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Governance Informatics: Managing the Performance of Inter-Organizational Governance Networks

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Governance Informatics: Managing the Performance of Inter-Organizational Governance Networks[1]

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ABSTRACT

This article introduces an informatics approach to managing the performance of inter-organizational governance networks that are designed to create, implement and evaluate public policies and the range of activities undertaken by practicing public administrators. We label this type of information flow process management "governance informatics" and lay out a range of theoretical constructs that may be used to collect, categorize, and analyze performance in inter-organizational governance networks. We discuss how governance informatics may be able to assess and re-design the accountability and transparency regimes of information flows in inter-organizational governance networks. The integration of a governance informatics-driven performance management system into an existing regional transportation planning network is presented as an application of the framework.

Key Words: governance networks, performance management, network management, complex systems, situational awareness

The role of information in designing and implementing public policies has been a long standing consideration within public management theory, research and practice (McNabb, 2007) and the policy sciences (Parsons 1999), originating with the influence of Shannon and Weaver's (1949) theory of information processing on Laswell's conceptualization of policy sciences (Lasswell and Lerner, 1951). It is only within the last several decades, however, that the advancement of information technology and computational power have been combined with a focus on performance management, contributing of our emphasis on the role that informatics plays in contemporary governance networks. In this article we make the case for the development of "governance informatics" (GI), which we define here as the management of information flows pertaining to the structural, functional and process features of interorganizational governance networks. We see GI as a critical feature in advancing the "metagovernance" of these networks, which Sorensen describes as the "governance of governance" (2006). We suggest that governance informatics can be used to metagovern networks by giving policy makers, network managers and other stakeholders the opportunity to understand network governance processes, functions and structures. Governance informatics is predicated on the assumption that by building the capacity to describe governance

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processes of heterogeneously interacting agents in complex inter-organizational environments, network managers will be in a better position to adaptively manage the wicked problems surrounding the accountability and performance of inter-organizational governance networks.

The types of problems that governance informatics are designed to address encompass the routine, well-structured problems that can be mitigated when the right kind of information is available and used, to the ill-structured, "wicked" problems that persist (Rittel and Webber, 1973). Informatics systems designed to address well structured problems are very common—found in most routine data collection systems. Efforts to collect performance measures, undertake budget forecasting, or even conduct a public hearing involves the design and management of this kind of information. Informatics systems designed to capture the complexity of wicked problems are rarer, but are increasingly being devised by drawing on sophisticated computer simulation modeling techniques and a suite of other tools necessary to capture this complexity (OECD, 2009). In addition to computer models, systems of data information and integration, as well as applications of human-computer interactions are associated with informatics. We shall be referring to these suits of information collection, analysis and storage tools as an informatics "platform."

Informatics platforms are processes designed to handle information that are usually supported by technology (Gammock et al., 2007: 2). Under the best circumstances, informatics are used to ground decision making, and inform routine and strategic actions. The informatics field is guided by the central premises first laid out in mathematical and computational communication theory (Shannon and Weaver, 1949; Kolmogorov 1968). Gammock et al. (2007) have framed the classic themes of informatics in terms of naming and labeling the kind of analytical constructs that are most relevant to a particular management system. They note how informatics are shaped by the language and communication patterns that are socially constructed by those creating and using these informatics. They recognize that effective informatics systems will have the technical capacity to record and remember data, possess a systematized information management process, and a clear and compelling way to frame, identify and ultimately solve problems using this data. Ideally, these systems will be able to facilitate the solving of problems by using informatics to make routine and strategic decisions.

In this article we describe how GI may be used by practicing network managers, policy makers, and other stakeholders to inform the design and management of governance networks. "Governance networks" serve as the central, macro level unit of analysis in governance informatics platforms and are defined here, "as relatively stable patterns of coordinated action and resource exchange involving policy actors crossing different social scales, drawn from the public, private or non-profit sectors and across geographic levels; who interact through a variety of competitive, command and control, cooperative, and negotiated arrangements; for purposes anchored in one or more facets of the policy stream" (Koliba, Meek and Zia, 2010: 14).

We make the case that governance informatics can be used to make design decisions relating to questions of resource mobilization, network membership, the roles of network actors, and network wide structures and functions. Such design decisions are predicated on the emerging consensus in the performance management literature that all of these factors eventually influence the performance of inter-organizational governance networks. These process-oriented foci can be used to explore two of the most pressing challenges facing governance network managers, namely, ascertaining accountability and performance within these networks. We illustrate how our application of governance informatics to the study of one regional transportation planning network can provide some substantial insights into the range of problems being faced by this particular network, and provide some potential implications for other regional transportation planning networks, as well as for the management of governance networks more generally.

We begin the article by laying out a range of variables that may be used to categorize, describe and ultimately analyze governance informatics. We then discuss how a governance informatics framework is being devised for one regional transportation planning network, drawing inferences to other types of applications as well. A model for integrating governance informatics into the performance management systems of governance networks is presented.

A Conceptual Model of Governance Informatics

The increased use of indirect policy tools (Salamon, 2002; Kettle, 2002), the devolution of power (DeVita, 1998), and the increased blurring between the public, private and nonprofit sectors (Koppell, 2003) have all contributed to a theoretical shift away from the study of *governments* acting alone to deliver discrete policies, to *governance* processes (Cleveland, 1972) undertaken by networks of actors that span sectors and geographic scale. This is a theoretical shift that has been widely noted as one of the most important developments within the field of public administration over the course of the last few decades (Frederickson, 1999; Pierre and Peters, 2005).

Viewed broadly, ”governance” may be construed as, “the means by which an activity or ensemble of activities is controlled or directed, such that it delivers an acceptable range of outcomes according to some established social standard” (Hirst, 1997: 3). Viewed through the lens of public administration and policy studies, governance is construed as the process of coordination and control that is an integral dimension of public policy making and implementation. In this context, “governance refers to sustaining co-ordination and coherence among a wide variety of actors with different purposes and objectives such as political actors and institutions, corporate interests, civil society, and transnational organizations” (Pierre 2000: 3-4). Variations of modifiers used to describe governance in public administration and policy studies may be found. “New governance” (Durant, 2001), “third party governance” (Salamon, 2002), “collaborative governance” (Ansell and Gash, 2007), “public governance” (Stone and Ostrower, 2007), “meta governance” (Sorensen, 2006), and most predominantly in terms of “network governance” (Rhodes, 1997; Kickert et al., 1997; Lynn, et al., 2000; Goldsmith and Eggers, 2004; Milward and Provan, 2006; Provan and Kenis, 2007; Sorensen and Torfing, 2008) have been terms used to describe the type of governance of most interest to the field. The role of the state (and its governmental institutions) as actors in these networks has been a central concern across all of this literature (Pierre and Peters, 2005).

The interest in governance processes has been coupled with the use of network metaphors to describe the range of policy actors involved in governance arrangements. The first use of networks in the field can be found in the early literature on iron triangles and issue networks (Helco, 1978), and eventually extending to descriptions of policy networks (Rhodes, 1997; Kickert et al., 1997), policy systems (Baumgartner and Jones, 1993; Sabatier and Jenkins-Smith, 1993), public management networks (Milward and Provan, 2006; Agranoff, 2007), policy implementation networks (O'Toole, 1990) and governance networks, (Sorensen and Torfing, 2005; 2008). Over this period of time, a view of governance in terms of "lattices of complex network arrangements" (Frederickson and Frederickson, 2006) has emerged. Across this literature networks of interorganizational actors have been described in terms of the coordinated actions and resources exchanged between agents within a network. These governance networks draw membership from some combination of public, private and non-profit sector actors; and have been described as carrying out one or more policy functions (Koliba, Meek and Zia, 2010: 46).

The proposition that governance is explicitly shaped by certain network level properties was first articulated by A.W. Rhodes who argued that governance processes are shaped by: 1.) *Interdependence* between organizations. Governance is broader than government, covering non-state actors as well as state actors; 2.) *Continuing interactions* between network members, caused by the need to exchange resources and negotiate shared purposes; and 3.) *Game-like interactions,* rooted in trust and regulated by rules of the game negotiated and agreed by network participants (1997). As a self-organizing phenomena, governance arrangements are influenced by the kinds of interdependencies that exist between network actors, the resources they exchange, and the joint purposes, norms, and agreements that are negotiated between them.

Despite the substantial theoretical developments in recent decades, there have been relatively few conceptual frameworks that have tried to develop a comprehensive view of governance arrangements. The most widely known and respected framework is the institutional analysis and development (IAD) framework first developed by Nobel Laureate, Elinor Ostrom. The IAD framework draws on institutionalism and neo-institutionalism theories to craft a description of multi-institutional systems. Ostrom (2005) emphasizes the roles that rules play in structuring governance arrangements. Drawing on her empirical analysis of natural resource management networks she makes a compelling argument in favor of more decentralized concentrations of power and authority for enhancing performance in some institutional contexts and conditions. Other comprehensive theories of network governance may be found in John Kingdon's multiple streams framework (1984) and Paul Sabatier and associates' advancement of the advocacy coalition framework (1993). Although these frameworks provide useful conceptual frameworks on which to build models of governance networks, they are not easily translated into network structures. Some of these frameworks impose homogenous assumptions about human decision making behaviors, such as expected utility maximizing behaviors in IAD, while others assume unpredictable chaotic decision making behavior, such as found in the multiple streams framework. By distilling governance arrangements down to their network nodal, tie and whole network characteristics, we believe it is possible to move beyond some of the systemic constraints found in these existing frameworks and test the validity and explanatory power of these frameworks through experimental simulations (Zia et al., 2010; Koliba and Zia, 2011).

Arguably, the extent to which governance processes are fully comprehended by actors operating within complex networks will vary according to the situational awareness of practicing public administrators and policy makers (Koliba, Meek and Zia, 2010). The logic of governance has also emphasized the role of the public administrator as the guardian of sound, "good" governance practices, network performance (Lynn et al., 2000; Stone and Ostrower, 2007), and the importance of hybrid "accountability regimes" of the network (Mashaw, 2006). Given the recent recognition that complex governance processes are relatively common (Frederickson, 1999; Agranoff and McGuire, 2003; Sorenson and Torfing, 2005), little has been done to codify which governance processes and structures are most effective using informatics platforms. The casual link between governance structures and policy selection is not well understood and is a matter that GI initiatives may help to explain.

Ostrom makes a distinction between frameworks, theories and models. A "meta-theoretical framework" identifies a set of variables and the relationships among them that presumably account for asset of phenomena under different theories. A "theory" provides a denser and more logically coherent set of relationships. It applies values to some of the variables and usually specifies how relationships may vary depending upon the values of critical variables. Lastly, a "model" is a representative of a specific situation. It is usually much narrower in scope, and more precise in its assumptions, than the underlying theory. Ideally, it is mathematical (as paraphrased by Sabatier, 2007: 6). The framework presented in Table 1 serves as the outline of a meta-theoretical framework of governance networks. For a more complete review of these variables and the theoretical foundations that exist to support them, see Koliba, Meek and Zia, (2010).

As shown in Table 1, the building blocks of a meta-theoretical framework for a governance informatics platform draws on basic network architecture: nodes, ties, and system-wide network characteristics that *emerge* out of the collective actions of the nodes and ties. Within the context of governance networks, the "nodes" in the network may be comprised of actors existing at differing levels of social scale: individuals, groups (construed as groups of individuals), and organizations (construed as groups of groups). These nodal actors may be defined by their social sector (public, private, nonprofit), their level of geographic scale (global to national to local), as well as their relative level of centrality within the network. These actors will also possess sinks of a variety of resources (financial, physical, natural, social, human, political, cultural and knowledge capital) that may or may not be exchanged or pooled with other actors in the network. Each network actor will also possess its own combination of democratic, market and administrative accountabilities (Koliba, Mills and Zia, In press).

Table 1. A Meta-Theoretical Framework of Governance Networks (Koliba, Meek, and Zia, 2010)

TYPE OF VAR.	VARIABLE	DESCRIPTORS
Agents (Nodes)	Social scale	Individual; Group; Organizational/Institutional; Inter-organizational
	Social sector (organizational level)	Public; Private; Nonprofit
	Geographic scale	Local; Regional; State; National; International
	Role centrality	Central – peripheral; Trajectory
	Capital resources actor provides (as an input)	Financial; Physical; Natural; Human; Social; Cultural; Political; Knowledge
	Providing accountabilities to….	Elected representatives; Citizens and interest groups; Courts; Owners/Shareholders; Consumers; Bureaucrats/Supervisors/Principals; Professional Associations; Collaborators/Partners/Peers
	Receiving accountabilities from…	See above
	Performance/Output and Outcomes Criteria	Tied to policy function and domain
Ties	Resources Exchanged/ Pooled	Financial; Physical; Natural; Human; Social; Cultural; Political; Knowledge
	Strength of tie	Strong to weak
	Formality of tie	Formal to informal
	Administrative authority	Vertical (command and control); Diagonal (negotiation and bargaining); Horizontal (collaborative and cooperative); Competitive
	Accountability relationship	See above
Whole Network	Policy tools	Regulations; Grants; Contracts; Vouchers; Taxes; Loans/loan guarantees, etc.
	Operational functions	Resource exchange/pooling; Coordinated action; Information sharing; Capacity building; Learning and knowledge transfer
	Policy functions	Define/frame problem; Design policy solution; Coordinate policy solution; Implement policy (regulation); Implement policy (service delivery); Evaluate & monitor policy; Political alignment
	Policy domain functions	Health, environment, education
	Macro-level governance structures	Lead organization; Shared governance; Network administrative organization
	Network configuration	Inter-governmental relations; Interest group coalitions; Regulatory subsystems; Grant and contract agreements; Public-private partnerships
	Properties of network boundaries	Open – closed; Permeability
	System dynamics	Systems-level inputs; processes; outputs and outcomes

The kinds of ties that are forged between network actors possess a range of characteristics that have been widely described in the social networking literature as the relative “strength” and “formality” of the ties. These ties characteristics may also be predicated on certain types of "administrative authorities," often described within the literature in terms of hierarchically-oriented vertical ties; collaboratively—oriented horizontal ties; and those ties predicated on negotiated or bargained ties (Agranoff and McGuire, 2003; Kettl, 2006). Our view of complex governance networks is that they will likely incorporate all forms of administrative authority, a view that is not uniformly accepted across the network governance literature (see Koliba and Meek, 2009 for a discussion of this issue). The ties between these actors facilitate the flow of resources between two or more network actors.

Drawing on Milward and Provan's (2006) typology of network functions and Kingdon's multiple policy stream framework, we may describe whole networks in terms of their operating and policy functions. Whole networks will also possess certain structural capacities. Provan and Kenis describe network structures as falling into one of three different forms: some networks may be directed by a lead organization, others may evolve some form of shared governance structures, while other networks will create their own network administrative organizations (2007). Whole networks may be structured by the policy tools (Salamon, 2002) that are used: grants and contracts, regulations, vouchers, etc. Networks may possess certain kinds of boundaries that have different levels of permeability and openness. Networks will also be governed by certain key leverage points that exist within system dynamics that persist as positive and negative feedback loops, stocks and flows (Meadows, 2008), inputs and outputs (Poister, 2003) across the system.

There are several subsystems operating within all governance networks that are of particular concern, namely, those charged with designing and managing them. We have noted that the logic of governance that has evolved within public administration and policy studies has been predicated on two critical considerations: accountability and performance. In other publications (Koliba, Meek and Zia,, 2010) we have discussed how the kind of multi-sector governance networks that now proliferate as a result of privatization, contracting out, and devolution calls for the expansion of accountability to include not only the traditional bureaucratic, political, professional and legal frameworks often described in the literature (Romzek and Dubnick, 1987), but also must be expanded to include the role of market logic, collaboration and a more nuanced view of the "democratic anchorage" (Sorensen and Torfing, 2005) of governance networks (Mashaw, 2006; Koliba, Meek and Zia,, 2010; Koliba, Mills and Zia, In press). Collecting information relative to the nature of the hybridized accountability relationships that persist within governance networks needs to be one of the central features of any governance informatics platform. Ensuring accountability in complex governance networks is a wicked, ill-structured problem, a point widely noted by those who have considered accountability in the light of networks (Page, 2004; Frederickson and Frederickson, 2006, Koliba, Mills and Zia, In press). Accountability may be analyzed as a matter of network properties—as a series of relationships between network actors. We believe it is possible to construct computer simulation models that incorporate the kind of accountability influences that shape the decision heuristics of individual network actors in inter-organizational governance networks (Zia, et al., 2010).

One of the chief reasons for developing *any* informatics systems lies in achieving the goal of improved performance, whether it means supporting healthier people, more efficient machines, more resilient ecosystems, or more effective governance networks. The extent to which any system possesses the capacity to monitor itself in a robust way needs to be a critical consideration. Within the context of governance informatics, it is not enough to simply generate more information about the network's performance. An effective performance management system designed to engage in robust interactive dialogue about performance information is needed. Donald Moynihan has described these as "performance management systems" (2008) that provide a means by which critical actors, "engage in coding, interpreting and refining information from the external environment and internal stakeholders into a series of information categories such as strategic goals, objectives, performance measures, and targets" (2008, p.6). The existence of these kinds of spaces within a governance network can be documented through a governance informatics process. Information regarding networks governance processes may be fed into the communication systems of the network, facilitating system-wide learning, adaptation, and the emergence of new strategies (Guney and Cresswell, 2010). This is done by identifying the key "communities of practice" (Wenger, 1998; Koliba and Gajda, 2009) that collect, process and use performance information within the network. These communities of practice serve as the "action arenas" (Ostrom, 2005) or critical strategy spaces for the network. The identification of these action arenas becomes a critical, early step in a governance informatics project, as these spaces serve the duel purpose of being the site for the regulation of network performance, but also as the eventual user of governance informatics. It is within these spaces that the "democratic anchorage" required of politically accountable networks needs to be established (Sorensen and Torfing, 2005), and by inference, monitored. These spaces may ultimately carry on the "metagovernance" functions of a governance network, as it is within these action arenas that major decisions concerning the allocation and pooling of resources are made.

In order to narrow down the fuller range of possible actors and actor ties to focus on, we believe that performance management systems that use governance informatics will best be served by focusing on describing and analyzing the dynamics of those action arenas that are most critical. These action arenas may be situated in certain kinds of configurations of people in relatively small groups of strategic decision makers. These groups serve as the metaphorical brains of the network, making important decisions about resource distribution, regulations, and strategic goals. They may be the board of directors of a coalition of nonprofit organizations or the ongoing dynamics of a legislative committee operating at every level of government.

The contextual complexity that often accompanies governance networks of different structures and functions is not easily explained or factored away by top-down analytical models. Choices must be made regarding which governance dynamics are most critical to the assessment of performance based on the kind of process measures that are possible. In addition to building the capacity to collect and analyze governance informatics pertaining to very particular contexts, we believe it is possible to develop more robust empirical comparisons between governance networks of similar functions and structures, as well as across governance networks that possess dissimilar functions and structures.

An Application of Governance Informatics Framework in Assessing a Regional Transportation Planning Network

In this section we provide an application of how governance informatics may be used to assess the performance of a regional transportation planning network, which is a classical example of an inter-organizational governance network. In the United States regional transportation planning functions are undertaken by certain combinations of regional organizations (such as metropolitan planning organizations (MPO), regional planning commissions (RPC) and regional authorities), local governments, state agencies, chief executive offices, state legislative committees, public transit, local and regional interest groups, economic developers, businesses and households. The growth in capacity to undertake transportation planning at the regional level is, largely, the result of federal level mandates and funding programs (GAO, 2009; Koliba, Campbell and Zia, accepted for publication). In larger population centers, the federal government has mandated the creation or designation of MPOs—giving them certain discretion to allocate federal resources to regional transportation projects. Those who have studied these networks often take note of the tensions that exist between actors operating at differing levels of geographic scale (local versus regional; regional versus state; state versus local) in these types of networks (Meyers, 1999; Goetz, et al., 2002; Vogel and Nezelkewicz, 2002; Koliba, Campbell and Zia, accepted for publication). Such geographic tensions have been noted in studies of other kinds of networks operating across regional scale—be they watershed management, emergency management, or land use management networks (Koontz et al., 2004; Imperial, 2005; Comfort, 2007).

Regional transportation networks tend to be information rich. Mandated to collect a range of transportation data, regions of more than a certain size are required to undertake travel demand modeling, and track traffic congestion, vehicle miles traveled and other metrics. Due to their regional scope and information rich environments, regional transportation planning networks provide fertile ground for developing governance informatics. We believe that the application of the governance informatics architecture described earlier to these networks will have an easier chance of replication in other networks of similar scope and information rich environments.

Figure 1 provides a conceptual model of the region's transportation planning network based on the range of institutional actors that comprise the regional planning network of Chittenden County, Vermont, the most densely populated county (153,000 in a state of 630,000 people). In this conceptual model, the major institutional actors are organized into their social sectors (government, private and non-profit), with the government actors broken down into levels of geographic scale. We will now briefly describe some of the critical actors implicated in this network, discuss some of the important ties that persist within the network, and pin point one of the central transportation project prioritization functions undertaken by this network.

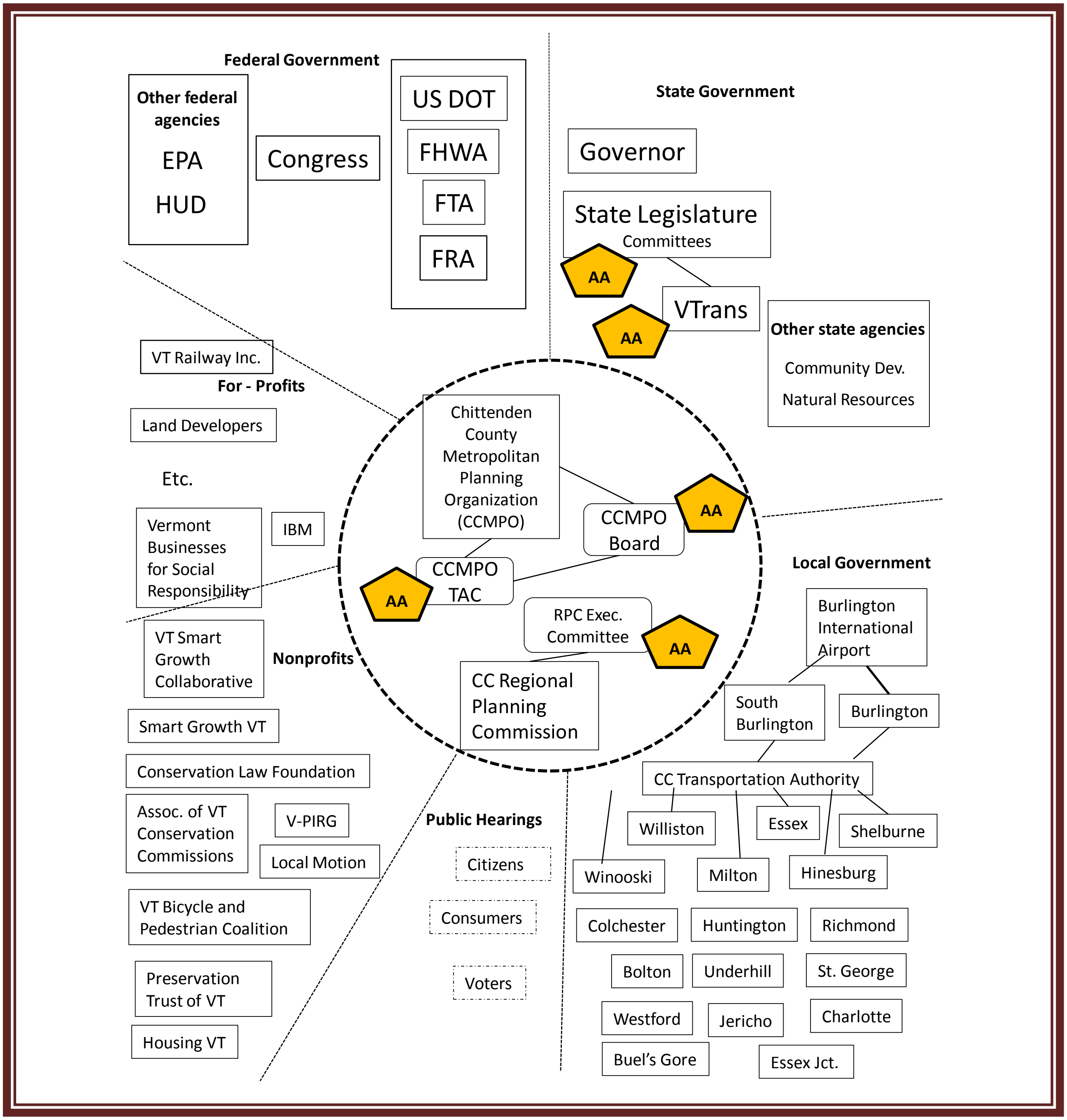


Figure 1. A Conceptual Model of Key Agents in the Regional Transportation Planning Network of Chittenden County, Vermont

Network Actors

Regional actors lie at the center of the conceptual model, with the ovals indicating the key committees and boards that undertake planning for the county. The Chittenden Country Metropolitan Planning Organization (CCMPO) exists as a stand alone regional organization, as are 18% of all MPOs in the United States (GAO, 2009). The CCMPO is conjointly housed with the Chittenden County Regional Planning Commission (CCRPC). Two different boards of directors govern each entity. During our initial year of study, the state legislature and governor's office were pushing for these entities to consolidate.

"VTrans," the State of Vermont Agency of Transportation, plays a pivotal role in the regional transportation planning process. VTrans has a representative on the CCMPO governing board. VTrans approves projects for "scoping" (a preliminary design and assessment phase) and provides the region with an approved list of projects to be considered for ranking. The score that VTrans assigns to projects usually carry a weight of 80%, compared to the 20% weight given to the score assigned by the region. After the weights are combined, VTrans provides the state legislature with a list of rank order transportation projects. The state Senate and House Transportation Committees review the list for approval. The state legislature works with the governor to set the budget for VTrans. Increasingly, VTrans is having to work with other state agencies around integrating transportation project planning with land use, economic development, environmental management, and other policy integration needs.

Federal funding programs, and their stipulations for matching requirements of project types, play a strong role in determining which projects get prioritized. A representative from the regional office of the Federal Highway Administration (FHWA) sits on the MPO board of directors and actively participates in the deliberations and possesses veto power over particular projects, especially those projects that must conform to federal specifications. We are interested in the extent to which federal stipulations and funding programs play a significant role in determining which transportation projects get on the prioritization list. Federal criteria may also be filtered through decision criteria considered at both the state and regional levels.

Chittenden County is comprised of nineteen towns, including the state's largest city of Burlington. Population is concentrated in Burlington and the surrounding suburban towns of South Burlington, Shelburne, Williston, Essex Junction and Colchester. Lake Champlain borders this region to the west and the Green Mountains lie on the eastern boarder of the county. The remaining towns are rural, with many having small town centers within only a few businesses located in them. The type of municipal government found across the county ranges from a city council and mayor structure to elected select boards/town manager or town clerk models. Because Vermont is a "Dillon's rule" state, the state legislature much approve any changes to town charters. Within the context of regional transportation planning, each of these towns is responsible for maintaining its local roads. Local planning commissions are charged with updating their town plans every five years. Some of the larger towns employ town planners, many of whom sit on the CCMPO technical advisory committee. Each town in the county appoints a representative to the CCMPO governing board.

The county's public transit agency, the Chittenden County Transit Authority (CCTA), runs buses within the county as well as links neighboring counties to accommodate commuters. CCTA is a municipal entity, and the board of commissioners is comprised of representatives (two each) from Williston, Winooski, Milton, Essex, Shelburne, Hinesburg, Burlington, and South Burlington. Burlington International Airport (BTV) is a department of the City of Burlington. Burlington holds all 4 of the board seats, and South Burlington appoints the chair of the board. I've indicated this by having a thick line connecting between Burlington and BTV and a thin line between S. Burlington and BTV.

The county's regional transportation planning is also impacted by the periodic involvement of regional businesses and nonprofit advocacy groups. Several larger scale circumferential and highway connector projects have been proposed and been caught in legal battles, in some cases going on 30 years. Large area businesses and land developers are pushing for these capital projects, while regional environmental and anti-sprawl groups have been fighting the projects in the courts. These interests do not have a formal role in the CCMPO governing board. However, their presence and potential for influence warrant our inclusion of these business and nonprofit actors in this network.

Action Arenas for the Network

In this regional transportation planning network, we identified the key action arenas as the governing board of the MPO, the governing board of the regional planning commission (RPC), the technical advisory committee (TAC) of the MPO, the transportation prioritization management team at VTrans, and the house and senate legislature transportation committees at the state level. In figure 1 these action arenas are indicated by "AA" hexagons. The decision making processes of these AAs are a crucial component of the conceptual model.

The Network's Transportation Project Prioritization Structures and Functions

The regional transportation network for Chittenden County is comprised of all of the actors mentioned above. The kinds of ties that exist in this network are, predictably, mixed. A clear intergovernmental arrangement exist that may best be described in terms of Wright's "coordinate authority model" (2000), in which a nested hierarchy of sorts exists between the federal, state, regional and local levels of government. The range of administrative ties that exist within this nested authority structure is a mixture of classic top-down controls mediated through mandates and other legal requirements dictated by federal, state and local laws. In this network, VTrans is expected to conform with federal requirements relating to transportation safety and accessibility, financial management, air quality standards, data collection requirements, and mandated planning exercises. Unlike a pure nested hierarchy, in regional transportation planning networks that encompass a large enough population, MPOs have direct links with the federal government, and are accountable to the federal government officials for delivering short, medium and/or long range plans mandated under state legislation. As a state agency, VTrans serves as the financial intermediary for the majority of the resources flowing from the federal government to the region. VTrans has the capacity to have projects scoped and placed on the list of potential projects. In many instances, however, the interpretation of mandates and laws, as well as particular decisions relative to certain projects are subject to negotiation and bargaining within this network. Collaborative agreements are made with equitable input from a critical number of stakeholders. One recent example of such collaborative agreement came in 2007 when a new project prioritization scoring framework was devised. The process used by the state to prioritize transportation projects unfolds as a series of exchanges within and between the network's action arenas. A comprehensive transportation project scoring process was devised that divided transportation projects into discrete categories: roadway projects, paving projects, traffic control project, bridge project, and bike/pedestrian projects. These projects are prioritized by the region (MPO staff, TAC members) and by professional staff members in VTrans. The weighting scheme used to prioritize projects serves as a "boundary object" (Wenger, 1998) that mediates the interactions between action arenas that make up the project weighting process.

A governance informatics project has been launched in collaboration with the key stakeholders in this network. Several questions have been framed to guide the development of the governance informatics platform for this network.

- How might a performance management system be developed for the CCMPO and CCRPC?
- How and to what extent are local, regional and state information systems compatible?
- How equitable is the project prioritization weighting scheme?
- How much of an influence do federal funding programs have on project prioritization?
- How does accountability work in this network? How equitable is the state's prioritization process?
- How can this network adapt to the new demands for integrated planning that will require that transportation planning be coupled with greenhouse gas emissions mitigation, climate change adaptation, land use, economic development, food systems, and environmental management planning?

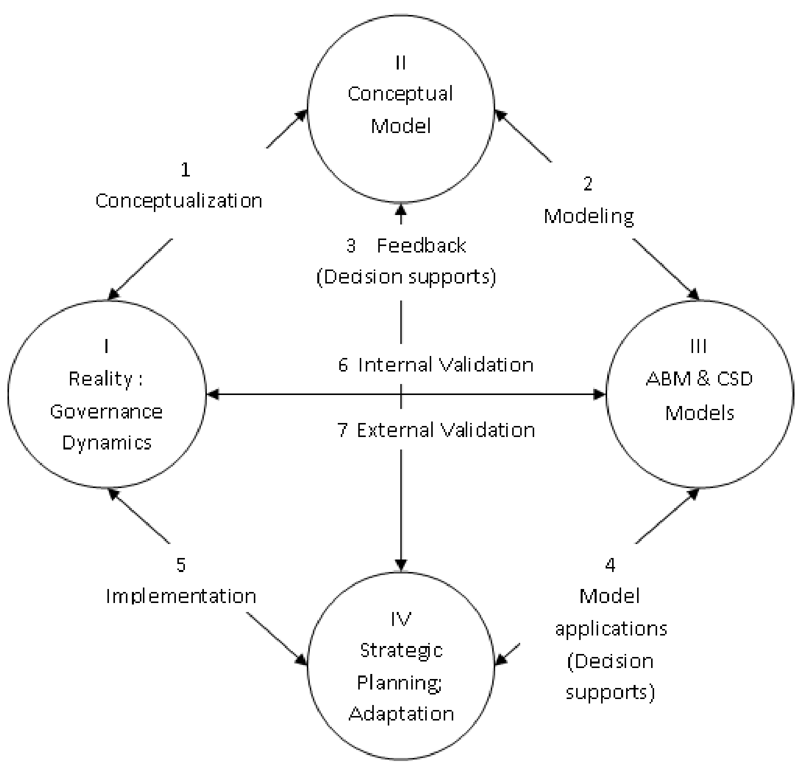
These questions and others to emerge over the course of the project will be used to guide the development of the governance informatics platform for the regional transportation planning network described in this section. In the next section we describe the process that is being followed to derive this platform.

Operationalizing a Governance Informatics Project

Governance informatics may be viewed as the informational currency used to manage performance or the metagovernance of the network. In this case then, the development of an informatics platform requires a long term commitment to information management and use, which ultimately entails the harnessing of computational power. The use of computers to collect and store information also provides a unique opportunity to study and model some of the more complex interactions that occur within governance networks. These complex interactions are both the causes and consequences of ill-structured problems.

Creating the capacity for governance network actors to utilize the kind of experimental simulations possible using these techniques hinges on the development of computer supported governance informatics platforms. A GI platform supports decision making for semi-structured or unstructured problems through a computer-based system of information management. A GI platform relies on process modeling methods that provide predictions and future scenarios under different conditions (Zachary, 1986). We are instituting a GI platform that will rely on calibrated agent based models (ABMs) that use real-time information from the regional transportation planning network described in the previous section. This GI platform will provide decision makers with critical information concerning the administration of the "black boxes" that comprise the structures and functions of their existing regional planning networks. Figure 2 visually lays out the relationship between conceptual and empirically tested models in this process.

Figure 2. A Systems View of Problem Solving: Modeling for Decision Support (Adapted from: Mitroff et al., 1974)



The phases of model development being employed in our research begins with the creation of a conceptual model of governance dynamics (see (1) in figure 2) using the framework presented in table 1. Conceptual models are static, two dimensional renderings of the governance network and are used to develop a common mental model of the relationships between network actors. Figure 1 illustrates an example of one of the conceptual models being devised for the regional transportation planning network of one small metropolitan county. This particular conceptual model is used to engage the eventual users of the GI platform in clarifying the common perceptions around actors, the nature of the ties between them and the boundary parameters that distinguish the edges of the simulation model. The development of this common mental model of the governance network is accomplished through a series of mediated modeling sessions (van den Belt, 2004), with early sessions structured to clarify details of the conceptual model that will be used to design the computer simulation model (see (2) in figure 2). It should also be noted that the stakeholder's dialogue around the parameters of the mental model of the governance network may provide more direct benefits to those stakeholders. We anticipate formulating this assertion into a testable hypothesis concerning the efficacy of the conceptual model development phase of this work. We characterize this feedback loop (see (3) in figure 2) as one form of decision support that is directed toward the development of a shared mental model of the governance network. Therefore, the conceptual model that is to be used to create the simulated model informs the situational awareness of stakeholders.

The utilization of models of complex governance networks to support the learning and decision-making of policy makers and other agents implicated in a governance network is represented in the feedback processes resulting from stakeholder interface with information presented through the conceptual model (see (3) in figure 2) and as the application of computer simulated models of existing governance networks to a GI platform (see (4) in figure 2). Computer models can account for uncertainty and adaptability of agents, and eventually support scenario planning and the non-linear analysis of governance process dynamics. The process-based models like ABMs allow, "knowledge to emerge and be used throughout the course of an interactive analytic process. Consequently, it can provide a bridge for moving from deductive analysis of closed systems, to interactive analytic support for inductive reasoning about open systems where the contextual pragmatic knowledge possessed by users can be integrated with quantitative information residing in the computer" (Bankes, 2002: 7264). Such process-based modeling may be tangibly represented in a GI platform that organizes and presents information concerning the network's governance dynamics to network stakeholders. The effective utilization of these decision supports should impact how policies and related practices are implemented (see (5) in figure 2), assisting in the development of the network's capacity to learn, adapt, and change. The internal validity of the modeling enterprise, both at the conceptual and the computer simulated levels, is determined by the extent to which the GI platform positively impacts the capacity of the network to achieve favorable outcomes. The internal validity of the conceptual model and the ABM can be tested through a series of surveys of critical stakeholders in each participating regional planning network. Groundwork can be laid to test the external validity of the computer simulated models (see (6) in figure 2). Significant longitudinal information concerning the evolving dynamics of governance networks will ultimately need to be collected to accomplish this task.

In discussing the relationship between modelers and stakeholders, Agarwal et al. (2002) emphasize that, "to answer policy questions, policy makers will have to begin to identify the key variables and sectors that interest them, their scales of analysis, and the scenarios they anticipate. At the same time…. modelers should begin discussions with policy makers to understand their needs. Given policy makers' needs, modelers will have to translate those needs with particular attention to implicit and explicit temporal, spatial, and human decision-making scale and complexity and the interactions between scale and complexity" (2). Parker and Manson (2003) propose that participatory agent-based modeling provide a promising and useful approach to model the integration of land use change with policy analysis and management of complex system dynamics. Stakeholder group dialogue, surveys, and interviews can provide a qualitative source of information to guide the development of agent heuristics for governance decisions at a variety of scales. In this way, the proposed research follows the example of Manson and Evan (2007), who used similar qualitative and quantitative techniques to compare model outcomes with rational and boundedly-rational decision rules. To be useful, the ABM governance models developed for the GI platform must be linked to realistic decision issues and scenarios. As abstract representations of the complexities of governance, the models require grounding in the experience and knowledge of decision makers.

Our increased capacity to harness computational power to generate, analysis and disseminate governance informatics may bring some clarity to previously ill structured problems. By translating conceptual models of governance network dynamics into simulation models guided by agent based modeling (ABM), it may be possible to generate governance informatics through scenarios that may be used by decision makers situated within the network and/or outside of the network to steer the performance of governance networks. We believe that ABMs provide a useful modeling framework to capture the interplay between the micro, meso, and macro levels that we have identified here in terms of social and geographic scale. ABMs can accommodate the varying degrees of detail that are possible and desirable within models of governance networks. In discussing the value of ABMs to the study of policy and governance dynamics, Squazzoni and Boero observe that, "Standard policy making models consider agents as atomized entities possessing rational expectations which individually react to a set of incentives, do not consider interactions or the mutual influence between agents and seem to take place 'off-line' and outside the particular system involved" (Squazzoni and Boero, 2010: 5). They go on to add that ABM is currently, "the only technique available today to formalize models based on micro-foundations, such as agents' beliefs and behavior and social interactions, all aspects that we know are of a certain importance [in order] to understand macro outcomes…" (Squazzoni, and Boero, 2010: 6). They suggest that in ABMs, "… agents are not usually viewed as fully rational utility maximizers who behave independently of each other, but rather as adaptive agents who are context dependent and follow heterogeneous threshold preferences…" (2). These threshold preferences may be described as the "decision heuristics" of network agents (North and Macal, 2007). ABMs provide effective means of modeling the complexity of emergent behaviors, structures, functions and actions that occur as a result of "bottom-up" dynamics.

Those who have considered the promise of ABMs to the study of policy processes recognize that the field is still in the early stages of development (OECD, 2009). The capacity of ABMs of complex governance networks to lead to accurate forecasting and predicting particular policy outcomes is predicated on a "deep uncertainty" that characterizes our current state of understanding of complex social systems. Bankes (2002) characterizes this deep uncertainty arising as, "the result of pragmatic limitations in our ability to use the presentational formalisms of statistical decision theory to express all that we know about complex adaptive systems and their associated policy problems" (7263). Squazzoni and Boero (2010) suggest that "… the challenges for policy… is not to predict the future state of a given system, but to understand the system's properties and dissect its generative mechanisms and processes, so that policy decisions can be better informed and embedded within the system's behavior, thus becoming part of it" (3). To restate their point, the very process of providing feedback concerning a system's dynamics back into the system itself becomes an important component of decision making and action with respect to performance management of governance networks. "Once viewed as something that is embedded within the system, rather than taking place before and off-line, policy starts to be practiced as a crucial component that interacts with other components in a constitutive process" (Squazzoni and Boero, 2010: 3). We believe that in addition to assessing performance management of inter-organizational governance networks ABMs can be used "when policy makers need to *learn from science* about the complexity of systems where their decision is needed," as well as "when policy makers need to *find and negotiate certain concrete ad hoc solutions*, so that policy becomes part of a complex process of management that is internal to the system itself" (Squazzoni and Boero, 2010:6).

By developing an ABM of the transportation prioritization process of the network described earlier in this paper we believe it is possible to experiment with different weighting schemes and decision making processes, running scenarios about forecasted outcomes that will be shared within the various action arenas found within the network. These ABMs will be designed with the involvement of the participating stakeholders through an ongoing "mediated modeling" process (van den Belt, 2004). A core steering committee comprised of the executive directors of the MPO and RPC and lead researchers is meeting quarterly to review progress. An annual report to all of the stakeholder groups, including all of those participating in focus groups and interviews will be provided. These reports will include results from the kinds of analysis described here and the relevant recommendations drawn from this analysis. As the ABM attains a certain level of reliability, stakeholder groups will be invited to participate in periodic scenario planning workshops, which will review revised and new conceptual models, computer simulation scenarios and consider the information culled from them when making new design or redesign decisions.

In the case of the regional transportation planning network described here, we believe that the ABM will help us determine how much the rational transportation prioritization process employed by the region actually influences real outputs: namely the implementation of certain types of transportation projects. We will be able to experiment with altering the criteria that is used to assign weights and provide avenues for stakeholders to undertake certain redesign experiments. Our own interests in ascertaining the democratic anchorage of the network will be explored by experimenting with the integration of different public participation, democratic norms, and elected official involvement design considerations. By eventually adding more standard system dynamics models into the informatics platform we will be able to determine how federal funding priorities and regulations impact what projects are built. A very tangible outcome of this project lies in the opportunity that the regional transportation planning network will be given to consider its own network properties and devise performance management systems to track and measure performance going forward. Other uses are "improved decision making" and the "analysis of outcomes" that have not been directly addressed in this paper, but could be done in future research using governance informatics.

The compelling reason to undertake this kind of effort lies in the prospect that governance informatics brings to the improved performance and accountability of complex governance networks. In this framework the "management of performance" becomes, unto itself, a subject of scrutiny. The capacity of the network to monitor its own performance, and calibrate its performance to future actions may be undertaken. External stakeholders may, likewise, develop a more clearly articulated understanding of where the metagovernance of the network takes place. In the process, the efficacy of the methods used to prioritize transportation projects may be scrutinized and become embedded as one of the critical accountability structures guiding network functions.

We have noted that much has been written about the challenges of holding network actors accountable for their actions. We believe that the development of GI platforms contribute to our evolving understanding of accountability on two levels: 1.) by shedding light on how complex governance networks are structured and function, thereby, making them more transparent; and 2.) by integrating the hybridized accountability regimes that exist across a network into the conceptual and simulated models of the network. In the process of integrating accountability ties into the modeling effort we will be able to understand the impacts of certain accountability ties on network structures and functions and, in the process, judge the extent to which these accountability ties adequate meet the expectations associated with democratic anchorage and professional competency.

Conclusions: The Promise of Governance Informatics

We believe that the further development of governance informatics will be predicated on specific conceptual advances that may only be found through the inculcation of computational principles and practices into the administrative and policy sciences. It has been noted that the application of computational power to harness and employ governance informatics is still very much in its early stages of development (Bankes, 2002; OECD, 2009). As other articles in the volume discuss, the methodological challenges that confront the field are great. Social reality may be described, categorized, and codified in a myriad of ways. It is not a cliché to say that we are all bombarded with information. Access to more information is also increasing "information entropy," as Shannon and Kolgomorov's information theory predicted. Filtering out useful information from not useful information can be time consuming. One of the chief challenges confronting those looking to simulate governance processes lies in determining what information is most useful to practitioners, theorists, and researchers. It is likely that "usefulness" will be determined differently through each of these lenses. To bring some measure of balance to this undertaking, the framing of this effort as one oriented toward the development and application of informatics implies two very critical things: 1.) that this effort must be undertaken as an exercise involving practitioners; and 2.) that computational power welded in traditional and nontraditional ways will need to be harnessed in the process.

One of our goals in this project can ultimately lead to discerning the correlation between high functioning governance processes and highly desirable performance outputs and outcomes. We are also interested in how accountability ties are formed and influence the behaviors of individual actors and the network on the whole. As the process unfolds, we will be in a better position to discern which combinations of administrative authority, hybrid accountability regimes, resource exchanges, and policy tools lead to effective performance and democratically anchored accountability. The very effort to construct a governance informatics platform in partnership with members of a governance network will likely yield new insights, practical lessons, and the structuring of wicked problems into ones that are discernable and better structured. By comparing the performance of particular networks to others across the country by using some of these metrics to differentiate "effective" networks from "underperforming" networks, we may begin to integrate governance structure, function and processes into our assessments and build a body of evidence to suggest which governance arrangements work best under what conditions. We also believe that governance informatics can be particularly useful in answering important design considerations, as policy makers and governance network administrators try to optimize the governance configurations that add public value and address pressing social needs.

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References

Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P., & Schweik, C. M. (2002). *A review and assessment of land-use change models: Dynamics of space, time, and human Choice*. Bloomington IN, CIPEC Collaborative Report Series No. 1, Center for the Study of Institutions, Population, and Environmental Change, Indiana University.

Agranoff, R. (2007). *Managing within networks: Adding value to public organizations*. Washington, DC: Georgetown University Press.

Agranoff, R., & McGuire, M. (2003). *Collaborative public management: New strategies for local governments*. Washington, D.C.: Georgetown University Press.

Ansell, C., & Gash, A. (2007). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory*. 18(4): 543-571.

Bankes, S. (2002). Tools and techniques for developing policies for complex and uncertain systems. *PNAS*. 99(3): 7263-7266.

Baumgartner, F. R., & Jones, B. D. (1993). *Agendas and instability in American politics*. Chicago and London: The University of Chicago Press.

Cleveland, H. (1972). *The Future Executive*. New York: Harper & Row.

Comfort, L. (2007). Crisis management in hindsight: Cognition, communication, coordination, and control. *Public Administration Review, 67*(Supplement): 189-197.

DeVita, C. (1998). Nonprofits and devolutions: What do we know? In E.T. Borris & C.E. Steurle (Eds.), *Nonprofits and governments: Collaboration and conflict*. Washington, DC: The Urban Institute: 213-233.

Durant, R. F. (2001). A way out of no way? Strategy, structure, and the 'new governance'. In R. T. Golembiewski (Ed.), *Handbook of organizational behavior: Second edition*. New York: Marcel Dekker, Inc.: 689-723.

Frederickson, H. G. (1999). The repositioning of American public administration. *Political Science and Politics*, *32*(4): 701.

Frederickson, D., & Frederickson, H. G. (2006). *Measuring the performance of the hollow state*. Washington, DC: Georgetown University Press.

Gammack, J., Hobbs, V. & Pigott, D. (2007). *The book of informatics*. South Melbourne, Australia: Thomson.

Government Accountability Office (GAO) (2009). *Metropolitan transportation planning organizations: Options exist to enhance transportation planning capacity and federal oversight*. GAO-09-868.

Goldsmith, S., & Eggers, W. (2004). *Governing by network*. Washington D.C: Brookings.

Goetz, A.R., Dempsey, P.S. & Larson, C. (2002). Metropolitan planning organizations: Findings and recommendations for improving transportation planning. Publius. 32(1): 87-105.

Guney, S. & Cresswell, A. M. (2010). *IT governance as organizing: Playing the game.* Paper presented at the 43rd Annual Hawaii International Conference on System Sciences, Kona, HI.

Heclo, H. (1978). *Issue networks and the executive establishment*. Washington, DC: American Enterprise Institute.

Hirst, P. (1997). *From statism to pluralism*. London: UCL Press.

Imperial, M. T. (2005). Using collaboration as a governance strategy. *Administration & Society, 37*(3): 281-320.

Kettl, D. (2006). Managing boundaries in American administration: The collaborative imperative. *Public Administration Review, 66*(6): 10-19.

Kickert, W. J. M., Klijn, E.-H., & Koppenjan, J. F. M. (Eds.). (1997). *Managing complex networks: strategies for the public sector*. London: Sage Publications.

Kingdon, J. (1984). *Agendas, alternatives, and public policies*. New York: Harper Collins.

Koliba, C., Campbell, E. & Zia, A. (Accepted for publication) Performance measurement considerations in congestion management networks: Evidence from four cases. *Public Performance Management Review.*

Koliba, C., & Gajda, R. (2009). Communities of practice as an empirical construct: Implications for theory and practice. *International Journal of Public Administration*, 32: 97-135.

Koliba, C. & Meek, J. (2009). 'Mixed-form' governance structures: An analytical turn. *Public*. Institute of Public Governance and Management. 47(19). http://www.esade.edu/public/modules.php?name=news&idnew=521&idissue=47

Koliba, C., Meek, J. & Zia, A. (2010). *Governance networks in public administration and public policy*. New York: CRC Press/Taylor & Francis.

Koliba, C., Mills, R. & Zia, A (In press). Accountability in governance networks: Implications drawn from studies of response and recovery efforts following Hurricane Katrina. *Public Administration Review.*

Koliba, C. & Zia, A. (2011). Theory testing using complex systems modeling in public administration and policy studies: Challenges and opportunities for a meta-theoretical research program. COMPACT Conference. Rotterdam, The Netherlands.

Kolmogorov, A. (1968), Three approaches to the quantitative definition of information. *International Journal of Computer Mathematics*. 2(1-4): 157-168.

Koontz, T., Steelman, T., Carmin, J., Korfmarcher, K., Moseley, C., & Thomas., C. (2004). *Collaborative environmental management: What roles for government?* . Washington, DC: Resources for the Future.

Koppell, J. G. S. (2003). *The politics of quasi-government*. Cambridge: Cambridge University Press.

Lasswell, H. & Lerner, D. (1951). The policy sciences: Recent developments in scope and method. Stanford, CA: Stanford University Press.

Lynn, L. E., Heinrich, Carolyn, J., & Hill, Carolyn, J. (2000). Studying governance and public management: Why? How? In C. Heinrich, J. and Lynn, Laurence, E. (Ed.), *Governance and performance: New perspectives*. Washington, D.C.: Georgetown University Press. 1-33.

Manson, S. & Evans, T. (2007). Agent-based modeling of deforestation in southern Yucatan, Mexico, and reforestation in the Midwest United States. *Proceedings of the National Academy of Sciences (PNAS)*, 104(52): 20678-20683.

Mashaw, J. L. (2006). *Accountability and institutional design: Some thoughts on the grammar of governance*. Cambridge: Cambridge University Press.

McNabb, D. E. (Ed.). (2007). *Knowledge management in the public sector: A blueprint for innovation in government*. Armonk, NY: M.E. Sharpe.

Meadows, D. H. (2008). *Thinking in systems*. White River Junction, VT: Chelsea Green Publishing.

Meyer, M. (1999). Demand Management as an element of transportation policy: using Carrots and sticks to influence behavior. *Transportation Research Part A* 33: 575-599.

Milward, H., & Provan, K. (2006). *A manager's guide to choosing and using collaborative networks*. Washington, DC: IBM Center for the Business of Government.

Mitroff, I. I., Betz, F., Pondy, L. R., & Sagasti, F. (1974). On managing science in the systems age: Two schemes for the study of science as a whole systems phenomenon. *Interfaces, 4*(3): 46-58.

Moynihan, D. P. (2008). *The dynamics of performance management: Constructing information and reform*. Washington, D.C.: Georgetown University Press.

North, M. & Macal, C. (2007) *Managing business complexity: Discovering strategic solutions with agent-based modeling and simulation.* Oxford: Oxford University Press.

OECD. (2009).*Applications of complexity science for public policy: New tools for finding unanticipated consequences and unrealized opportunities.* Global Science Forum. Retrieved: *7/15/10: http://www.oecd.org/dataoecd/44/41/43891980.pdf*

Ostrom, E. (2005). *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.

O'Toole, L. J. (1990). Multiorganizational implementation: Comparative analysis for wastewater treatment. In R. W. Gage & M. P. Mandell (Eds.), *Strategies for managing policies and networks*. New York: Praeger Publishers.

Page, S. (2004). Measuring accountability for results in interagency collaboratives. *Public Administration Review, 64*(5): 591-606.

Parker, D. C., & Manson, S. M. (2003). Multi-agent systems for the simulation of land-use and land cover change: A review. *Annals of the Association of American Geographers*, 93(2): 314-337.

Parsons, W. (1999). Public policy: An introduction to the theory and practice of policy analysis. Cheltenham, UK: Edward Elgar.

Pierre, J. (Ed.). (2000). *Debating governance: Authority, steering, and democracy*. Oxford: Oxford University Press.

Pierre, J., & Peters, B. G. (2005). *Governing complex societies: Trajectories and scenarios*. New York: Palgrove Macmillan.

Poister, T.H. (2003). *Measuring performance in public and non-profit organizations*. San Francisco, CA: Jossey-Bass.

Provan, K. G., & Kenis, P. (2007). Modes of network governance: Structure, management and effective. *Journal of Public Administration Research and Theory, 18*: 229-252.

Rhodes, R. (1997). *Understanding governance: Policy networks, governance, reflexivity and accountability*. Buckingham: Open University Press.

Rittel, H. W. J., & Webber, M. M. (1973). Planning problems are wicked problems. In N. Cross (Ed.), *Developments in design methodology*. Chichester: John Wiley and Sons. 135- 144

Romzek, B., & Dubnick., M. (1987). *Accountability in the public sector: Lessons from the Challenger tragedy*. Boulder: Westview Press.

Sabatier, P. A. (Ed.). (2007). *Theories of the policy process* (Second ed.). Boulder: Westview Press.

Sabatier, P. A., & Jenkins-Smith, H.C. (1993). *The advocacy coalition framework: An assessment*. Boulder, CO: Westview Press.

Salamon, L. (Ed.)(2002). The new governance and the tools of public action *The tools of government: A guide to the new governance*. New York: Oxford University Press: 1-47.

Shannon, C.E. & Weaver, W. (1949). *The mathematical theory of communication.* Chicago: Univ of Illinois Press.

Sorensen, E. (2006). Metagovernance: The changing role of politicians in processes of democratic governance. *American Review of Public Administration, 36*(1): 98-114.

Sorensen, E., & Torfing, J. (2005). The democratic anchorage of governance networks. *Scandinavian Political Studies, 28*(3): 195-218.

Sorensen, E., & Torfing, J. (Eds.). (2008). *Theories of democratic network governance*. New York: Palgrave Macmillan.

Squazzoni, F. & Boero, R. (2010). Complexity-friendly policy modeling. In Ahrweiler, P. (ed.) *Innovation in complex systems.* London: Routledge.

Stone, M. M., & Ostrower, F. (2007). Acting in the public interest? Another look at research on nonprofit governance. *Nonprofit and Voluntary Sector Quarterly, 36*(3): 416-438.

Van den Belt, M. (2004). *Mediated Modeling: A system dynamics approach to environmental consensus building*. Washington, D.C.: Island Press.

Vogel, R.K. & Nezelkewicz, N. (2002). Metropolitan planning organizations and the new regionalism: The case of Louisville. *Publius*. 32(1): 107-129.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Wright, D. S. (2000). *Models of national, state, and local relationships*. Washington, D.C.: CQ Press.

Zachary, W. (1986). A cognitively based functional taxonomy of decision support techniques. *Human-Computer Interaction.* 2: 25-63.

Zia, A., Metcalf, S., Koliba, C. & Widner, M. (2010). Management of complex governance networks: Opportunities and challenges for agent based models of policy analysis. American Society of Public Administration Annual Conference. San Jose, CA.