacts could be conceptualized as a chain of different group processes that "transformed" artifacts during the project (Figure 4). Along the creation of tangible artifacts, group processes also yielded the creation of several social accumulations such as understanding, trust, or engagement. The effectiveness in the creation of a social accumulation could also depend upon the current state of some other accumulations (i.e. the creation of engagement inside the group could be a function of the level of understanding).

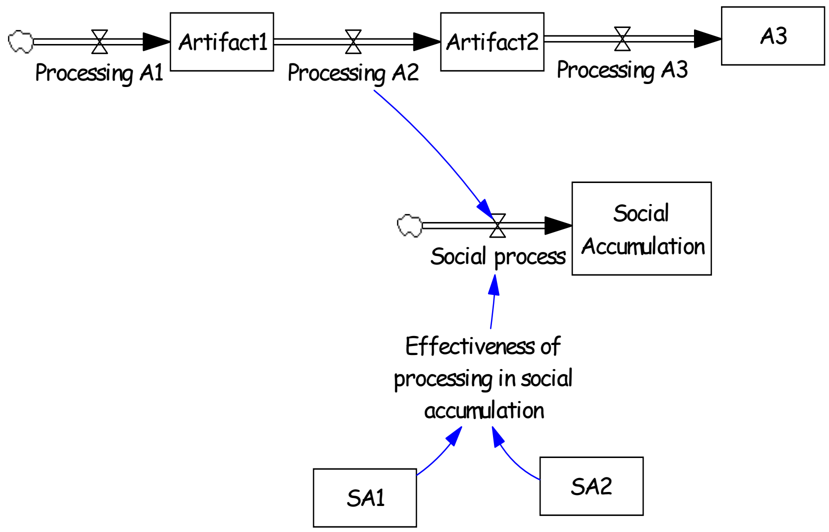

Figure 4. Acting builds social accumulations.

Overlapping the basic stock-and-flow structures of Figures 3 and 4 creates a series of reinforcing and counterbalancing feedback processes associated which each activity or group process in the project (see Figure 5). The three balancing loops in the figure could be considered control feedback processes. The two balancing loops in the bottom of the picture represent increases either in pressure or need to increase effort in a specific process in the project because of the accumulation of tangible artifacts. Increases in the quantity of artifacts 1, for example, create pressure to increase effort in process B. This process exists in many project models, in which accumulation of *work to do* create pressure to process that work, reducing the amount of tasks to be done, "pushing" them to the next process. Being a chain of processes, the lack of artifacts 2 creates the need of more effort in process B to create more artifacts for the next process, "pulling" artifacts to the next process. The counterbalancing loop in the upper part of the figure is another control loop representing reductions (or increases) in effectiveness as the group ran out (or accumulates) work to do, assuming processing is easier when the group has a lot of artifacts to work with.

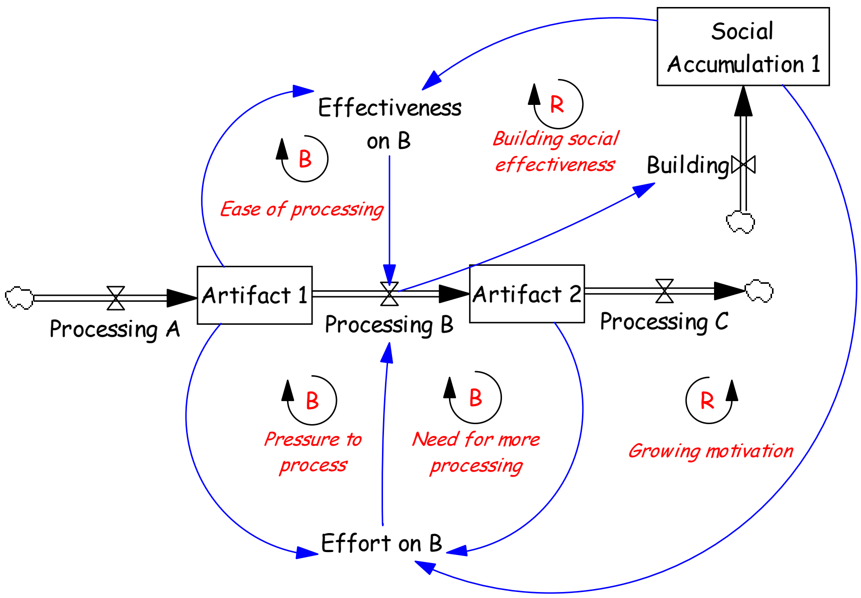

Figure 5. Generic processes creating technical artifacts in a social process.

The two reinforcing processes in the figure represent virtuous cycles or potential traps in the development of the project. On the upper side of the figure, the group builds effectiveness on the task as they build social capabilities or gets trapped in the process because of the lack of such capability. Additionally, increases on the social accumulation also have the potential of increasing motivation for devoting more effort to the project. Lack of such accumulation, however, is an additional trap for the group. For example, lack of understanding of the project objectives could prevent group members from investing time on task preventing further development of understanding.

IV. System Dynamics Model Structure for Inter-Agency Information Integration

As a result of the theory development process the modeling team selected three kinds of artifacts and four social accumulations to be included in the model of the Justice NY project (see Figure 6). The artifacts consisted of issues brainstormed, clarified, and formalized by the group to be transformed from raw issues to legitimate proposals. For example, if this structure were to be used to represent some form of development of an information system, Legitimate proposals might represent portions of code implemented by the organization (that is fully formalized). High quality rendered issues might represent data models or data dictionaries, intermediate products that are necessary to final formalization. The accumulation of Raw issues could include stakeholder maps, preliminary system specifications, or other facts that might occur early on in a system development cycle.

The main social accumulations considered in this initial theory include two representing individual accumulations (understanding and commitment), and two constituting group accumulations (understanding and engagement). In the final theory as illustrated below, all four of these social accumulations play important roles in facilitating or impeding the creation of artifacts. In turn, these four social accumulations are built as by-products of the process of working on the system. In many cases, project managers are focusing on *Brainstorming*, *Clarifying*, or *Formalizing* processes while at the same time their activities are creating Shared or Individual understanding, Individual commitment, or Group engagement. The exact process of defining these seven stocks has been more fully described in a separate paper appearing in these proceedings (Luna-Reyes *et al.*, 2004).

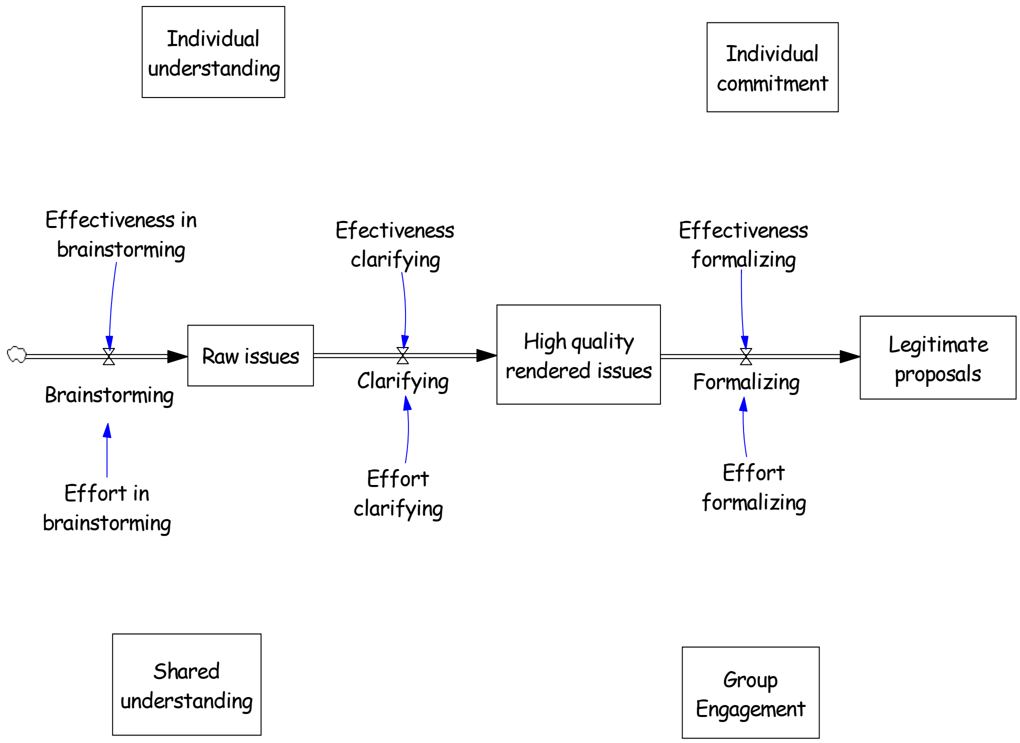

Figure 6. Overview of model stock and flow structure.

The research team spent considerable time working in a group model-building session to more fully specify the feedback relationships between these seven key stock variables. The research team captured major feedback effects in the model by looking at the causal forces driving *Brainstorming*, *Clarifying*, and *Formalizing*. Another key set of effects centered on processes associated with achieving legitimacy and full engagement of the client group. Each of these processes is described in brief below.

Brainstorming. The work of the system development group starts as it meets to brainstorm the raw issues and ideas that will later on be clarified and formalized. The existence of an upstream stock of High quality rendered issues or even fully complete Legitimate proposals will influence both the *Ease of brainstorming* and the *Need for brainstorming*. These first order effects show in Figure 7 serve to initiate a stream of needed Brainstorming and to close down the Brainstorming process once a pool of raw issues have been generated that are in balance with ideas being worked on down stream in the overall work chain. In this theory, a high level of individual understanding on the part of participants on the work team facilitates effective brainstorming. The bottom portion of Figure 7 indicates a final influence on the brainstorming process sometimes caused by confusion. If the individual members of the work team do not share a homogeneous view of the work process (indicated by the Diversity factor in Figure 7) the simple act of brainstorming and placing new ideas on the table can generate confusion for some members of the team. Hence brainstorming and confusing can be a co-flow. Confusing the group can decrease shared understanding and over time drop the actual effort devoted to brainstorming.

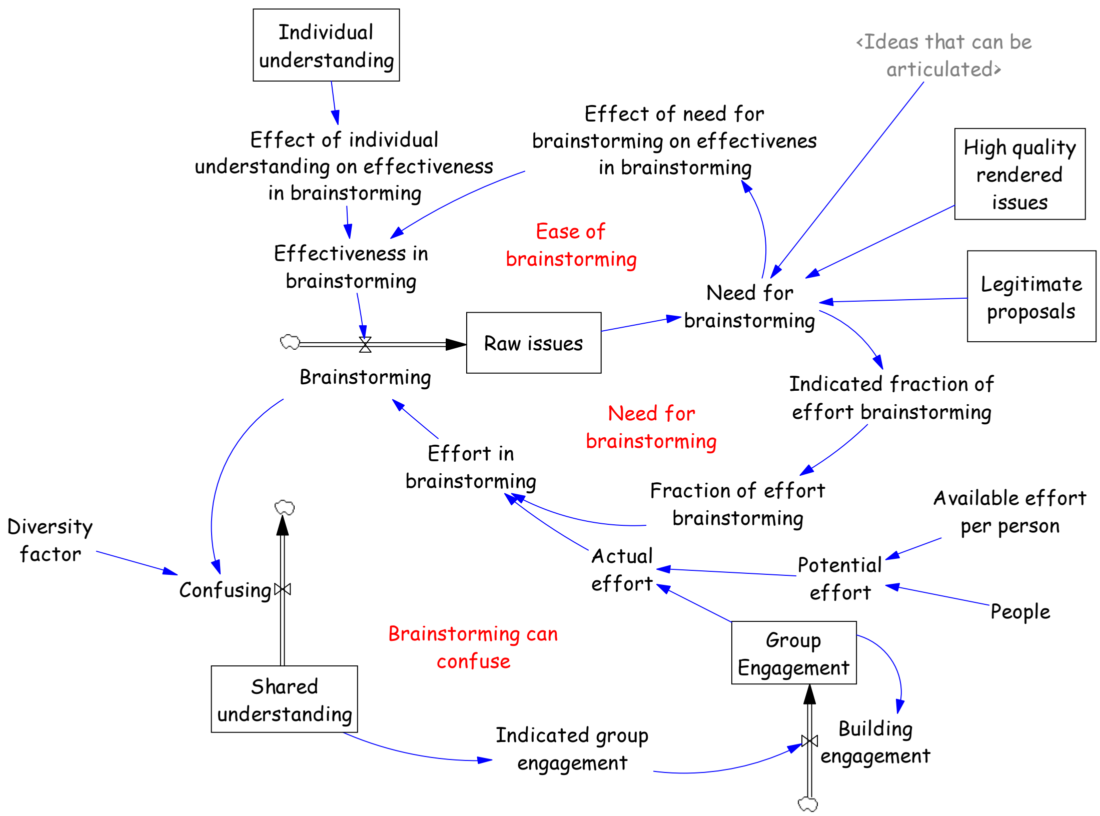

Figure 7. Key structures involved in brainstorming.

Clarifying. In our theory, the process of *Clarifying* transforms Raw issues into High quality rendered issues. The feedback loops presented in Figure 8 below indicate how the accumulation of artifacts in the system development process interact with social accumulations to both enhance and inhibit this focal clarifying process. As indicated in Figure 8, the simple process of accumulating Raw issues generates two first order controlling pressures. The first is an increasing *Pressure to process* which acts over time to allocate more effort to the clarification process. Similarly, *Pressure for clarifying* created by an accumulation of brainstormed issues works to increase the *Ease of processing*, thereby driving up the effectiveness of overall clarification. Figure 8 indicates two key social processes operating around the clarifying structure in the upper areas of the diagram.

As the total number of ideas being discussed (that is either clarified or formalized) increases, both individual and shared understanding increases. In turn, increases in Shared and Individual understanding touch off reinforcing processes of *Building* *individual effectiveness* and *Building social effectiveness*. These positive loops can act as virtuous cycles or traps to overall effectiveness in the clarifying process.

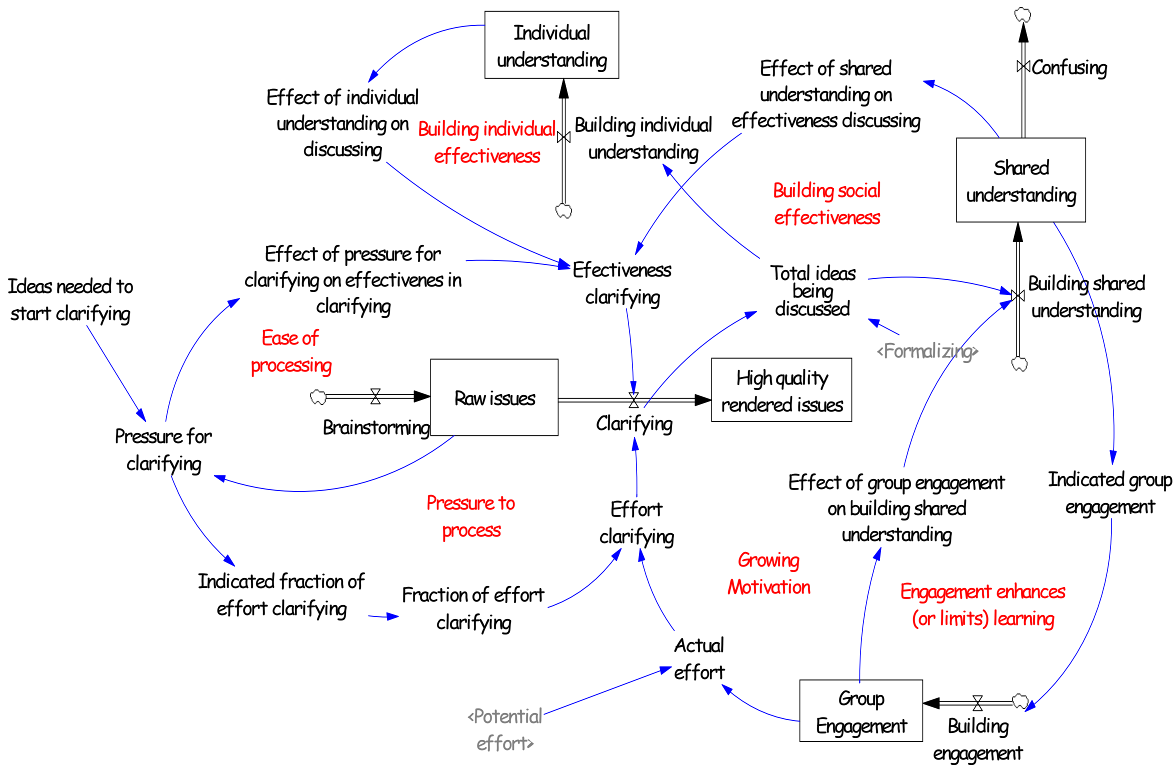

Figure 8. Key structures involved in clarifying.

Finally, Figure 8 illustrates two feedback effects impacting on overall clarifying processes that involve overall Group engagement. *Engagement enhances (or limits) learning* is a reinforcing cycle involving Shared understanding and Group engagement. Simply put, the model assumes that increasing levels of Shared understanding drive up overall Group engagement which feeds back to enhance (or inhibit) the *future Building of shared understanding*. The final feedback process shown in Figure 8, *Growing Motivation*, indicates that Group Engagement can enhance (or suppress) *Effort clarifying*, thereby closing an additional loop.

Formalizing. The final process of *Formalizing*, as shown in Figure 9, shares much common structure with the *Clarifying* flow as discussed above. *Pressure to process* and *Ease of processing* feedback loops act as first order controls on the formalization process. Similarly, feedback processes involving *Building individual effectiveness* and *Building social effectiveness* can reinforce the effectiveness of the formalizing process. A final set of parallel structures involve *Growing motivation* and a loop in which *Engagement enhances (or limits) learning*. Figure 9 shows a final feedback process that is not parallel to anything shown in the *Clarifying* structure. The *Ambiguity reduces engagement* senses the final proportion of all work initiated that has been completed and uses it to drive an ambiguity of final product measure. The lowest level of ambiguity results when the most work has been fully completed. The perception of ambiguity is modeled as a weighted average of the *Ambiguity about project products*, and *an Anticipated ambiguity of products*, implemented as a SMOOTH3 function. At the beginning of the project, the Perception of ambiguity starts at zero (equal to the Anticipated ambiguity of products), approaching to the observed *Ambiguity about project products* which results from the proportion of work done. The *Tolerance to ambiguity* (measured in Months) represents the number of months that the group can keep doing work without significant progress, thus tolerating a high level of ambiguity. Leaving work unfinished in an ambiguous state can ultimately shut down a process as ambiguity leads to Eroding engagement ultimately shutting down the *Actual effort* being applied to formalizing activities

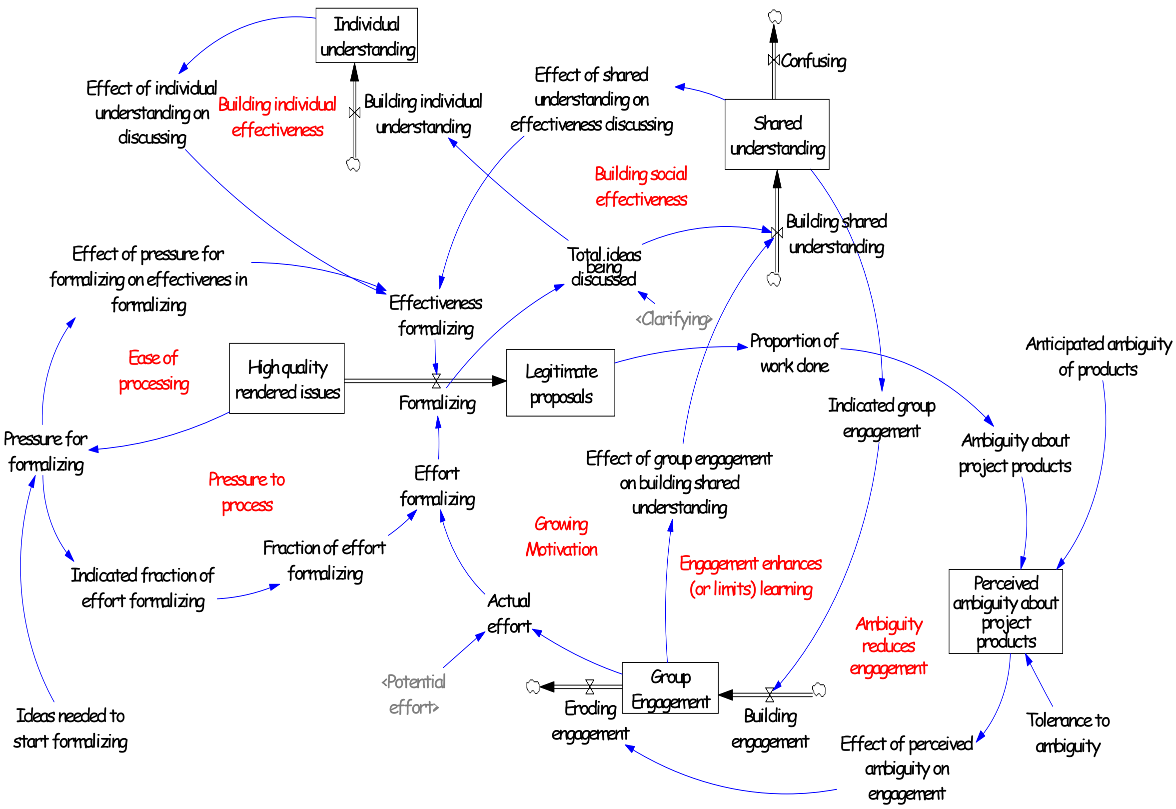

Figure 9. Key structures involved in formalizing.

Process legitimacy and group engagement. Figure 10 shows in overview the last feedback effect articulated by the research team. Portions of this key loop, *Legitimacy of the process enhances (or limits) engagement*, have been shown in Figures 8 and 9 above. In the portions of this loop that we have already seen, Engagement is driven by Shared understanding and acts to *enhance or limit effort* applied to both *Clarifying* and *Formalizing* work. Figure 10 illustrates a number of “soft” variables that the research team posited as playing a key role in achieving Group engagement. The Perceived legitimacy of the process is a dynamic variable that is driven by the Total ideas being discussed in the project, the Level of activity needed to perceive legitimacy, and the Average time to build a perception of legitimacy. Operating as an endogenous process, this loop says that open and prolonged group activity works with a delay to build a solid sense of process legitimacy.

A second set of factors, assumed to be exogenous for the purposes of the runs discussed below, also impact Perceived legitimacy of the process. The Exercise of group influence plays off against the Exercise of power by a strong or appointed leader of the group in determining overall process legitimacy. The presence of neutral facilitation by an external actor such as CTG can tip this delicate balance between group influences on the process and the exercise of power in the process. Moving both Group engagement and Perceived legitimacy of the process over a critical tipping point was found to be a prerequisite of success in both model simulations as well as in observations of the several projects studied in this research.

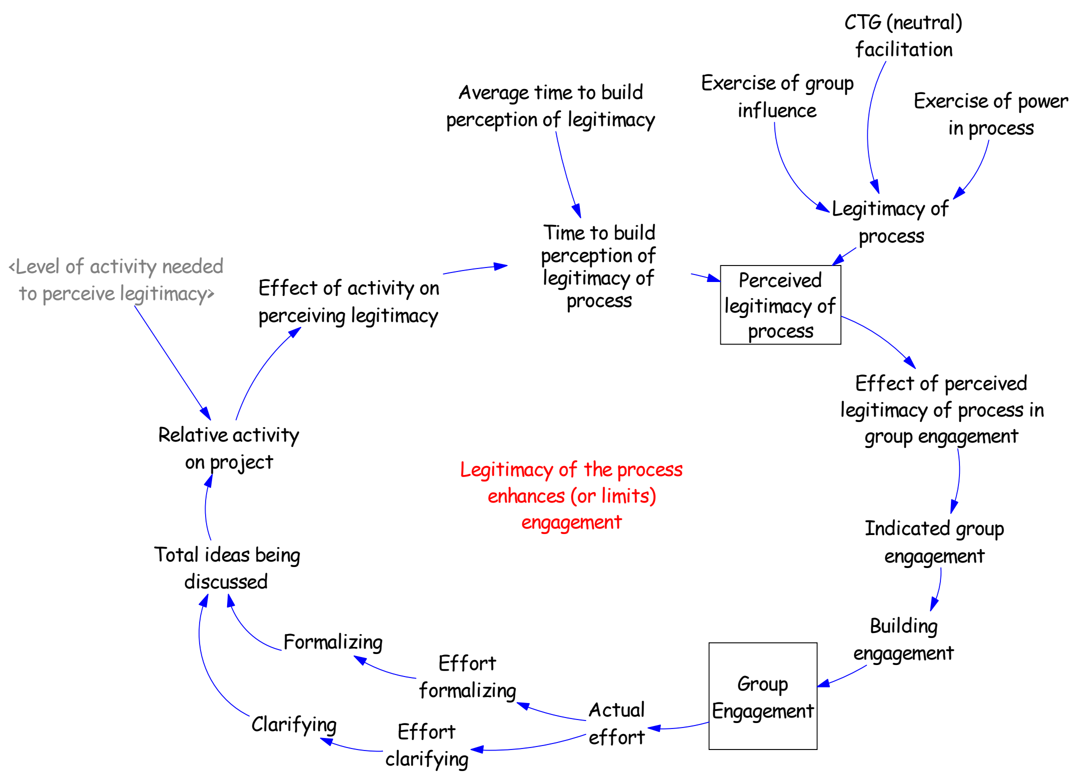

Figure 10. Process legitimacy and group engagement.

V. Model Behavior

The system structure illustrated in Figures 6 through 10 above represents a logically complete theory of a set of technical and social interactions that can create both successful and failing inter-agency integrated information projects. The import of this theory is that it can explain, within a single framework, common processes that can drive projects either to succeed or to fail. A preliminary simulation of these results is presented below.

The Model Interface. The model can be run interactively from a simple Vensim interface as shown in Figure 11 below. The base run simulation displayed in the interface illustrates a successful project spanning a period of 10 months. The stock of Raw issues jumps to nearly 20 by month one and tails off after that as clarifying and formalizing processes move raw issues forward to successful completion. High quality rendered issues peak between months 4 and 5 representing an orderly progression of accomplishment on the overall project. Finally, in this successful project, the number of Legitimate proposals rises through S-shaped growth to a final value of 40 at month 10. By clicking on the boxes immediately below the variables for the current run, the user can see dynamics for any of the seven stock variables shown in Figure 6 plus the two key variables, Perceived ambiguity about project products and Perceived legitimacy of the process—both key variables identified in Figure 10.

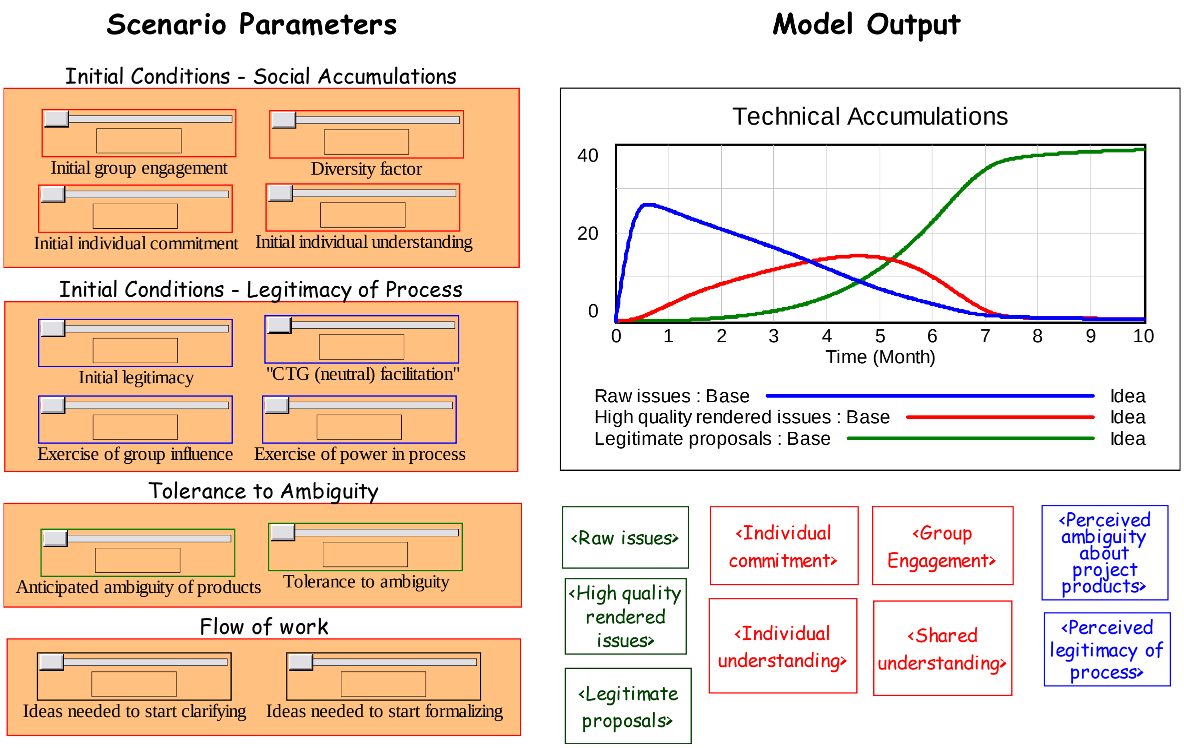

Figure 11. Preliminary model interface.

The sliders on the left side of the interface allow the user to experiment with key scenario parameters. Four sliders test for differences in initial conditions in the social accumulations and four sliders test for differences in initial conditions in the legitimacy of the process. Finally, two sliders can implement changes in assumptions concerning tolerance to ambiguity and two implement changes in assumptions about flow of work.

Scenarios. In principle, a wide variety of scenarios can be run in the preliminary simulation model developed in this research. Figure 12 illustrates three simple scenarios that were created by changing just one parameter in the simulation. In addition to showing changes needed to implement these three scenarios, Figure 12 gives the values for a dozen of the key assumed values in the final simulation. Many of the variables are dimensionless scaled from 0 to 1. For example Initial group engagement could range from none to a maximally engaged group at the start of the project with a value of 1. For the base run, Initial group engagement is set moderately high at .7. Tolerance to ambiguity is set at 10 in this simulation run except for the Small tolerance to ambiguity scenario where it is set to only 3. By comparing this scenario run to the base run, the user can see the "pure" effect of the Tolerance to ambiguity parameter. Finally the Ideas needed to start clarifying and formalizing set a scale factor for the model—in each case 20 ideas are enough to trigger clarifying and formalizing activities within the simulation. These assumptions do not change in any of the scenarios reported in this paper.

Run / Scenario Parameter	Base	Not neutral facilitation	Innovative technology	Small tolerance ambiguity
Initial group engagement [0,1]	0.7	0.7	0.7	0.7
Diversity factor [0,1]	0.5	0.5	0.5	0.5
Initial individual understanding [0,1]	0.7	0.7	***0.25***	0.7
Initial individual commitment [0,1]	0.7	0.7	0.7	0.7
Initial legitimacy [0,1]	0.1	0.1	0.1	0.1
Exercise of group influence [0,1]	1.0	1.0	1.0	1.0
Exercise of power on process [0,1]	1.0	1.0	1.0	1.0
CTG (neutral) facilitation [0,1]	0.8	***0.2***	0.8	0.8
Anticipated ambiguity of products [0,1]	0.0	0.0	0.0	0.0
Tolerance to ambiguity (0,n)	10.0	10.0	10.0	***3.0***
Ideas needed to start clarifying (0,n)	20.0	20.0	20.0	20.0
Ideas needed to start formalizing (0,n)	20.0	20.0	20.0	20.0

Figure 12. Parameter values defining selected scenarios.

The Not neutral facilitation scenario is exactly the same as the base run except that the strength of CTG (neutral) facilitation drops from .8 to .2, testing the impact of neutral facilitation on the process legitimizing loop as shown in Figure 10. The innovative technology scenario is implemented by dropping Initial individual understanding from an assumed value of .7 to .25, thereby creating a situation where individuals involved in the project begin their work with less base-level comprehension of the technology being used in the project. Finally, the small tolerance to ambiguity scenario is implemented by reducing the number of months that the group can tolerate with high level of ambiguity (small progress) to 3 months.

Simulations implementing these three simulations are presented in Figures 15 through 19 below.

Base Run. The base run shows a project that is successful over a ten month time frame. Figure 13 shows the three technical accumulations in the base run as shown and described in the user interface immediately above.

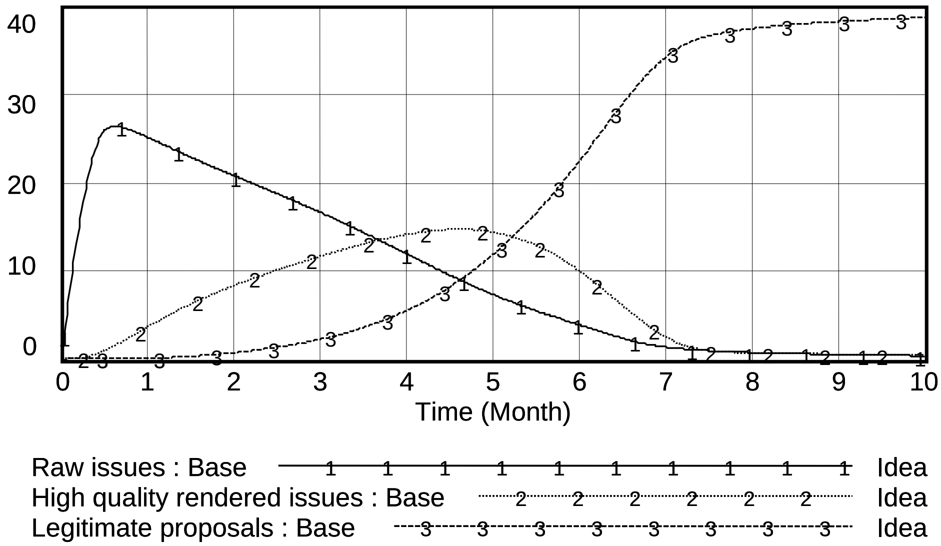

Figure 13. Technical accumulations in the base run.

Figure 14 shows the over time behavior of the social accumulations in the base run. In this run, Group engagement, Individual commitment, and Individual understanding all start at a high initial value of .7. Shared understanding starts out relatively low at .3 representing the assumption that the key task facing the system development group is developing such a shared understanding.

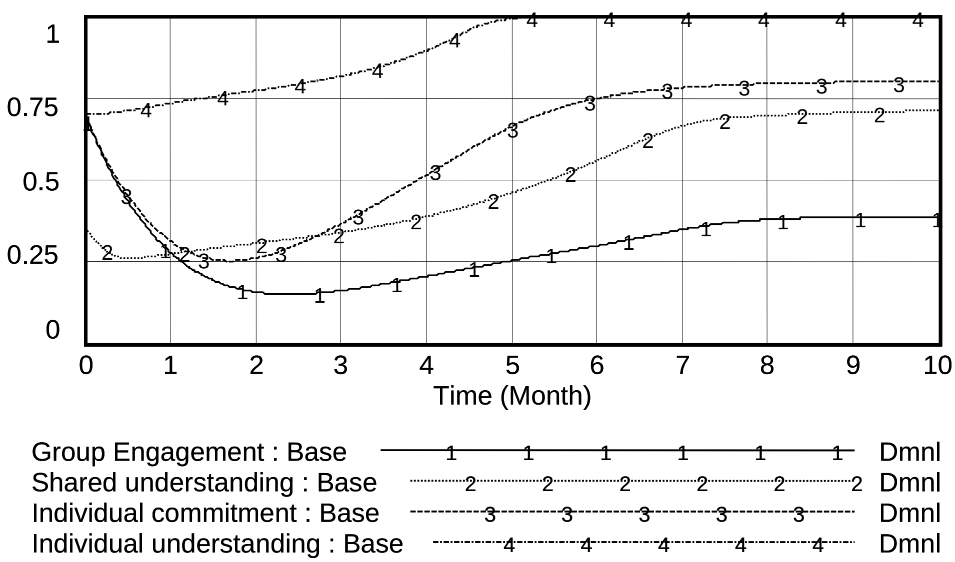

Figure 14. Social accumulations in the base run.

As shown in Figure 14, feedback processes in the base run lead to a rapid initial fall off in group engagement as well as individual commitment. The loop responsible for this fall is the loop of *Legitimacy of the process*. The project is not making satisfactory progress on clarifying issues and formalizing proposals to keep these levels high. However, as progress is made and the process is perceived as legitimate, Individual commitment makes a come back and the decline in Group engagement halts. Strong growth in individual understanding near the beginning of the project fuels the recovery of the social accumulations. Importantly, after a slight initial decline (caused by the confusion that emerges during brainstorming), shared understanding rises steadily through the base run. The dynamics of these social accumulations can vary dramatically over the three scenarios causing both project failure and overall success.

Comparative Runs. Figure 15 contrasts a successful base run against three scenarios, all of which have difficulty achieving a high level of Legitimate proposals at the end of 10 months. Although in the three scenarios the low level of legitimate proposals can be traced to low levels of group engagement (see Figure 16), three different feedback processes are responsible for the low levels of engagement in each scenario.

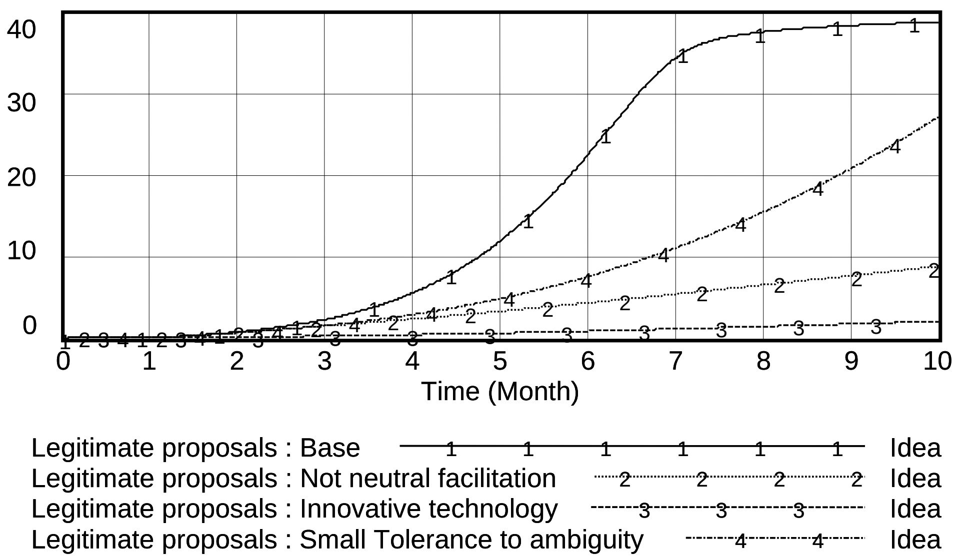

Figure 15. Comparative plot of legitimate proposals across scenarios.

In the Small Tolerance to ambiguity run engagement does not accumulate as fast as in the base run because of the erosion process depicted in Figure 9. The higher levels of perceived ambiguity caused by the smaller Tolerance to ambiguity increase the erosion of group engagement making Engagement to grow slower. The Not neutral facilitation run fails to take off because the Legitimacy of the process is being disrupted by the Exercise of power in the process as shown and discussed in Figure 10. The lack of legitimacy also prevents the group to engage in the project. Finally, the Innovative technology run fails to achieve success because individual understanding fails to take off and subsequently suppresses shared understanding of how the whole system will work as a whole. The lack of shared understanding prevents the group to engage in the whole process as shown in Figures 7 through 9. As second order effects, low levels of individual and shared understanding disrupt brainstorming and clarifying at the front end of the system as well as formalizing near the back end of the system.

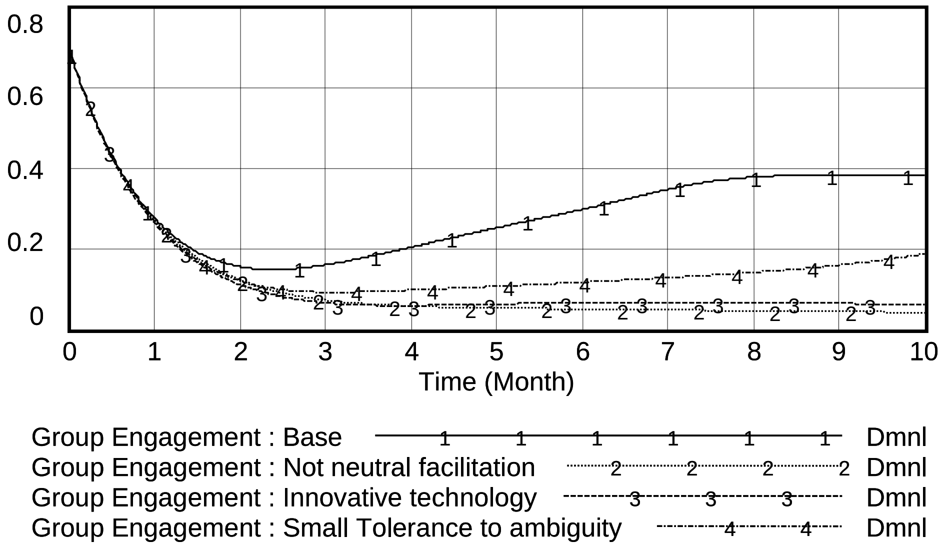

Figure 16. Comparative Plot of Group Engagement across the scenarios.

A key feature to note in Figures 15 and 16 is that the same hypothesized causal structure can drive both project success and failure. However, the model also illustrates multiple distinct modes of failure as feedback loops at both the front end of the system and the back end of the system must work in unison to create an overall successful project.

Figure 17 shows a comparative plot of the behavior of Shared understanding across the four scenarios. The initial value of Shared understanding is a Function of Individual Understanding and the Diversity factor. In this way, the difference in the initial conditions of Individual understanding in the Innovative technology scenario explains the difference in the initial values of Shared Understanding. All runs show a small decrease in Shared Understanding in the initial month of the project. This reduction in understanding is caused by the initial confusion caused by brainstorming individual (and different) views of the project in the brainstorming phase (see Figure 7).

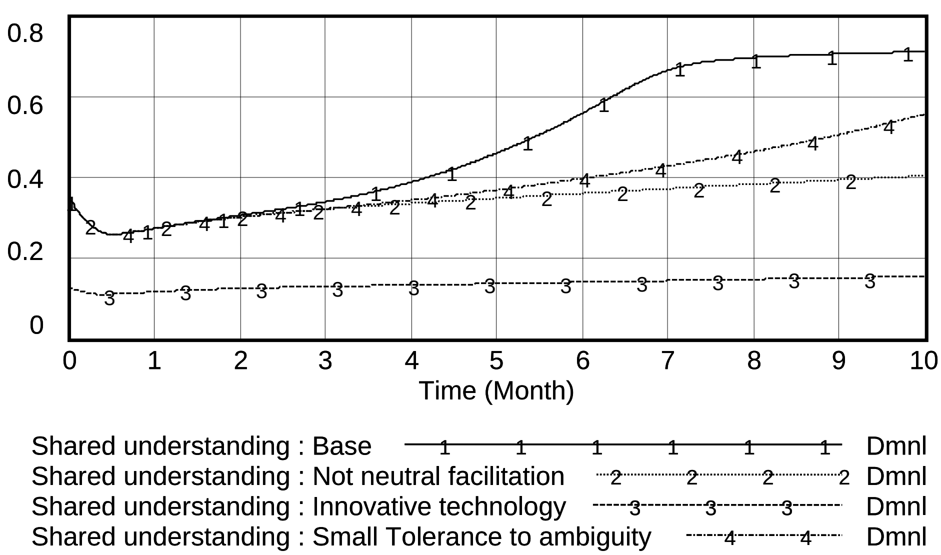

Figure 17. Comparative plot of shared understanding across the scenarios.

Shared understanding builds as the group engages in the discussion of different ideas related to the project (clarifying and formalizing). Similarly, individual understanding grows as the committed individual gets involved in the conversation. In the Innovative technology scenario, Individual understanding does not take of (see Figure 18) because of a reinforcing trap existing between individual commitment and individual understanding. Individuals in the group do not understand the technology, promoting then low levels of individual commitment. Low levels of commitment in turn limit their capacity to learn and build individual effectiveness. The small effectiveness of the group affects the amount of ideas discussed limiting their capability to build shared understanding (Figure 17). Lower levels of Shared understanding in the Not neutral facilitation and Small tolerance to ambiguity scenarios can be traced to low levels of engagement. These low levels of engagement are explained by different feedback processes as described in previous paragraphs.

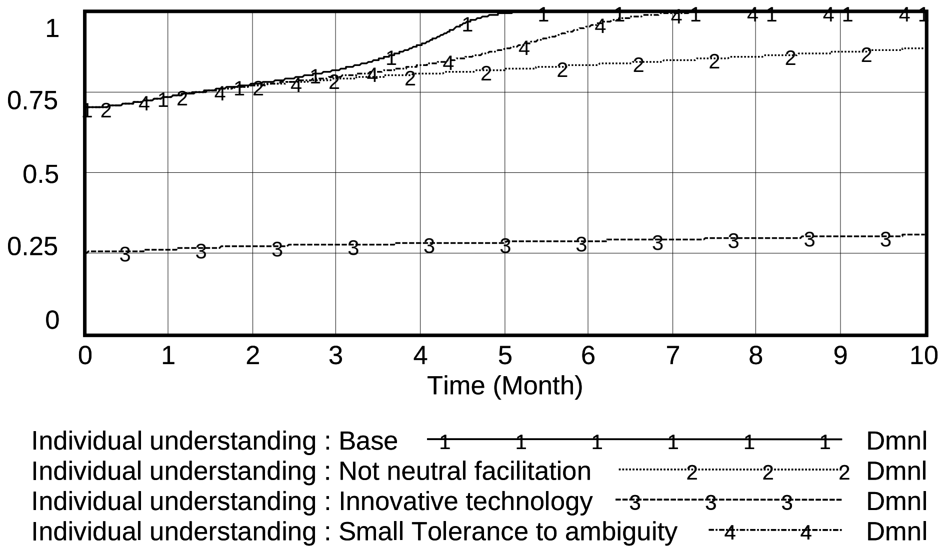

Figure 18. Comparative plot of individual understanding across scenarios.

Figures 18 and 19 present comparative graphs of the behavior of Individual Understanding and Individual commitment. In the scenario of innovative technology, individual understanding does not grow because of the trap involving individual understanding and individual commitment described in the previous paragraph. In the case of Not neutral facilitation, individual understanding grows slower and individual commitment stays low because of the lack of legitimacy of the process (see Figure 10). In the Small tolerance to ambiguity, the behavior is similar to the base run, but it took longer to build both individual commitment and understanding. Both behaviors can be explained because of the erosion of engagement caused by the small tolerance to ambiguity.

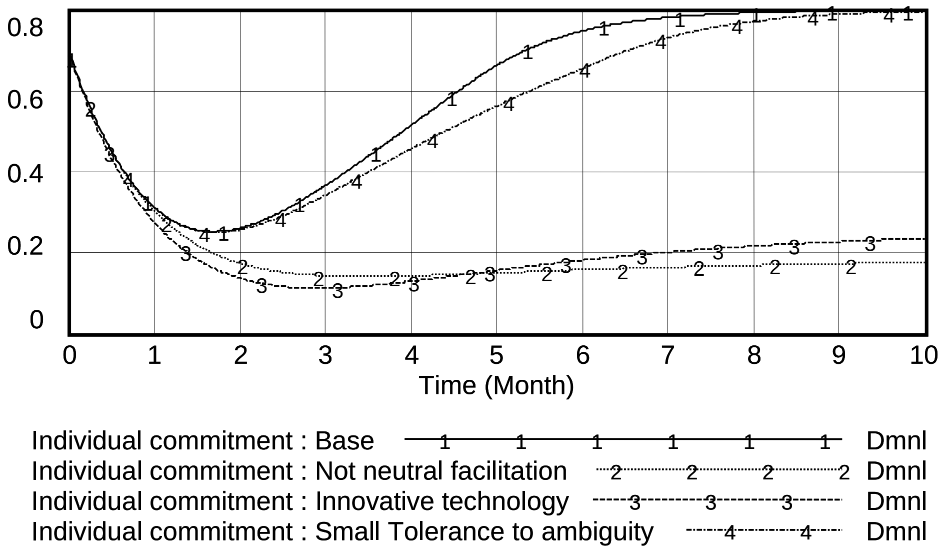

Figure 19. Comparative plot of Individual commitment across the scenarios.

VI. Discussion and Future Research

The model presented in this paper is still preliminary and further work needs to be done. However, the model is capable to generate interesting behaviors with reasonable changes in the initial values of some parameters. Moreover, the modeling tool is highly consistent with the literature describing socio-technical processes, which describe them as recursive interactions among technical and social elements, thus full of feedback processes. The model illustrates a powerful way to use group model building and simulation as theory-building tools. Some of the main issues discussed during the last two GMB sessions that need to be fully addressed in the future are listed in Appendix B.

Validating and confirming this initial theory remains a challenge to this stream of research. Such a theory needs to generalize beyond the several cases upon which this formal model is based. The two-year project of which this theory-building exercise forms an integral part includes in its plans an empirical follow up with participants involved in integration initiatives at six selected sites plus a national survey. This follow up research will involve both focus groups and survey research.

References

Andersen, D. and S. Dawes (1991). Government information management. A primer and casebook. Englewood Cliffs, NJ, Prentice Hall.

Andersen, D. F. and G. P. Richardson (1997). "Scripts for group model building." System Dynamics Review **13**(2): 107-129.

Anderson, R. J. (1994). "Representations and requirements: The value of ethnography in system design." Human-Computer Interaction **9**(2): 151-182.

Arnold, M. (2003). Systems design meets habermas, foucault and latour. Socio-technical and human cognition elements of information systems. S. Clarke, E. Coakes, M.

G. Hunter and A. Wenn. Hershey, PA, Information Science Publishing (an imprint of Idea Group, Inc.)**:** 226-248.

Bardach, E. (1998). Getting agencies to work together: The practice and theory of managerial craftmanship. Washington, DC, Brookings Institution Press.

Baskerville, R. L. (1999). "Investigating information systems with action research." Communications of the AIS **2**(19): 1-32.

Benbastat, I., D. Goldstrein and M. Mead (1987). "The case research strategy in studies of information systems." MIS Quarterly **11**(3): 369-386.

Berg, M. (1998). "The politics of technology: On bringing social theory into technological design. (humans, animals, and machines)." Science, Technology, and Human Values **23**(4): 456-488.

Black, L. (2002). Collaborating across boundaries: Theoretical, empirical, and simulated explorations. Sloan School of Management. Cambridge, MA, MIT.

Black, L., P. Carlile and N. Repenning (2001). A dynamic analysis of cross-boundary behaviors emerging from similar organizations. Academy of Management, Washington, DC.

Black, L. J. (2002). Collaborating across boundaries: Theoretical, empirical, and simulated explorations. Sloan School of Management. Cambridge, MA, MIT.

Black, L. J., A. M. Cresswell, T. A. Pardo, F. Thompson, D. S. Canestraro, M. Cook, L. F. Luna, I. J. Martinez, D. F. Andersen and G. P. Richardson (2003). A dynamic theory of collaboration: A structural approach to facilitating intergovernmental use of information technology. Hawaiian International Conference on System Sciences-36, Hawaii, IEEE.

Cresswell, A. M., L. J. Black, D. S. Canestraro, M. Cook, T. A. Pardo, F. Thompson, L. F. Luna, I. J. Martinez, D. F. Andersen and G. P. Richardson (2002). Evolution of a dynamic theory of collaboration: Modeling intergovernmental use of information technology. 20th International System Dynamics Conference, Palermo, Italy, System Dynamics Society.

Cresswell, A. M. and T. A. Pardo (2001). "Implications of legal and organizational issues for urban digital government development," Government Information Quarterly **18** (4): 269-278.

CTG (2002). Modeling interorganizational information integration: Project description. Albany, NY. http://www.ctg.albany.edu/projects/miii?proj=miii&sub=summary.

Davidson, E. (2002). "Technology frames and framing: A socio-cognitive investigation of requirements determination." MIS Quarterly **26**(4): 329-358.

Dawes, S. (1996). "Interagency information sharing: Expected benefits, manageable risks." Journal of Policy Analysis and Management **15**(3): 377-394.

Dawes, S. and T. Pardo (2003). Building collaborative digital government systems: Systemic constraints and effective practices. Advances in digital government: Technology, human factors, and policy. W. J. McIver and A. K. Elmagarmid. Boston, MA, Kluwer Academic Publishers**:** 259-273.

Dawes, S. S., T. A. Pardo and A. M. Cresswell (2004). "Designing electronic government information access programs." Government Information Quarterly **21**(1): 3-23.

Dawes, S. S., T. A. Pardo, S. Simon, A. M. Cresswell, M. F. LaVigne, D. F. Andersen and P. A. Bloniarz (2003). Making smart it choices: Understanding value and risk in government it investments. Albany, NY, Center For Technology in

Government, University at Albany/SUNY. http://www.ctg.albany.edu/publications/guides/smartit2/smartit2.pdf.
De Reuck, J., O. Schmidenberg and D. Klass (1999). "A reconceptualisation of decision conferencing: Towards a command methodology." International Journal of Technology Management **17**(1/2): 195-207.
DeSanctis, G. and M. S. Poole (1994). "Capturing the complexity in advanced technology use: Adaptive structuration theory." Organization Science **5**(2): 121-147.
Doherty, N. F. and M. King (1998). "The consideration of organizational issues during the systems development process: An empirical analysis." Behaviour & Information Technology **17**(1): 41-51.
Doherty, N. F. and M. King (1998). "The importance of organisational issues in systems development." Information Technology & People **11**(2): 104-123.
Eisenhardt, K. (2002). Building theories from case study research. The qualitative research companion. A. M. Huberman and M. B. Miles. London, Sage Publications.
Fountain, J. (2001). Building the virtual state: Information technology and institutional change. Washington, D.C., The Brookings Institution.
Glaser, B. G. and A. L. Strauss (1967). The discovery of grounded theory: Strategies for qualitative research. Chicago, Aldine Publishing Company.
Gray, B. (1989). Collaborating: Finding common ground for multiparty problems. San Francisco, CA, Jossey-Bass Inc.
Hanneman, R. and S. Patrick (1997). "On the uses of computer-assisted simulation modeling in the social sciences." Sociological research Online **2**(2).
Kling, R. and W. Schacchi (1982). The web of computing: Computer technology as social organization. Advances in computers. M. V. Zelkowitz. New York, Academic Press. **21:** 1-90.
Lee, A. S. (1989). "A scientific methodology for mis case studies." MIS Quarterly **13**(1): 33-50.
Luna-Reyes, L. F. (2004). Collaboration, trust and knowledge sharing in information-technology-intensive projects in the public sector. School of Information Science and Policy. Albany, NY, University at Albany.
Luna-Reyes, L. F., A. M. Cresswell and G. P. Richardson (2004). Knowledge and the development of interpersonal trust: A dynamic model. Hawiaiian International Conference on System Sciences-37, Hawaii, IEEE.
Luna-Reyes, L. F., M. Mojtahedzadeh, D. F. Andersen, G. P. Richardson, T. A. Pardo, B. Burke, Y.-j. Wu, A. M. Cresswell, T. Bodor, D. Canestraro, S. Dawes, F. Demircivi, and F. Thompson (2004). Scripts for group model building: Modeling the emergence of governance for information integration across government agencies. 22nd International Conference of The System Dynamics Society, Oxford, England, System Dynamics Society.
Mumford, E. (2000). "A socio-technical approach to systems design." Requirements Engineering **5**(2): 125-133.
Orlikowski, W. (2000). "Using technology and constituting structures: A practice lens for studying technology in organizations." Organization Science **11**(4): 404-428.
Pardo, T. A.,Cresswell, A. M., Dawes, S. S. & Burke, G. B. (2004). "Modeling the Social and Technical Processes of Interorganizational Information Integration."

Proceedings of the 37th Hawaiian International Conference on System Sciences. IEEE Computer Society Press: Los Alamitos CA.
Patrick, S. (1995). "The dynamic simulation of control and compliance processes in material organizations." Sociological Perspectives **38**(4): 497-518.
Repenning, N. (2002). "A simulation-based approach to understanding the dynamics of innovation implementation." Organization Science **13**(2): 109-127.
Richardson, G. P. and D. F. Andersen (1995). "Teamwork in group model building." System Dynamics Review **11**(2): 113-137.
Rohrbaugh, J. (2000). The use of system dynamics in decision conferencing. Handbook of public information systems. D. Garson. New York, Marcel Dekker: 521-533.
Rouwette, E. A. J. A. (2003). Group model building as mutual persuasion. Nijmegen, Wolf Legal Publishers.
Sarker, S. (2000). "Toward a methodology for managing information systems implementation: A social constructivist perspective." Informing Science **3**(4): 195-205.
Stallinger, F. and P. Grünbacher (2001). "System dynamics modelling and simulation of collaborative requirements engineering." The Journal of Systems and Software **59**(3): 311-321.
Suchman, L. (2002). "Practice-based design of information systems: Notes from the hyperdeveloped world." Information Society **18**(2): 139-144.
Van Lamsweerde, A. (2000). Requirements engineering in the year 00: A research perspective. 22nd International Conference in Software Engineering, Limerick, Ireland, IEEE Computer Society.
Vennix, J. A. M. (1996). Group model building: Facilitating team learning using system dynamics. Chichester, Wiley.
Walsham, G. (1995). "Interpretive case studies in is research: Nature and method." European Journal of Information Systems **4**(2): 74-81.

Appendix A: Equation Listings for the Vensim Model[3]

(001) Actual effort=
Potential effort*Effect of work done on effort*Group Engagement
Units: People*Hour/Month

(002) Ambiguity about project products= WITH LOOKUP (
Proportion of work done,
([(0,0)-(1,1)],(0,1),(0.1,0.99),(0.2,0.95),(0.3,0.85),(0.4,0.7),(0.5,0.5
),(0.6,0.3),(0.7,0.15),(0.8,0.05),(0.9,0.01),(1,0)))
Units: Dmnl

(003) Anticipated ambiguity of products=
0
Units: Dmnl [0,1,0.05]

(004) Available effort per person=
8
Units: Hour/Month

[3] The Vensim Model is in the CD as a supplementary file.

(005) Average effectiveness formalizing=
0.5
Units: Idea/(People*Hour) [0,2,0.05]

(006) Average effectiveness in brainstorming=
1
Units: Idea/(People*Hour)

(007) Average effectiveness in clarifying=
0.5
Units: Idea/(People*Hour) [0,2,0.05]

(008) Average time to build perception of legitimacy=
2
Units: Month

(009) Brainstorming=
Effectiveness in brainstorming*Effort in brainstorming
Units: Idea/Month

(010) Building commitment=
(Indicated individual commitment-Individual commitment)/Time for individual understanding to impact commitment
Units: 1/Month

(011) Building engagement=
(Indicated group engagement-Group Engagement)/Time for shared understanding to impact engagement
Units: 1/Month

(012) Building individual understanding=
Individual understanding per idea discussed*Total ideas being discussed*Effect of previous individual understanding on building new understanding
*Effect of individual commitment on building individual understanding
Units: 1/Month

(013) Building shared understanding=
Total ideas being discussed*Shared understanding per idea discussed*Effect of group engagement on building shared understanding
*Effect of previous shared understanding on building new understanding
Units: 1/Month

(014) Clarifying=
Effort clarifying*Efectiveness clarifying
Units: Idea/Month

(015) Confusing=
Brainstorming*Shared understanding eroded per idea brainstormed*Effect of existing shared understanding on eroding understanding
*(1-Diversity factor)
Units: 1/Month

(016) "CTG (neutral) facilitation"=
0.8
Units: Dmnl [0,1,0.01]

A value smaller than one represents non-effective facilitation
techniques, and a value greater than one represents effective
facilitation techniques

(017) Diversity factor=
0.5
Units: Dmnl [0,1,0.05]

(018) Efectiveness clarifying=
Average effectiveness in clarifying*Effect of shared understanding on effectiveness discussing
*Effect of individual understanding on discussing*Effect of pressure for clarifying on effectivenes in clarifying
Units: Idea/(People*Hour)

(019) Effect of activity on perceiving legitimacy= WITH LOOKUP (
Relative activity on project,
([(0,0)-(2,2)],(0,2),(0.2,1.37719),(0.4,0.88),(0.6,0.63),(0.8,0.46),(1,0.33
),(1.2,0.25),(1.4,0.19),(1.6,0.17),(1.8,0.15),(2,0.14)))
Units: Dmnl

(020) Effect of existing shared understanding on eroding understanding= WITH LOOKUP
(
Percentage of shared understanding,
([(0,0)-(1,1)],(0,0),(0.1,0.35),(0.2,0.61),(0.3,0.775),(0.4,0.865),(0.5,
0.93),(0.6,0.965),(0.7,0.985),(0.8,0.99),(0.9,0.995),(1,1)))
Units: Dmnl

(021) Effect of group engagement on building shared understanding= WITH LOOKUP
(
Group Engagement,
([(0,0)-(1,2)],(0,0.5),(0.1,0.54),(0.2,0.6),(0.3,0.69),(0.4,0.82),(0.5,1
),(0.6,1.26),(0.7,1.5),(0.8,1.73),(0.9,1.89),(1,2)))
Units: Dmnl

(022) Effect of individual commitment on building individual understanding=
WITH LOOKUP (
Individual commitment,
([(0,0)-(1,2)],(0,0.5),(0.1,0.54),(0.2,0.6),(0.3,0.69),(0.4,0.82),(0.5,1
),(0.6,1.26),(0.7,1.5),(0.8,1.73),(0.9,1.89),(1,2)))
Units: Dmnl

(023) Effect of individual understanding on discussing= WITH LOOKUP (
Individual understanding,
([(0,0)-(1,2)],(0,0.5),(0.1,0.54),(0.2,0.6),(0.3,0.69),(0.4,0.82),(0.5,1
),(0.6,1.26),(0.7,1.5),(0.8,1.73),(0.9,1.89),(1,2)))
Units: Dmnl

(024) Effect of individual understanding on effectiveness in brainstorming=
WITH LOOKUP (
Individual understanding,
([(0,0)-(1,2)],(0,0.5),(0.1,0.54),(0.2,0.6),(0.3,0.69),(0.4,0.82),(0.5,1
),(0.6,1.26),(0.7,1.5),(0.8,1.73),(0.9,1.89),(1,2)))
Units: Dmnl

(025) Effect of need for brainstorming on effectivenes in brainstorming= WITH LOOKUP

(
Need for brainstorming,
([(0,0)-(1,1)],(0,0),(0.1,0.62),(0.2,0.78),(0.3,0.88),(0.4,0.93),(0.5,0.97
),(0.6,0.975),(0.7,0.98),(0.8,0.985),(0.9,0.99),(1,1)))
Units: Dmnl

(026) Effect of perceived ambiguity on engagement= WITH LOOKUP (
Perceived ambiguity about project products,
([(0,0)-(1,1)],(0,0),(0.1,0.1),(0.2,0.2),(0.3,0.3),(0.4,0.4),(0.5,0.5),(
0.6,0.6),(0.7,0.7),(0.8,0.8),(0.9,0.9),(1,1)))
Units: Dmnl

(027) Effect of perceived legitimacy of process in group engagement= WITH LOOKUP
(
Perceived legitimacy of process,
([(0,0)-(1,1)],(0,0),(0.1,0.1),(0.2,0.2),(0.3,0.3),(0.4,0.4),(0.5,0.5),(
0.6,0.6),(0.7,0.7),(0.8,0.8),(0.9,0.9),(1,1)))
Units: Dmnl

(028) Effect of perceived legitimacy of process in individual commitment= WITH LOOKUP
(
Perceived legitimacy of process,
([(0,0)-(1,1)],(0,0),(0.1,0.1),(0.2,0.2),(0.3,0.3),(0.4,0.4),(0.5,0.5),(
0.6,0.6),(0.7,0.7),(0.8,0.8),(0.9,0.9),(1,1)))
Units: Dmnl

(029) Effect of percentage of engagement on eroding engagement= WITH LOOKUP
(
Percentage of engagement,
([(0,0)-(1,1)],(0,0),(0.1,0.35),(0.2,0.61),(0.3,0.775),(0.4,0.865),(0.5,
0.93),(0.6,0.965),(0.7,0.985),(0.8,0.99),(0.9,0.995),(1,1)))
Units: **undefined**

(030) Effect of pressure for clarifying on effectivenes in clarifying= WITH LOOKUP
(
Pressure for clarifying,
([(0,0)-(1,1)],(0,0),(0.1,0.62),(0.2,0.78),(0.3,0.88),(0.4,0.93),(0.5,0.97
),(0.6,0.975),(0.7,0.98),(0.8,0.985),(0.9,0.99),(1,1)))
Units: Dmnl

(031) Effect of pressure for formalizing on effectivenes in formalizing= WITH LOOKUP
(
Pressure for formalizing,
([(0,0)-(1,1)],(0,0),(0.1,0.62),(0.2,0.78),(0.3,0.88),(0.4,0.93),(0.5,0.97
),(0.6,0.975),(0.7,0.98),(0.8,0.985),(0.9,0.99),(1,1)))
Units: Dmnl

(032) Effect of previous individual understanding on building new understanding
= WITH LOOKUP (
Percentage of individual understanding,
([(0,0)-(1,1)],(0,1),(0.1,1),(0.2,1),(0.3,1),(0.4,1),(0.5,1),(0.6,1),(0.7
,1),(0.8,0.99),(0.9,0.964912),(0.917431,0.95614),(0.95,0.890351),(1,0)))
Units: Dmnl

(033) Effect of previous shared understanding on building new understanding
= WITH LOOKUP (

Percentage of shared understanding,
([(0,0)-(1,1)],(0,1),(0.1,1),(0.2,1),(0.3,1),(0.4,1),(0.5,1),(0.6,1),(0.7
,1),(0.8,0.99),(0.9,0.964912),(0.917431,0.95614),(0.95,0.890351),(1,0)))
Units: Dmnl

(034) Effect of shared understanding on effectiveness discussing= WITH LOOKUP
(
Shared understanding,
([(0,0)-(1,2)],(0,0.5),(0.1,0.54),(0.2,0.6),(0.3,0.69),(0.4,0.82),(0.5,1
),(0.6,1.26),(0.7,1.5),(0.8,1.73),(0.9,1.89),(1,2)))
Units: Dmnl

(035) Effect of work done on effort= WITH LOOKUP (
Proportion of work done,
([(0,0)-(1,1)],(0,1),(0.1,0.99),(0.2,0.973684),(0.3,0.951754),(0.4,0.921053
),(0.5,0.881579),(0.6,0.828947),(0.7,0.758772),(0.8,0.627193),(0.9,0.416667
),(1,0)))
Units: Dmnl

(036) Effectiveness formalizing=
Average effectiveness formalizing*Effect of shared understanding on effectiveness discussing
*Effect of individual understanding on discussing*Effect of pressure for formalizing on effectivenes in formalizing
Units: Idea/(People*Hour)

(037) Effectiveness in brainstorming=
Average effectiveness in brainstorming*Effect of individual understanding on effectiveness in brainstorming
*Effect of need for brainstorming on effectivenes in brainstorming
Units: Idea/(People*Hour)

(038) Effort clarifying=
Actual effort*Fraction of effort clarifying
Units: People*Hour/Month

(039) Effort formalizing=
Actual effort*Fraction of effort formalizing
Units: People*Hour/Month

(040) Effort in brainstorming=
Actual effort*Fraction of effort brainstorming
Units: People*Hour/Month

(041) Eroding engagement=
maximum erosion of engagement*Effect of perceived ambiguity on engagement
*Effect of percentage of engagement on eroding engagement
Units: 1/Month

(042) Exercise of group influence=
1
Units: Dmnl [0,1,0.01]

(043) Exercise of power in process=
1
Units: Dmnl [0,1,0.01]

(044) FINAL TIME = 10
Units: Month
The final time for the simulation.

(045) Formalizing=
Effort formalizing*Effectiveness formalizing
Units: Idea/Month

(046) Fraction of effort brainstorming=
SMOOTH(Indicated fraction of effort brainstorming,Time needed to reallocate effort
)
Units: Dmnl

(047) Fraction of effort clarifying=
SMOOTH(Indicated fraction of effort clarifying,Time needed to reallocate effort
)
Units: Dmnl

(048) Fraction of effort formalizing=
SMOOTH(Indicated fraction of effort formalizing,Time needed to reallocate effort
)
Units: Dmnl

(049) Group Engagement= INTEG (
Building engagement-Eroding engagement,
Initial group engagement)
Units: Dmnl

(050) High quality rendered issues= INTEG (
Clarifying-Formalizing,
0)
Units: Idea

(051) Ideas needed to start clarifying=
20
Units: Idea

(052) Ideas needed to start formalizing=
20
Units: Idea

(053) Ideas per people=
4
Units: Idea/People

(054) Ideas that can be articulated=
Potential number ideas*Individual understanding
Units: Idea

(055) Indicated commitment per understanding unit=
1
Units: Dmnl

(056) Indicated engagement per understanding unit=
1

Units: Dmnl

(057) Indicated fraction of effort brainstorming=
Need for brainstorming/Total perceived need of working
Units: Dmnl

(058) Indicated fraction of effort clarifying=
Pressure for clarifying/Total perceived need of working
Units: Dmnl

(059) Indicated fraction of effort formalizing=
Pressure for formalizing/Total perceived need of working
Units: Dmnl

(060) Indicated group engagement=
Shared understanding*Indicated engagement per understanding unit*Effect of perceived legitimacy of process in group engagement
Units: Dmnl

(061) Indicated individual commitment=
Individual understanding*Indicated commitment per understanding unit*Effect of perceived legitimacy of process in individual commitment
Units: Dmnl

(062) Individual commitment= INTEG (
Building commitment,
Initial individual commitment)
Units: Dmnl

(063) Individual understanding= INTEG (
Building individual understanding,
Initial individual understanding)
Units: Dmnl [0,1,0.05]

(064) Individual understanding per idea discussed=
0.01
Units: 1/Idea [0,1,0.01]

(065) Initial group engagement=
0.7
Units: Dmnl

(066) Initial individual commitment=
0.7
Units: Dmnl

(067) Initial individual understanding=
0.7
Units: Dmnl

(068) Initial legitimacy=
0.1
Units: Dmnl

(069) INITIAL TIME = 0
Units: Month

The initial time for the simulation.

(070) Legitimacy of process=
Exercise of group influence*"CTG (neutral) facilitation"+(1-Exercise of power in process
)*(1-"CTG (neutral) facilitation")
Units: Dmnl

(071) Legitimate proposals= INTEG (
Formalizing,
0)
Units: Idea

(072) Level of activity needed to perceive legitimacy=
20
Units: Idea/Month

(073) Maximum engagement=
1
Units: Dmnl

(074) maximum erosion of engagement=
0.5
Units: 1/Month [0,1,0.01]

(075) Maximum shared understanding=
1
Units: Dmnl

(076) Maximum understanding=
1
Units: Dmnl

(077) Need for brainstorming=
1-((High quality rendered issues+Legitimate proposals+Raw issues)/Ideas that can be
articulated
)
Units: Dmnl

(078) People=
10
Units: People

(079) Perceived ambiguity about project products=
smooth3i(Ambiguity about project products,Tolerance to ambiguity,Anticipated
ambiguity of products
)
Units: Dmnl

(080) Perceived legitimacy of process=
smooth3i(Legitimacy of process,Time to build perception of legitimacy of process
,Initial legitimacy)
Units: Dmnl

(081) Percentage of engagement=
Group Engagement/Maximum engagement
Units: Dmnl

(082) Percentage of individual understanding=
Individual understanding/Maximum understanding
Units: Dmnl

(083) Percentage of shared understanding=
Shared understanding/Maximum shared understanding
Units: Dmnl

(084) Potential effort=
Available effort per person*People
Units: People*Hour/Month

(085) Potential number ideas=
People*Ideas per people
Units: Idea

(086) Pressure for clarifying=
Raw issues/Ideas needed to start clarifying
Units: Dmnl

(087) Pressure for formalizing=
High quality rendered issues/Ideas needed to start formalizing
Units: Dmnl

(088) Proportion of work done=
Legitimate proposals/Ideas that can be articulated
Units: Dmnl

(089) Raw issues= INTEG (
Brainstorming-Clarifying,
0)
Units: Idea

(090) Relative activity on project=
Total ideas being discussed/Level of activity needed to perceive legitimacy
Units: Dmnl

(091) SAVEPER =
TIME STEP
Units: Month [0,?]
The frequency with which output is stored.

(092) Shared understanding= INTEG (
Building shared understanding-Confusing,
Initial individual understanding*(1-Diversity factor))
Units: Dmnl

(093) Shared understanding eroded per idea brainstormed=
0.01
Units: 1/Idea

(094) Shared understanding per idea discussed=
0.01
Units: 1/Idea [0,1,0.001]

(095) Simulated actual effort=
Effort in brainstorming+Effort clarifying+Effort formalizing
Units: People*Hour/Month

(096) Time for individual understanding to impact commitment=
1
Units: Month

(097) Time for shared understanding to impact engagement=
1
Units: Month

(098) Time needed to reallocate effort=
1
Units: Month

(099) TIME STEP = 0.015625
Units: Month [0,?]
The time step for the simulation.

(100) Time to build perception of legitimacy of process=
Average time to build perception of legitimacy*Effect of activity on perceiving legitimacy
Units: Month

(101) Tolerance to ambiguity=
10
Units: Month
Number of months that an average person will tolerate without a clear picture of the process

(102) Total ideas being discussed=
Clarifying+Formalizing
Units: Idea/Month

(103) Total perceived need of working=
Need for brainstorming+Pressure for clarifying+Pressure for formalizing
Units: Dmnl

Appendix B: Proposed Future Refinements of the General Model.

In the final stages of the modeling project that created the simulation model reported in this paper, the research team that had been working with the client teams suggested the following possible refinements and improvements to this preliminary model:

- Memories of previous experiences and efforts have an important effect in the current effort (these previous experiences can be embedded in the initial conditions or parameters of the model or in the time that takes to build social accumulations).
- Agreement and disagreement are two different social processes interacting that also affect in the formalizing stage.
- Issues and ideas are synonyms in the model, thus it is needed to change all the references to ideas into issues in the model.

- Different boxes contain different things. A participant suggested that Raw issues are conflicting and confusing. Through a successful clarifying process, confusion goes away, but the High quality rendered issues can still be conflicting. An effective formalizing process will reduce conflict existing in the issues before transforming them into legitimate proposals.
- There is the need to clarify what happens to ideas as they move forward. Also some ideas get thrown out.
- Ambiguity is different than confusion. Confusion refers to what are we doing, and Ambiguity to where are we going? Confusion is the same that lack of shared understanding, and shared understanding is a result of a combination of human capital and social capital. There is a need to review the formulation of ambiguity.
- Ambiguity impacts on confusion.
- Rendered ideas as well as legitimate proposals should influence ambiguity.
- Tolerance to ambiguity may depend on some accumulations like shared understanding.
- The group said that group influence and the power exercise both were dynamical rather than external inputs.
- CTG (facilitator) activity influences both, effort and effectiveness. Process facilitation helps to build legitimacy, and content facilitation helps to keep progress. We need to show CTG effort explicitly in the model. There is a threshold effect in which early effort go into group understanding, and late effort goes into technical understanding
- CTG is not a neutral facilitator. It works as a buffer (compare in experiments the effects of having external vs. internal facilitation, process vs. content facilitation, and good vs. bad facilitation).
- CTG understanding is different from agency understanding.
- Perceived legitimacy and tipping point formulation (trap vs. enabler)
    - There is a threshold effect involving shared understanding of social processes
    - When group is more engaged, group facilitator's efforts go down –there is a tipping point between "their" work and "our" work (Group Empowerment?)
    - Individual commitment needs work: specifically it should help engagement (Champion factor?)
- Individual understanding is about substantive ideas [Technical]
    - Prior understanding of integration
    - Understanding of the job to be done
    - Understanding of the issues
- Shared understanding is about group process [Social]
    - How to be a better group
- An alternative view suggests that shared understanding needs to be disaggregated into a technical and a group process component.
- Disaggregate effort into Technical work and Group process work

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