

Characterizing the Next Generation Knowledge Organization

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ABSTRACT

This paper investigates the major characteristics needed by the next generation knowledge organization. The paper then proposes five organizational characteristics that support sustainable competitive advantage within an environment of rapid change, high complexity and large uncertainty. Next, eight major system characteristics are proposed that will allow the organization of the future to survive and compete. These characteristics are emergent phenomena arising out of the structure and relationships of the proposed organization, an example of an Intelligent Complex Adaptive System (ICAS). They are: Organizational Intelligence; Unity and Shared Purpose; Optimum Complexity; Selectivity; Knowledge Centric; Flow; Permeable Boundaries; and Multi-Dimensionality. After describing these characteristics, the four processes through which the organization transforms its capabilities into actions are addressed. These processes are: Creativity; Problem Solving; Decision-making; and Implementation. A model is proposed that shows the top-level interactions among the characteristics.

This paper is intended to be more suggestive than definitive. A number of these areas are uncharted territory with many streams and rivulets that have not been explored. Research is currently underway to further develop each of these characteristics in more detail and to investigate their mutual interactions and support of the major processes. The next step planned is to identify actions, processes and tools for implementation by ICAS agents and subsystem groups.

The Future Environment

While it is impossible to predict the future, there are major trends driven by fundamental underlying forces that give some confidence in extrapolating into it. For example, while progress in science and technology is not linear, overall advances in science and technology have - consistently led to an increase in knowledge, and advances in their application have created the present world economy and standard of living. The technology to access data, information and knowledge is growing rapidly with time and may well overwhelm our limited human ability to find, identify and retrieve data, information, and knowledge objects in time to interpret and apply them to fast changing crises and opportunities.

Recognizing that a great many factors and forces impact organizations, and accepting that their number will likely increase in the future, we have attempted to identify the drivers that are behind the phenomena of change, complexity and uncertainty that currently cast a shadow over our institutions. Five drivers of the current and future environment are identified that represent fundamental forces that will challenge future organizational survival. They are: connectivity; data, information and knowledge; speed; access and digitization (see Figure One). In addition to impacting how firms must structure themselves and what strategies and form they take on, these drivers will also impact employees, customers, legislative policies and international relationships, all of which carry over to influence every organization's ability to meet its objectives.

Major Characteristics of the ICAS World

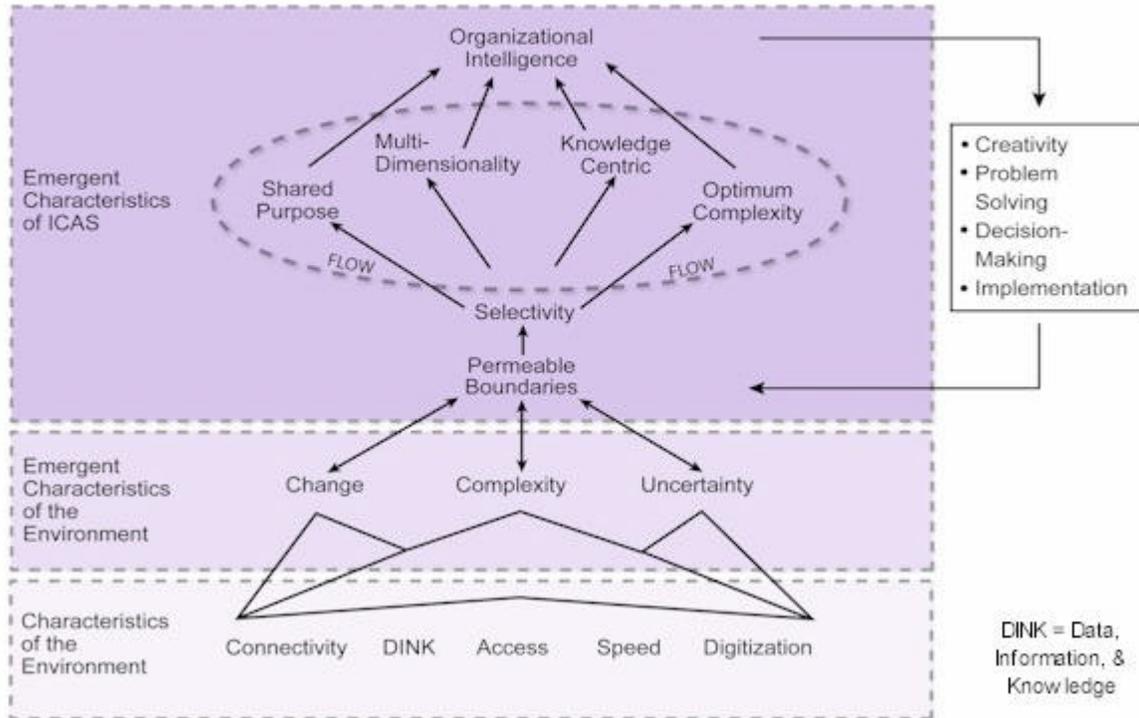


Figure One -- Characteristics of the ICAS

The first major force of the future environment is *connectivity*: the number and ease of connecting different parts of the world. Technology has provided totally new ways of moving and transferring data, information, and knowledge among individuals, organizations and governments. Anyone in the world can talk at any time to almost anyone else in the world in real-time through the Internet, satellite

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or fiber optic cables. Virtual conferences and video cameras will be commonplace.

The result will be much more communication - potentially reducing costs and - speeding up the flow of ideas, the making of decisions and, hopefully, the sharing of understanding. Collaboration will involve experts from all over the world, brought together rapidly and efficiently to solve problems or brainstorm ideas. The ability to enter into a formal dialogue with strangers will become a factor in success, as the need for synergistic thinking and rapid action becomes a survival competency. The resulting pressures on organizations will mandate their ability to scan, select and quickly respond to the consequences of this environmental network and web of exchanges and actions. As the number of nodes in a network increases, the number of links increases exponentially. As the links and their consequent relationships increase, so does the complexity.

The second driver impacting organization is *data, information and knowledge*. In addition to possible overload from saturation, organizations will have technology and human systems that search and seek the data, information and knowledge needed to meet their objectives. These systems must validate the information, categorize it, identify the context and develop the best interpretation, thereby laying the groundwork for knowledge application. Each of these activities is difficult enough by itself, but when existing in an environment where information is a bombardment, changing quickly, noisy and possibly random, or with little meaning, the organization will be forced to develop new capabilities that can respond to such terrain.

Speed is the next force behind the accelerating world: Speed in the movement of goods and services, in the creation of new ideas through virtual collaboration, in the spread of information through increased bandwidth, in smart search engines and learning software and in the sharing and diffusing of knowledge. Speed shortens time and creates a demand for faster decision-making. It also increases uncertainty by limiting the time available to comprehend what is going on. As discussed below, it exacerbates the problems of validation and assurance of information and knowledge. In general, the pace of everything will continue to accelerate-while simultaneously demanding that the human brain keep up. One challenge for the new organization is the resolution of conflict between the limitations of human processing and the increasing speed of change and exponential growth of data, information and knowledge.

Access is a recent problem emerging from the confluence of the three previous phenomena. It has several aspects. The first is how to identify the context of the information so that understanding can be extracted and relevant knowledge created by the user. The combination of large amounts of information coming from multiple networks using high-speed transfer systems that need rapid, quality decisions makes this "context" extraction a - difficult problem. When one

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considers the global sources of information and the language and cultural differences that come with international participants in communication networks the challenges become staggering. A second element of access is competition. In the organization of the future competitors will have the ability to quickly and reliably find information on each other, thereby improving their own competitive status and driving other competitors to match or exceed their own. The world of competitive intelligence is already turning in this direction for those with the human capital necessary to understand the whats and hows of Internet superiority. In addition, every organization's customers will have access to more information and their standards and expectations of products and services will be high. A third effect of increasing access to information is the changed perspective and expectations of employees relative to their place of employment. For example, employees with a broader understanding of their world may constantly assess their own situation relative to employment. To respond to such assessments may necessitate a carefully structured approach to management and leadership, one that ensures long-term employment of the best employees. A final impact of increased access to information is the opportunity of the organization to make use of information as a major internal process and competency.

Any of the above characteristics of the environment may have one or all of these impacts on the organization. As the amount and availability of data, information and knowledge continues to increase, of necessity so will the complexity of the organization. Connectivity, speed and large amounts of information from everywhere on earth will seed the culture of the future. How the above characteristics can be turned into shared understanding and knowledge application for the good of the organization is unanswered at this time. A vital question is: "Can organizations adapt and learn fast enough to keep up with the environmental changes driven by these forces?"

The digital economy, as it is popularly known, describes the overall movement to make maximum use of digital technology to create new products and increase efficiency. The scope of impact is almost unbelievable, ranging from computers to telephones to publishing to banking to education to medicine to cyberspace. Donald Tapscott considers the digital economy's driver to be an alliance of converging technologies. In his latest book, Blueprint to the Digital Economy, Tapscott [1, P. 1] offers the following forecast:

"Clearly the first 40 years of the computing revolution have been a preamble. Much greater changes lie just ahead. The marriage of computers and communication networks is transforming most aspects of business and consumer activities. Organizations face enormous changes, many occurring simultaneously."

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It seems clear to most students of the economy that the current and future world will be driven by technology as the number of networks and relationships increase and encourage consumers, businesses, the media and government to expand their range of activities and options through collaboration. As nanotechnology, biotechnology, the communications highway and smart machines embed themselves into the world of homo sapiens, their very invisibility will quietly create an entirely different milieu. This new world will be as different and challenging as the shift from horse transportation to space travel. The changes are more than simply increasing speed, complexity and connectivity. The digital world brings its own set of rules, limitations and constraints that demand a reorientation, restructuring and, in many areas, a redesign from the bottom up for those organizations that will lead the economy. This paper offers a glimpse of what those firms in the knowledge industry may look like.

Each of the five major environmental forces discussed above influences the other four. For example Connectivity has made data, information and knowledge more widespread and available, while digitization has provided the technology for wide bandwidth connectivity. These five characteristics of the environment represent major drivers that create an overall landscape upon which the organization of the future must live and adapt.

This landscape can be described at the highest level by three characteristics that emerge from the interaction of these five forces. They are familiar to all readers as: *Change, Complexity and Uncertainty*.

The major characteristics of the model proposed in this paper arise from the lower level interactions and relationships found within and external to the organization of the future. Because these results are not directly caused by individual actions, the approach to designing, building, and maintaining the organization must be one of a gardener or orchestra conductor who creates and orchestrates an environment within which the right things are encouraged to happen. This sharply contrasts with the classic design approach where determinism and clear lines of control are assumed. One must be careful not to presume that an open structure, or the free will of individuals, will result in the desired organizational performance. As usual, balance -- even in the crazy, fast paced and confusing world of the future -- will provide the fundamental form and functions needed.

Introduction to ICAS: The Intelligent Complex Adaptive System

In our research it quickly became clear that neither the classic bureaucratic nor the currently popular flat organization could provide both the unity and selectivity necessary. A different approach to design was needed to create an organizational system that could enter into a symbiotic relationship with its cooperative enterprise, virtual alliances and external environment while

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simultaneously retaining unity of purpose and selectivity of incoming threats and opportunities. Thus the *living system* metaphor has to be turned into a reality. The organization that will follow the currently anticipated knowledge organization must be a living system composed of other living systems that combine and interact to provide the capabilities of an advanced, intelligent techno-sociological adaptive enterprise. This system is an ICAS.

By *complex* we mean an organization that can take on a very large number of states. A complex system is made of a large number of individual, intelligent agents, each with their own ability to make decisions and strive for certain goals. These agents (workers) have multiple relationships within the system, and externally through its boundaries, and these relationships can become highly complex and dynamic. Groups of these agents may work together to form components of the system, and these components together may form the whole system or organization under consideration. The word *adaptive* implies that the entire system is capable of studying and analyzing its environment and taking actions that adapt itself to forces in the environment in fulfilling its overall (organization) goals.

This paper addresses the distinctive characteristics of the ICAS as differentiated from current world-class organizations. Most world-class organizations are a combination of hierarchical and team-based structures. The differences between these organizations and the ICAS rest in the domain of the eight emergent characteristics to be discussed and other individual and dynamic group characteristics. We therefore ignore the necessary collateral functions and infrastructure that all successful firms possess. Where current world-class organizations use rules and policies to ensure results, our focus is on creating an environment out of which organizational intelligence emerges and leads to desired results. A basic assumption is that nature, with her millions of years of experience through Darwinian evolution, represents a metaphor that offers good guidelines and insights to lead us in the right direction. We believe that some properties of the human mind are transferable to organizations in more than superficial ways. Another assumption is that the key to success in living systems is how they handle information both within their boundaries and in interaction with their environment. So it is with organizations.

One of our main resources in this regard is the recent work done by the Nobel Laureate, Gerald Edelman, in his search to understand consciousness through neuro-scientific research. We also make use of Karl Wiig's work on knowledge management and intelligent behavior. Csikszentmihalyi's extensive work on flow theory provides insight into the desirable internal movement of relationships and data, information and knowledge. Finally, complexity theory in general, and the theory of complex adaptive systems in particular, provide a framework for understanding how organizations will be able to pull it all together to compete effectively in the future.

Intelligent complex adaptive systems (ICAS) may be highly unpredictable or superbly self-organized, depending on their precise internal structure and relation to their environment. They will exhibit a unity of purpose and a coherence of action while being highly selective and sensitive to external threats and opportunities. They will be able to bring diverse knowledge located anywhere in the organization (or beyond) to solve problems and take advantage of opportunities.

There will be much more emphasis on individual worker competency and freedom in terms of learning, making decisions, and taking actions in given areas of responsibility coupled with multiple and effective networks that provide sources of knowledge, experience and insights from others. These dynamic networks will represent the main infrastructure of the next generation knowledge-based organization. Made available by increased bandwidth and processing power of both silicon and biotechnology, They offer the opportunity for virtual information and knowledge support systems that connect data, information, knowledge and people through virtual communities, knowledge repositories and knowledge portals. The foundation and grounding of these future firms will be strengthened through a common set of strong stable values held by all employees. Such values not only provide guidance that enhances empowerment but also motivate and strengthen the self-confidence of the workforce, thereby magnifying the effectiveness of the self-organized teams within the ICAS. These organizations will possess a number of emergent characteristics that permit them to survive and successfully compete in the future world.

Emergent Characteristics of ICAS

As organizations change and take on new forms, they often do so through the creation and development of what systems theorists call emergent characteristics. Auyang, [2] in citing Mills suggests three criteria for emergence:

“First, an emergent character of a whole is not the sum of the characters of its parts; second, an emergent character is of a type totally different from the character types of the constituents; third, emergent characters are not deducible or predictable from the behaviors of the constituents investigated separately”. [P. 174]

The sources of emergent properties include both structural and relational. Auyang [2, P. 176] notes that “Emergent characters mostly belong to the structural aspect of systems and stem mainly from the organization of their constituents.” Whereas Holland [3] writes that

“Emergence is above all a product of coupled, context-dependent interaction. Technically these interactions, and the resulting system, are

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nonlinear. The behavior of the overall system *cannot* be obtained by *summing* the behaviors of its constituent parts. ... However, we can reduce the behavior of the whole to the lawful behavior of its parts, *if* we take the nonlinear interactions into account." [Pp. 121-2]

Ingber [4], in investigating biological design principles that guide self-organization and emergence, extends the normal complexity-based approaches that focus on nodes, connections, and resultant pattern formation to include the importance of architecture, mechanics and structure in the evolution of biological forms. [4, Pp. 269-280]

Some examples of emergent properties from Coveney and Highfield [5] are: life is an emergent property arising from physicochemical systems organizing and interacting in certain ways; a human being is an emergent property of huge numbers of cells; a city is an emergent property of thousands or millions of humans; and a company is more than the sum of its technology, real estate and people [5, P. 330]. The connection between processes and relationships within the organization and its emergent properties is complex and difficult, if not impossible, to follow via cause and effect chains. It is also difficult to predict the precise nature of emergent characteristics. This is one reason why planned change is so difficult and the change process so hard to control. For instance, it is easy to create a vision of a team-based organization with high employee empowerment. But, the exact details of the best team structure or the specific way that employees should be empowered are very hard to predetermine. People are not machines and their variability and self-determination are essential for their efficacy. Thus, while a desirable emergent characteristic can be nurtured, it cannot be decreed.

Every one of the eight characteristics of what we call ICAS must emerge from the nature of the organization, and cannot be pre-designed and implemented by managerial fiat. These top-level properties best describe the necessary conditions for the optimum operation of four major processes to deal effectively with the external environment and with competitors. These processes represent the primary ways that organizations internally prepare themselves to take actions that affect their environment and thereby ensure survival. The processes are: Creativity, Problem Solving, Decision Making and Implementation.

The eight emergent characteristics are shown in Figure One to highlight their relationships. The ICAS is in many ways a living system, as it must be to survive in a rapidly changing, nonlinear, complex, dynamic and uncertain world. These characteristics provide the internal capability to deal with the future environment. We will briefly address each of them in turn: Organizational Intelligence, Shared Purpose, Selectivity, Optimum Complexity, Permeable Boundaries, Knowledge Centric, Flow and Multi-Dimensionality. (See Figure Two.) These brief discussions do not describe those lower-level elements whose interaction produces these emergent characteristics.

Organizational Intelligence

Intelligence, according to Webster [6, P. 739], is the capacity for reasoning and understanding or an aptitude for grasping truths. When applied to organizations, Wiig [7, P. 84] broadens this view of intelligence and considers it as the ability of a person to think, reason, understand and act. He further considers intelligence as applying to organizations and includes the capabilities to innovate and acquire knowledge and apply it to relevant situations. From an organizational viewpoint, both employees and their organization can exhibit intelligent behavior.

Pinchot and Pinchot [8, Pp. 19-20] describe the intelligent organization as one which can face many competitors simultaneously and deal effectively with all of them and attend to all the details and supporting competencies that add up to cost-effective, superior performance. They further note that “the quality of relationships between members of the organization is a strategic issue that determines the very fabric of the organization.” [P. 70]

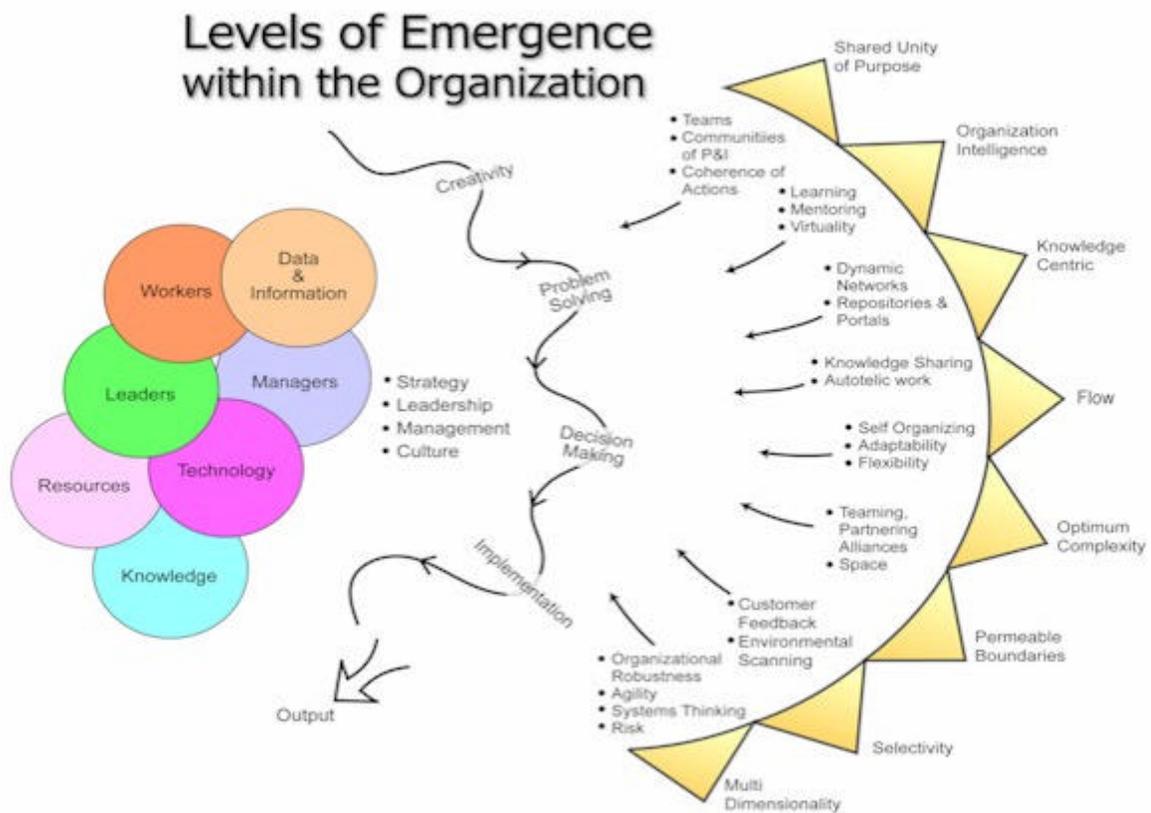


Figure Two -- Levels of Organizational Emergence

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McMaster [9, P. 3] refers to organizational intelligence as “the capacity of a corporation as a whole to gather information, to innovate, to generate knowledge, and to act effectively based on the knowledge it has generated. This capacity is the basis of success in a rapidly changing or highly competitive environment. ... Organizational intelligence refers to a capacity which is inherent in a system of organization. It is greater than the sum of the intelligence, information, and knowledge of each individual in that organization.”

We agree with the above authors. As a working concept, we take organizational intelligence to be the ability of an organization to perceive, interpret and respond to its environment in a manner that simultaneously meets its organizational goals while satisfying its stakeholders, that is, its employees, customers, investors, community and environment. Organizational intelligence is a descriptive term that indicates the measure of the organization's (and its workforce's) capability to exhibit intelligent behavior.

Intelligent behavior of individuals, groups and organizations [7, P. 38] can be understood in terms of (1) demonstrating behavior traits that are effective and acceptable; (2) being well prepared; (3) choosing the right posture in each situation; (4) being able to solve problems well; and (5) being able to make high quality decisions and take effective actions for their implementation. Each of these can be studied to find the specific competencies needed for success in each area.

For example, intelligent behavior traits range from listening to others, remaining objective and flexible to learning, and thinking before acting. Independent thought, the ability to collaborate well in pressure situations, and having strong principles all help create credibility and trust, and support good long-term relationships. Such relationships greatly enhance the speed and quality of decision-making and situational assessment. Intelligent behavior from an organizational perspective means that external firms, customers and partners will look with favor on the idea of interacting with the organization. Intelligent behavior leads to good working relationships at every level. According to McMaster [9, P. 166], relationships are the foundation of human intelligence. While good relationships have always been important, in the future they will be critical due to the advance of technology and the increasing role of knowledge in handling time compression and complexity.

Being well prepared means maintaining continuous context knowledge of surroundings, thinking ahead (anticipating possible events and evaluating worst-case scenarios), and rapidly developing opportunities that will be advantageous at all levels of the organization. Tomorrow's world will require a good knowledge of systems thinking and the ability to integrate large numbers of divergent data and information into a cohesive unity of understanding. We discuss this challenge in the section on Unity and Shared Purpose.

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For an organization to behave intelligently as a complex adaptive system, it must achieve continuous, interdependent collaboration and interplay among all levels of its system. This means balancing the knowledge and actions of its agents to achieve both the lowest-level tasks and highest-level vision of the organization, creating a distributed intelligence throughout the organization. This can be done by using teams and communities to amplify local intelligence levels, accelerate quality decision-making, and foster innovation and creativity.

Being well prepared enables the firm to choose the right tactics. This is not easy in a world supersaturated with information, access problems and complex nonlinear changes and threats impacting the organization. Quick reaction capabilities must be assembled using the knowledge and expertise needed to act effectively. Locating the right knowledge, experience and tools to effect right action and tactics is a major strength of an ICAS. While problem solving and decision-making are well known competencies, their implementation is made more difficult in the future world of change, complexity and uncertainty. To perform these processes will require more data, information and knowledge than any single person, and perhaps any one group, can possess. Just as no one part of the brain is responsible for a given thought or process [10, Pp. 31-2], no one part of ICAS will necessarily be sufficient to develop tactics, solve problems or make decisions. Undoubtedly, this approach will be widely resisted by many managers and leaders. It has disturbing consequences for the historical balance among authority, responsibility and accountability. These problems are already being faced with the extended use of teams (See Bennet, [11]).

In discussing intelligent behavior Wiig [7, P. 39] notes that knowledge plays a central role and suggests the following six knowledge areas that need to be developed:

- Knowledge of knowledge
- Thinking about thinking
- “World knowledge” of society, sciences, people, etc.
- Knowledge of primary work-related domains
- Knowledge of private life, hobbies, etc.
- Basic knowledge of “walking,” “talking,” 3 Rs, social skills, etc.

A study of knowledge workers in Bell Labs by Kelly and Caplan [12, Pp. 128-39] identified nine capabilities that lead to high performance . Their capabilities are laid out in some detail and, in general, agree with Wiig’s [7, Pp. 50-51] description. What has not been done to our knowledge is an investigation of each capability to see how it can be expanded to teams and larger components of an organization to create the desired level of organizational intelligence.

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Although data and information are necessary for acting intelligently, it is the knowledge that is created and acted upon that is the critical factor for the ICAS. There is currently much discussion and many interpretations of the terms data, information and knowledge. Since we are concerned with making organizations work better, we will take a somewhat pragmatic stance. We take these terms to have the following meaning. Data are facts, numbers or individual entities without context or purpose. Information is data that has relevance and may have some context and meaning associated with it. Knowledge, while made up of data and information, can be thought of as much greater understanding of a situation, relationships, causal phenomena, and the theories and rules (both explicit and implicit) that underlie a given domain or problem.

According to Wiig [7, P. 82], P. "Knowledge can be thought of as the body of understandings, generalizations, and abstractions that we carry with us on a permanent or semi-permanent basis and apply to interpret and manage the world around us. ... we will consider knowledge to be the collection of mental units of all kinds that provides us with understanding and insights." Thus knowledge is what each of us uses to determine *what something means*. In addition, it should not to be separated from action or from pragmatic concerns. McMaster [9, P. 83] says "Knowledge is information that is integrated with the entire system in such a way that it is available for action at potentially appropriate times." Data, information and knowledge support organizational intelligence through the competency and demonstrated actions of both individuals and groups within the organization.

In summary, an organization needs to exhibit intelligent behavior to provide the best response to its environment and to influence that environment in an effective way. Such intelligence must be coordinated throughout the organization at every level so there is a unity of purpose and a consistency of history as the firm evolves and grows within its outside surroundings. At the ICAS level, the characteristic of intelligence must emerge from a large number of individual agents and their relationships, supported by technology and other artifacts. Since intelligence is not a specific location within the ICAS organization, it must come from lower level actions, processes and characteristics. That is, intelligence is an emergent property of ICAS. We now turn to the other characteristics that, taken together, support intelligent behavior.

Unity and Shared Purpose

Unity and shared purpose represents the ability of the ICAS organization to integrate and mobilize its resources to (1) provide a continuous line of focus and attention and (2) pull together the relevant parts of the organizations when and where they are needed. Senge [13, P. 9] addresses a partial solution to this problem in his management book, *The Fifth Discipline*. He emphasizes the importance of a shared vision where employees participate in the development of a corporate vision, and can then make decisions and take actions consistent with

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the directions set by senior leadership . One can hardly disagree with this so long as the environment is reasonably stable and the vision does not change frequently. In the future world however, one can expect more changes within every organization that operates close to the field where knowledge and information are the prime movers as Senge envisions. Under such conditions, structures and relationships must be established that support and ensure continuous, rapid two-way feedback between key components throughout the organization *and* the central nexus where top-level decisions are made or orchestrated.

In the fifth of a series of books describing his research on consciousness, Edelman and his co-author, Tononi [14, P. 36], identify the mechanism that provides unity to consciousness, thereby creating a continuous history of thought and a consistency of identity and action.

“Our analysis leads to several conclusions. First, conscious experience appears to be associated with neural activity that is distributed simultaneously across neuronal groups in many different regions of the brain. Consciousness is therefore not the prerogative of any one brain area; instead, its neural substrates are widely dispersed throughout the so-called thalamocortical system and associated regions. Second, to support conscious experience, a large number of groups of neurons must interact rapidly and reciprocally through the process called reentry. If these reentrant interactions are blocked, entire sectors of consciousness disappear, and consciousness itself may shrink or split. Finally, we show that the activity patterns of the groups of neurons that support conscious experience must be constantly changing and sufficiently differentiated from one other. If a large number of neurons in the brain start firing in the same way, reducing the diversity of the brain’s neuronal repertoires, as is the case in deep sleep and epilepsy, consciousness disappears.”

Recognize that the brain has roughly 100 billion neurons, each with an average of 1000 connections to other neurons. Information is stored in the connections between neurons and in patterns of connecting neurons, which change continuously, dependent on external sensory inputs and other internal pattern inputs. It is also known that different regions of the brain process different parts of a visual image, for example, and that all of the outputs of these processes are combined to make the image a unitary whole so that the perceiver “sees” a self consistent, integrated picture [14, Pp. 113-24]. This ability to maintain different parts of the brain in harmony and to pull them together is exactly the challenge of the future organization, where the external environmental complexity continually impinges on many parts of the firm and may not in itself have any coherence or consistency. Evolution’s solution to the brain’s so called “binding problem” [14,

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Pp. 114-15] is to create certain neuron paths that provide continuous two-way communication between key operating networks.

“Finally, if we consider neural dynamics (the way patterns of activity in the brain change with time), the most striking special feature of the brains of higher vertebrates is the occurrence of a process we have called reentry. Reentry. . . depends on the possibility of cycles of signaling in the thalamocortical meshwork and other networks mentioned earlier. It is the ongoing, recursive interchange of parallel signals between reciprocally connected areas of the brain, an interchange that continually coordinates the activities of these areas’ maps to each other in space and time. This interchange, unlike feedback, involves many parallel paths and has no specific instructive error function associated with it. Instead, it alters selective events and correlations of signals among areas and is essential for the synchronization and coordination of the areas’ mutual functions.” [14, P. 48]

What are we to make of these findings? Clearly an individual is not a neuron and consciousness is not a good description of our future organization. But, if we think about the patterns of interaction and the way that information is shared and unified there are some telling lessons here.

For our new organization to work intelligently, it must be able to simultaneously unify its relevant parts to gain maximum situational understanding, knowledge and concentration of its power to act and to react. Because of the large number of threats and opportunities and the urgent need for fast response, the ICAS will put in place systems to reach into, and maintain, continuous two-way communication with a large number of relatively independent subsystems. According to complexity research [15, Pp. 72-106], these subsystems of agents should be self-organizing to maximize their learning and innovation. In addition, self-organizing groups are capable of creating emergent properties and are better at dealing with surprises and unknowable futures than the normal organizational structure. Stacy addresses this topic head on when he says [15, Pp. 268-9]:

“...The immediate conclusion drawn is that ignorance can be overcome by greater investment in gathering information, funneling it to some central point where it can be analyzed, and then feeding it back to the actors. The dominant schema therefore leads people to believe that ignorance can be overcome by research into organizational excellence, incompetence can be overcome by training and developing managers, and systems can be used to prevent bad behavior ... From the complexity perspective, however, we reach the opposite conclusion, namely, that the future is truly

unknowable. Creative futures emerge unpredictably from self-organizing interactions between members; therefore, they clearly cannot use some forecast of long-term outcomes to decide between one action and another.”

The need for unity and shared purpose and also for local freedom, empowerment and self-organization presents an apparent paradox. The solution lies in accepting both as necessary for intelligent behavior and in structuring relations among subsystems and organizational levels such that there is enough flexibility and two-way communication for both to coexist, each rising to meet local and organizational needs as appropriate.

Note that self-organization need not imply the lack of rules. A shared vision, common values and widespread communication of context information all support empowerment and self-organization. In any case, both rules and the freedom to self-organize are needed. The specific balance between rules for alignment and coherence of operations and empowerment for local work flow optimization and innovation is both situationally dependent and dynamic. There is no pat formula for a desired balance.

When achieved, unity and shared purpose create an integration of internal activities that make the whole organization greater than the sum of its parts. The synergy, differentiation, and variety of its subsystems provide the internal complexity needed to deal with the complexity of the outside world. To be effective, this complexity must be able to provide not only a large variety of responses but any particular response must be coherent with the rest of the ICAS organization.

The unity of the organization's experiences is closely associated with its perception of external events. This is where the flow of information, knowledge and optimal experience (feelings) becomes so important. Although an organization can be aware of several mutually incoherent events at the same time, if these are not integrated at some level, the responses may be inconsistent and deleterious. This emphasizes the need for continuous and widespread common context sharing throughout the organization.

A final word of caution, too strong a unity and shared purpose can become stifling if it prohibits divergent thinking or remains focused on one strategy for too long. The unity needed is the momentary unity of coherent action and its context knowledge. Specific directions and tactics will change frequently due to the non-linearity and dynamics of the external world.

Optimum Complexity

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Complexity is a popular research area ranging from artificial life to complex adaptive systems to social systems. Its use in management has been to carry over ideas that were developed in the hard sciences to the soft sciences. In a recent book, Axelrod and Cohen [16, P. 12] note that: "Social systems exhibit dynamic patterns analogous to physical, biological, and computational systems. This is perhaps the fundamental reason we pursue complexity research." In a discussion of the relationship between complexity and information they offer the following:

"If complexity is often rooted in patterns of interaction among agents, then we might expect systems to exhibit increasingly complex dynamics when changes occur that intensify interaction among their elements. This is of course exactly what the Information Revolution is doing: reducing the barriers to interaction among processes that were previously isolated from each other in time or space. Information can be understood as a mediator of interaction. Decreasing the costs of its propagation and storage inherently increases possibilities for interaction effects. An Information Revolution is therefore likely to beget a complexity revolution."

From our perspective, we see the Knowledge Revolution on the close-in radar screen and the Complexity Revolution soon to follow. The two phenomena are somewhat interdependent with a challenge and response type of relationship where each drives the other. As a result, neither revolution is likely to ever end. More likely, after initial surges they will co-evolve, with continuous shifting of stresses and strains between them. Nevertheless, as early preparation for an anticipated complexity avalanche, we are suggesting possibilities for organizational characteristics that will more effectively respond to complexity.

Complexity is commonly interpreted as being a measure of the number of elements and/or their relationships in a system. While useful in many applications, there are difficulties with this interpretation when considering organizations. It is not the number of possible states, either in the organization or in its external environment, that need concern an organization. It is the number of states *that make a difference* to the organization that are important. Of the almost infinite number of states of information, material or energy that impinge upon the organization, only a small number are meaningful and make a difference. Considering the subsystems within the organization, it is only those states that each subsystem takes on that make a difference within the organization or with the external world that are of concern.

Considering the internal design of the ICAS, we can see that if every worker and every subsystem (team, group or organizational element) were to act independently and randomly the largest number of states would be generated.

But this would not be useful to the organization, because there would be no coherence, only random behavior. At the other extreme, if every worker and every subsystem were constrained to behave in a predetermined way such that the organization became a rigid structure with a large number of elements with tightly controlled relationships, such as a “perfect” bureaucracy, then the organization would die from rigor mortis in our future world. An example from physics would be a perfect gas versus a rigid solid structure. Both could be said to have high complexity due to their large number of elements and relationships. From an organizational perspective, neither extreme is acceptable.

The right balance between unity and diversity has not been found and may not exist. Both unity and diversity may coexist, or the balance may vary with the specific external environment and the ICAS form. Most likely there is a range of operation and a range of external conditions over which the organization can function and sustain itself. However, to the extent that Edelman’s research on the brain offers insights into organizations [14], the ICAS will not be able to function at either extreme--strong control or full freedom. When operating in this middle range, complex adaptive system theory suggests that the three key factors are variation, interaction and selection. Clearly this combination enhances the ability of organizations to survive in an environment of rapid change, complexity and competition for survival.

Variation comes from new employees, virtual teams, learning and a willingness to explore new strategies and tactics. A balance between highly variable processes and tightly controlled ones can allow both variability and consistency. Interactions are the fundamental phenomenon of ICAS. They must be “managed” so as to achieve balance between interactions that make the difference to the organizations, - those that amplify knowledge and direct resource capabilities; and so as to identify interactions that waste time. Selection of incoming information represents the filter that prevents internal information saturation and determines what the organization will pay attention to.

Although the internal complexity of the organization can be influenced by structure, relationships, process design and culture, a major determinant is the individual. Each individual is an attenuator and amplifier of complexity within their local environment. Their behavior, knowledge, intentions, purposes and expectations can either increase or reduce the complexity within their subsystem. Team leaders, managers and influential workers throughout the ICAS may play a large role. Internal complexity must be carefully understood. A large variety in options and actions to meet goals is desirable while random actions, wrong approaches and shadow governance can do significant harm to the organization. We have returned to the issue of balance. Internal complexity is neither good nor bad, rather it is the role that complexity plays in supporting ICAS objectives that counts.

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A major conclusion is that complexity will play a strong role in ICAS and therefore it must be identified, monitored and nurtured, keeping in mind that it arises from processes and relationships within the organization; and from the transmission of data, information and knowledge through the organization's permeable boundaries. A second conclusion is that too much internal complexity can lead to chaos while too little complexity limits the organization's ability to respond to the external world. Recall Ross Ashby's law of requisite variety that proclaims to manage complexity one has to have more options, i.e., more complexity, than the thing managed. [17] There are no easy solutions to the problem of using internal complexity to *live* with external complexity, though the next section will address one approach to the problem—selectivity.

Selectivity

At any given moment, every individual and every organization has a huge number of signals impinging on its boundaries: data, information, sounds, images, ideas, etc. We are not even aware of many of these signals; for example, sounds above 20,000 hertz or infrared radiation. How the organization prevents itself from being overwhelmed with these signals and is able to select, receive, process and maintain a balance of unity, variety and flexibility is an amazing feat. Yet both organizations and people do this every waking moment of every day. As the external environment becomes more influential through its change, complexity and uncertainty parameters, the ability to select and control which signals make a difference may be the first line of defense (and opportunity) for the ICAS organization.

Selectivity, or the filtering of incoming information from the outside world, will always occur. Individual attention is limited by physiology to one thing at a time (and groups may have difficulty staying on a single topic). If left to itself, natural selectivity may become random and create more noise than purposeful action within the organization. This is exactly what subsystems such as teams or self-organizing groups are supposed to prevent. By analyzing incoming information through internal communication and "group digestion" of unusual events, the organization can improve its filtering ability. Many opportunities may be lost due to the non-recognition of the meaning and consequences of seemingly benign signals.

One approach to signal-to-noise filtering of incoming information is to establish value systems that are consistent across the organization, coupled with the unity and shared purpose discussed above. These provide ICAS members with guidelines and context knowledge—the basis for effective interpretation and filtering of signals. Values provide a means of rejecting signals that the organization chooses not to respond to. They are preconditions for intelligent behavior.

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Shared purpose and current organizational tactics make visible what signals the organization is interested in. If people are clear about the priorities that really matter to the organization, and keep these firmly in their awareness, they will be able to quickly evaluate incoming signals and make the appropriate decisions. This ability to discriminate among incoming signals (discernment and discretion) can become an art, to be continuously refined and perfected. The shared knowledge of what makes a difference to the organization will become more important as the rate of change increases.

Such knowledge should always be grounded in the tacit knowledge of individuals. It cannot become wholly implicit, however, because such tacit knowledge may not be shared fast enough to keep up with change. Knowledge repositories (explicit knowledge) and flow (discussed below) play a big role in knowledge sharing and in the ICAS of the future.

Sometimes the incoming signals may appear unrelated to the organizations purpose, yet are significant. Edelman and Tononi [14, P. 86] address this as follows: "All selectional systems share a remarkable property that is as unique as it is essential to their functioning: In such systems, there are typically many different ways, *not necessarily structurally identical*, by which a particular output occurs." This degeneracy means that for a given input, different parts of the - organization can produce the same output or interpretations. This capability reflects organizational insurance. If an important signal comes in it can be dealt with properly, even if structural changes have occurred within the ICAS.

As different subsystems evolve and change, the selection ability of the organization as a whole must remain strong. When the selection function loses its coherence the organization deteriorates, potentially into confusion, infighting and misdirected energy, resulting in a loss of competitive advantage and eventually death or merger.

Knowledge Centric

In the new knowledge world where ideas are central, knowledge shared is power. Knowledge is one of those rare things you can give away and still have. Hoarders of knowledge have limited value to the organization and become the primary cultural barriers to learning. As knowledge is shared, and through reciprocal sharing, innovation springs into being. This sharing relationship must be built on a foundation of trust.

A knowledge-centric ICAS will recognize the value of information and knowledge in decisionmaking. It will connect people to people, people to systems, and systems to people to ensure availability and delivery of the right information at the right time for decision and action. The creation, storage, transfer and application of knowledge (and perhaps wisdom) will have been refined and

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developed such that it becomes a major resource of the ICAS as it satisfies customers and adapts to environmental competitive forces and opportunities.

In the knowledge-centric organization, knowledge repositories, automated libraries, computer services, databases, etc. offer the capability for not only storing huge amounts of data and information but also efficient and intelligent retrieval and assemblage capability. Powerful search algorithms, intelligent agents and semantic interpreters allow employees to rapidly retrieve information needed for problem solving and decision-making.

Knowledge management will be imbedded in the ICAS as a process for optimizing the effective application of intellectual capital to achieve organizational objectives. Intellectual capital includes human capital, social capital and organizational capital, all three being essential contributors of the organization's enterprise knowledge. Human capital includes each employee's unique set of characteristics and values from the past (expertise, education and experience); their set of capabilities and ways of seeing and living in the world (such as creativity and adaptability); and their capacity for learning and potential for the future.

Social capital includes human and virtual networks, relationships and the interactions across these networks built on those relationships. It also takes into account all the aspects of language, including context and culture. Added to this grouping is patterning, which deals with timing and sequencing. Organizational capital includes intellectual property, and corporate functional and organizational processes, as well as all the data and information that has been made explicit and available to all employees. All three types of capital will be valued at the bottom line of the ICAS, and each employee will take responsibility for ensuring Intellectual Capital growth.

Knowledge centrality is closely related to organizational intelligence. In order for any complex adaptive system to behave intelligently it must achieve continuous, interdependent collaboration and interplay among all levels of the system. This capability highlights the importance of both internal and external networks as they heavily influence the relationships and amplify knowledge diffusion among agents, components and external systems. As these networks increase, the organization becomes more complex, harder to manage by those seeking direct control, but potentially capable of handling more complexity in its environment. Teams and communities accelerate quality decision-making and foster innovation and creativity. (See the following discussions of Flow and Processes.)

The bottom line for a knowledge-centric ICAS is optimal performance. It achieves this by [18]:

- Aligning strategic direction. The more information is shared, the better people collaborate, the more aligned the organization is in moving

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toward its vision of the future. This shared vision harnesses the collective energy of people and accelerates improvement.

- Enhancing mission performance - Operational and business performance improves as best practices are shared and new ideas build on ideas shared. Knowledge management drives development of a knowledge base relating to the organization's core competencies.
- Increasing collaboration opportunities. The collaborative and sharing aspects of knowledge-centricity will enrich the exchange between people and ideas at all levels of the ICAS.
- Driving process improvement - As the sharing of information becomes embedded in day-to-day activities, the flow and exchange of best practices increases, providing the fluid for true process improvement. In addition, the high visibility of content areas across the organization facilitates the exchange of new ideas regarding process change.
- Facilitating learning - Knowledge-centricity provides the opportunity for individuals to put new knowledge into practice while exposing them to new challenges. Since the value of individual knowledge becomes a major asset to the ICAS, an individual's contribution to this knowledge bank becomes recognized and rewarded.
- Facilitating availability of expertise – Knowledge-centricity utilizes "tacit" knowledge, defining content areas and identifying sources, thus providing intermediation between knowledge needs and knowledge sources. This "brokering" translates into availability of expertise which can be brought to bear on emerging issues.
- Increasing innovation and creativity. As information begets information, ideas beget ideas. Knowledge-centricity provides access to a rich pool of ideas, providing a foundation for others to build upon, sowing the seeds for innovation and creativity.
- Enhancing job performance. Knowledge-centricity provides the opportunity for adaptability in rapidly changing situations. Knowledge workers can quickly access, integrate and act on new knowledge, and efficiently find out what they don't know from a vast pool of organizational knowledge.

The knowledge-centric characteristics will ensure that learning will be continuous and widespread utilizing mentoring, classroom and distance learning, and will likely be self managed with strong infrastructure support.

Flow

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Flow enables knowledge-centricity. The emergent characteristic of Flow in the ICAS can be discussed in terms of the flow of data, information and knowledge; the movement of people in and out of organizational settings; and the optimal human experience. Flow, moving across networks of systems and people, is the catalyst for creativity and innovation. Social capital is the medium of exchange in this human framework.

The Flow of Data, Information and Knowledge.

The flow of data, information and knowledge is facilitated through teams, and communities, and can be accelerated through event intermediation. Teams, small groups, task forces, etc., accomplish specific objectives while concomitantly sharing data, information and knowledge with other people who may come from diverse parts of the ICAS. Communities of Practice or Interest, knowledge portals and knowledge repositories also facilitate the sharing of information and knowledge. Managers are often unaware that the greatest benefit from a team's effort is the long term payoff in future collaboration among team members. An ICAS that deliberately manages flows will factor this payoff into team formation and team member selection.

Event intermediation is not a new idea. All too often employees work and strive to create change with only slightly visible results. Then, some event occurs which connects all this prior activity, the understanding of change value jumps to a new strata of recognition, and the entire plane of behavior shifts upward to a new starting point. This pattern recurs again and again throughout history. Examples of recent event intermediation in the Department of the Navy include the Y2K Virtual Town Hall [19] and the Knowledge Fair 2000. The ICAS of the future will orchestrate such events, both formally and informally, as both change and knowledge sharing become a way of life.

The Flow of People In and Out of the Organizational Setting.

The fluid flow of people in and out of the ICAS must support the organization's need for flexibility in responding to demands of the global marketplace. The workforce grows and shrinks, engaging free agents, and buying intellectual capital as needed. Employees will have to be systems thinkers so they can quickly grasp the context and implications of rapidly changing events in response to orchestrated mobility throughout the ICAS. A benefit of moving people will be the increase in variety of talent mixes throughout the organization. These flows will also prevent long-term rigidity and maintain an organizational plasticity. In addition, continual change within the ICAS will maintain a population of new ideas that can make a difference in organizational performance. A continual flow of employees into and out of the organization will be needed to stay in touch with the environment and to maintain high internal standards of performance.

The Optimal Human Experience.

The concept of autotelic work is tied to the optimal experience of flow, a state where people are so involved that nothing else seems to matter. An individual, or a team, is said to be in a state of flow when the activity at hand becomes so intense that the normal sense of time and space disappear, and all energy is invested in the task. In a team setting, individuals lose the sense of identity or separateness during the experience, then afterward emerge from the experience with a stronger sense of self. Individuals involved in this flow state feel a sense of exhilaration and joy. As these optimal experiences are repeated, they develop a sense of experiencing their real reason for being, coupled with a strong feeling of being in control.

Each of us has experienced flow at times in our lives: playing a good tennis match, meeting a short deadline, or enjoying team camaraderie during an intense task. Autotelic workers create their own experience of flow. They are often creative, curious, and lead vigorous lives, taking everything that comes along in stride. They are "life-long learners" who enjoy everything they do, and, along the way, spread a bit of joy to those around them.

Although flow cannot be turned on and off, individuals and teams can develop the ability to experience flow and create environmental conditions that facilitate its onset. The experience of flow has been developed and studied by Csikszentmihalyi over the past thirty years and is best described in his book entitled *Flow, The Psychology of Optimal Experience* [20]. According to him, the conditions required for a flow experience are [20, P. 49]:

1. Tasks must have a good chance of being completed, yet not be too easy.
2. The team must be able to concentrate on what it is doing. Interruptions, distractions or poor facilities prevent concentration.
3. The task should have clear goals, so that the team knows when it has succeeded.
4. Immediate feedback should be provided to the team so that it can react and adjust its actions.

The phenomenon of flow results in individuals and teams giving their best capabilities to tasks at hand. Team members come away with feelings of accomplishment, joy and well being that influences their willingness to trust and openly communicate with other team members, enhancing collaboration and team performance. The bottom line for the ICAS is a high level of performance. The bottom line for the employee is personal growth and self-satisfaction.

Permeable Boundaries

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The bureaucratic model defined clear boundaries between jobs, between levels of management and between organizations. But those who are succeeding in today's world have already recognized the blurring of those boundaries as man and machine create virtual networks around the globe.

Boundaries between the individual, other individuals, the social organization and the organizational culture are the places where ideas are formed and change occurs. Social Psychology [21, P. 49] is the study of how influence is exerted across those boundaries, or "zones of interpenetration." The permeable and porous boundaries in the ICAS are those among individuals, the social organization and the organizational culture, as well as those across organizations and, indeed, across countries. Using terms from Social Psychology: (1) the individual is an entity having motives and resources; (2) relations between individuals (interpersonal relations) are composed of identities; (3) the social organization is comprised of interdependent sets of roles; and (4) the organizational culture is a system of shared beliefs. Individual motives and resources, and, within the system (at whatever system level you focus upon) identities, roles and shared beliefs provide the elements that will determine the permeability of boundaries.

The virtual world of the ICAS tears down our historic understanding of relationships and boundaries in terms of time and space. As people come in and out of the organization driven by increasing and decreasing demand, over time the "boundaries" of organizations become more difficult to define. As ideas are exchanged and built upon, the lineage of these ideas becomes impossible to follow. Add all of this to a fluctuating, complex environment which is constantly changing and we begin to understand just how important permeable and porous boundaries are to survival of the next generation knowledge organization.

The boundaries of the Phylum Porifera, what we call a sponge, provide a metaphor for the changing boundary conditions of the ICAS. Sponges are simple, multi-cellular animals that have minimal interdependence among their cells. In 1907 an embryologist, H. V. Wilson, [cited in 22, Pp. 559-560] discovered that a living sponge could be pushed through fine silk so that it was broken up into individual cells and cell debris. Over the next three weeks, the cells started crawling around and aggregating into larger masses until a functional sponge was re-formed. Although we would not suggest pushing a living organization through fine silk, nevertheless, the splitting and re-aggregating around goals (in the sponge's case survival) is a metaphor appropriate for the ICAS. With the living body, atoms and molecules constantly die and are replaced. The structure of the cell retains its identity even while the matter that composes it is continually altered. The cell rebuilds itself in line with its own pattern of identity, yet is always a part of emerging action, alive and responding even in the midst of its own multitudinous deaths.

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The permeable boundary of an ICAS will allow the organization to optimize its results through teaming, partnering, alliances, and close relationships with customers and all stakeholders. Teaming, partnering and alliances are terms we give to more formal relationships between organizations. They imply the intent of one or more organizations to work together to improve the efficiency and effectiveness of a common goal, and to reduce the costs of disagreements. These formal relationships -- driven by economic need and potential -- are much like a marriage. For success, they must be built on trust, open communications, and a thorough understanding of themselves and each other. The social psychology boundary model can also be applied to teaming, partnering and alliances, i.e., the elements that will determine the permeability of organizational boundaries are motives and resources, identities, interdependent sets of roles and shared beliefs.

Let's use the value of one, the individual, to understand relationships and boundaries in terms of space. We usually think of the boundary of the individual as framed by the outside of the physical body. This is not the case. Each of us sets up special boundaries that reflect our relationships with those around us. There are many models for this personal space, and many more variables affecting the validity of those models. For discussion purposes, we will use the widely-accepted categories proposed by Burgoon: [23, P. 53]

- Intimate distance – Reserved for intimate encounters and physical contact.
- Personal distance – Used in close interpersonal relationships or for private discussions.
- Social distance – Used for relatively impersonal encounters such as informal social interaction and business meetings.
- Public distance – Reserved for formal interactions and presentations.

There is sensory involvement (involving cutaneous, visual, olfactory, auditory and thermal receptors) ranging from high to some in both intimate and personal relationships. Social relationships are outside the range of touch, but do include some involvement of the other senses. Public distance minimizes kinesthetic involvement.

Although Burgoon attempted to assign distances to each of these categories, later social science research has shown that the variance of the norm was highly dependent on gender, age, degree of acquaintance, social status and personality, etc. Still, the construct itself has considerable value for addressing the changes in special relationships – the variance of boundaries – among individuals, and organizations.

In the ICAS, distances are closing. Proximity is as far away as the nearest computer, but built on a human network. Indeed, the social capital of an organization will determine success or failure.

The architectural firm of Thompson & Rose proposed nomadic, rounded work shells that can be minimized and connected in groups of varying sizes or disconnected, and distances to provide personal space. [24] This architectural concept provides an excellent seating model for the ICAS, providing ease of movement from personal space to collective space. It also opens personal distance through the elimination of walls and closes social distance through connected collective space.

What is missing from this model is technology. As wires become a constraint of the past, technology will float at an intimate distance with employees, that distance reserved in the past for intimate encounters and physical contact. This hands-on-keyboard relationship will bring private discussions, business meetings and presentations into closer proximity, but still built on human networks, and relationships. In private discussions, faces will project across distances; in business meetings visible body movements and the rise and fall of expressions will provide context; during presentations dialogue will occur throughout and exchange of ideas will build intimacy from a distance.

Multi-Dimensionality

From the perspective of evolution, Man, because of his intelligence, adaptability and robustness, has become the dominant species in a world where only the fittest survive. If the ICAS is to survive in the future environment, it must have the instinctual ability to sense, learn and respond with a wide repertoire of actions. To become the fittest of the fit in the anticipated intensely competitive organizational arena of the future, the ICAS must be able to demonstrate agility and robustness at all levels of its structure.

This requires the organization to continuously forget and learn; to identify and deal with risk; to think in terms of systems; to shift its frequency of operations; to perceive and analyze in terms of wide scope and long time-frames; and, finally, to keep its identity and unity. In other words, it must develop instincts and automatic competencies that are natural and become second nature at all levels. We label this group of basic competencies multi-dimensionality. While no one of these is more important than the others—it depends upon local circumstances—we will address systems thinking first because of its scope and potential payoff.

Systems thinking became widely known in the late 1960's with Von Bertalanffy's book on General Systems Theory [25]. Since then, systems research has moved away from general systems to Forrester's system dynamics and Senge's systems thinking to the research on complexity and complex adaptive systems coming out of the Santa Fe Institute (see references in bibliography). From an organizational viewpoint, the importance of being able to understand and analyze systems lies in the perspective afforded by systems thinking and the ability to look for fundamental systemic characteristics. This ability includes both synthetic

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and reductionist considerations, and can greatly aid in recognizing leverage points both within the organization and in the environment.

Systems thinkers naturally become aware of the surrounding context of their work and can recognize the impact of actions in one part of the organization on other parts. With people and teams scattered throughout ICAS with this capability, the organization can adapt flexibly and respond within the proper context. System thinking also encourages a broader perspective in both space and time. Carried to the extreme, everything is connected to everything else. System thinkers look for these connections, and interpret and generate actions correspondingly. (See, Auyang [2]; Morowitz and Singer [26]; Bar-Yam[27]; and Checkland and Holwell [28])

Another dimension of import to survival is that of forgetting and learning. Team learning in particular [13, P. 233-269] has been recognized as essential for adaptive enterprises. Unfortunately, the concomitant need to forget is usually forgotten. To learn means to change, and to change means to give up something. But giving up is difficult and is usually resisted because of the discomfort it causes. To continuously change and adapt, the organization must continuously forget.

Argyris [29, P. 22] has extensively researched the difficulties of learning and changing and has identified the fundamental reasons why organizations find it so hard to adapt. His major finding is that organizations build in special systems and defenses that prevent them from learning and questioning their basic beliefs and assumptions. His solution is called double-loop learning—a technique for getting individuals to review and question their basic assumptions.

Another dimension is that of risk. In an uncertain world risk becomes part of life. A robust organization must be willing and able to take on and manage risks in a manner that maximizes the probability of success while at the same time protecting against disasters. This requires the ability to estimate future events and assess the future result of contemporary changes. The discussion of knowledge earlier in this paper would indicate the importance of workers and subsystems having knowledge of their areas of work and being able to accurately judge cause and effects. The effective management of risk should be an invisible characteristic of the culture—built into the way the work gets done. The areas of probability assessments, scenario development and simulations are supportive of risk management. Recent work on management risk analysis may also be helpful. (See Morecroft and Sterman [30]; Van Der Heijden [31]; and Bennet [32].)

To be able to shift its frequency of operations, the ICAS must be built around processes and core competencies that are flexible and robust. This means that both the supporting technology and the workforce are capable of multi-tasks and

open to rearrangements through virtual connections or rapid reprogramming. Workload and resource problems must be amenable to quick resolution, with all parts of the ICAS working together in support of a response to outside perturbations or opportunities. A rapid shift in operating tempo is where the unity and shared purpose are tested for truth.

In summary, the range and depth of outside forces that the ICAS can effectively respond and adapt to is a fundamental measure of its survival capability. At the same time, its sustainable competitive advantage will be measured by its robust ability to take advantage of a wide range and depth of opportunities, opportunities originating both within and external to the firm.

Processes

Evolution has taught us that complex organizations evolve through a process of the random generation of ideas and individuals that are then modified by chance encounters and eliminated by others more fit to survive. The ICAS is a knowledge-based organization that will learn from evolution by building in the equivalent characteristics that include: survival of the fittest (a threshold of performance); trial and error by mutations and genetics (brainstorming, innovation, and analysis and problem solving); and recombining by sexual reproduction and combination (systems thinking, collaborative decision-making, and implementation). These three will be replicated by teams combining new ideas, employees coming in to offer new and different ideas and actions, and the system as a whole creating performance thresholds that filter out the bad ideas and decisions. The future ICAS will have developed measures of performance that serve to cull out inadequate ideas, decisions and actions. Selection of the best ideas and actions is as difficult as implementation of that selection.

The four major processes of any organization are creativity, problem solving, decision-making and implementation. Through these processes, an organization applies its capabilities to produce products. We will discuss the ICAS in terms of these four processes.

Creativity

Ideas are the mental implements used to gain competitive advantage. Ideas build upon ideas. The more these implements are used, the more ideas available for use; and the more opportunity for the organization to develop and fulfill its own unique competitive advantage.

The organization has significant influence on the development and effectiveness of creativity through its strong influence over the operating environment within which employees interact. A creative environment requires open communication, collaboration, a playful attitude and critical thinking, coupled with a clear vision and objective. Such an environment encourages new ideas and different ways of

seeing things, resulting in employee out-of-the-box suggestions for solving problems.

Employees have a tendency to follow their leader's approach to risk taking. If the leader support new ideas and is willing to take prudent risks, so will the employees. Senior management can encourage creativity through follow-up actions like accepting reasonable mistakes and not rejecting new ideas. These actions demonstrate the acceptability and importance of teams investigating, evaluating and proposing creative solutions to problems. Creating and sustaining the right environment is challenging and difficult, but over time an organizational culture develops around the philosophy of trying out new ideas, and creativity and innovation becomes the accepted and expected way of doing business.

Learning makes creativity easier and creativity reinforces learning. Creativity, learning, and flexibility are closely coupled and, as a group, will significantly improve the ICAS's ability to develop better products.

There are typically four stages in the creative process:

- Stage one is the problem, situation or opportunity identification where a thorough discussion of the issues and objectives occurs among interested/responsible organizational employees to ensure common understanding of the desired effort.
- Stage two is gathering relevant information needed to limit potential new ideas and to provide stimulations for idea generation.
- Stage three is the actual generation of ideas via brainstorming or some other technique.
- Stage four is the discussion, evaluation, and prioritization of ideas to determine which are the best.

Each of these stages is built on social capital, the interaction among individuals and exchange of ideas, or the idea of flow discussed earlier.

In the ICAS setting there is less formality to this process. As people are in close and flexible proximity to each other, with a nomadic flavor, and there is the expectation of responsibility at all levels of the organization, the innovation process occurs and reoccurs throughout the day. The close relationships and rapport of employees, and the non-threatening, supportive organizational climate, provide the opportunity for reaching the level of trust necessary for optimal sharing, and optimal innovation. Generating new ideas is sometimes, but not always, a predecessor to effective problem solving.

Problem Solving

Problem solving is one of the most important process in the organization. Taking inputs from the creative process as needed, the problem solving process provides the link between problems and decisions. The output of the problem solving team is a solution a set of alternatives that provide ways to achieve a desired situation or problem solution.

There is no one process for solving problems; even with simple problems it may be difficult to separate the problem from its symptoms. In the complex relationships of people and subsystems that make up the ICAS, it is difficult to identify single causes. In a very real sense, problems exist in the mind of the observer. Before any problem can be solved, people must agree on exactly what the problem is, and why it is a problem.

A problem can be viewed as an *undesirable situation*. Its solution then becomes a new, desirable situation. The process of finding ways to change the undesirable situation into a desirable one is a creative part of problem solving, or the process of gap analysis. Problem solving can also be used to find and take advantage of opportunities, with an opportunity defined as a desired situation that is different from the current state of affairs.

The more options available to solve a problem, the better the final solution. This simple heuristic drives the organization to share large problems and issues widely, and to welcome the thinking and passion of those who contribute critical thinking and creative ideas. For the most complex problems there is never enough of the right information or time to provide a definitive, clean solution. Finding solutions to complex problems is a creative act. Experience, intuition, reflection and dialogue among all problem solvers will usually produce a set of sensible alternatives. These will be based on the group's collective judgment and *comfort level*.

Decision-Making

Decision-making refers to the selection of one or more alternatives generated by the problem solving process. There is no single way to make decisions: it is both an art and a science. Decision-making cannot be avoided where responsibility is concerned. In a complex adaptive system all agents are purposeful goal-seeking decision-makers. In the ideal ICAS decisions are made at all levels, with each level having a band of decision authority commensurate with their experience and scope of responsibilities. Although team decision-making is more complex and time consuming than individual decision making, most of the difficult and complex decisions are likely to be made by teams because of the expected improvement in decision quality.

Teams can be particularly effective when decisions are complex and require a balance among functional disciplines and/or between short and long-term

priorities. A team can provide the full range of knowledge and the different perspectives needed to filter out biased views, and to objectively consider all options. Through a collaborative interaction process the team can arrive at balanced, high quality decisions, though they do not come easily or quickly. The more complex a decision, the more the decision is judgment-driven versus data-driven, and the more important the input from the team becomes. In the ICAS, team decision-making is facilitated by a shared vision and approach, providing a common reference on which to judge the decision.

Team decisions also offer the opportunity for individual members to learn from each other and to understand the decision making process, as well as providing knowledge and understanding that will aid in implementation of the decision once it is made. The use of technology -- common databases, intelligent algorithms, high-powered three-dimensional visualization, complex display graphics, and modeling and simulation, etc. -- help teams make decisions. There is a free flow of accurate, real-time data, information and resource knowledge available to all team members.

The quality of complex decisions is a major factor in determining final product value. Good team innovation and problem solving processes are precursors to good decisions. These decisions, coupled with the effectiveness of their implementation, are the predominant influence on how successfully the organization functions. When needed, a robust strategy is built into decision options to reduce the risk level. This strategy might include parallel development paths, market research, simulation, environmental scanning, and virtual feedback networks.

Flow is an important consideration in decision-making. This aspect of flow has to do with the flow of the product and the flow of the organization. Stakeholders must be ready to accept and take action on the decision. Also, the political climate must be right. If the results of a decision create political disturbances or major stakeholder opposition that could have long-term negative consequences for the organization, the decision must be very carefully reconsidered. A major decision may require a lot of pre-decision work on the part of the team to smooth its implementation.

Implementation

Results make the difference. Making high quality decisions is essential to getting good results, but it is not enough. Taking good decisions and turning them into actions and changes that create improved products is a big challenge for all organizations.

When individuals who will have responsibility for implementation are aligned with the decision, implementation becomes much more effective. Big decisions that

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set the fundamental tone and nature of the ICAS require greater understanding and support throughout the organization. Ultimately, implementation is built on relationships. Efficiency and clarity of communication, coupled with openness and a sincere concern to share understanding and get participation is a tenet of the ICAS.

The ICAS keeps a "virtual brain book," or common data package and historical record (complete with context through video clips and special context fields for decision makers) to ensure consistent presentation and accurate tracking of past decisions. Organizations are at their best when they have a common perception of the intent and desired results of the decision and they can communicate these to all concerned.

Summary

These four processes will be embedded within the ICAS and under ideal conditions will become a natural part of its culture, a culture resulting from the processes, structure, relationships and people that make up the next generation knowledge organization. These properties -- working together within the framework provided above in the discussions related to the eight emergent characteristics -- will create and sustain the Intelligent Complex Adaptive System as it maneuvers through change, complexity and uncertainty to fulfill its mission.

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