Complexity Theory and Strategy

A Basis for Product Development

In this paper is given a brief description of complexity theory in connection with teamwork, as well as strategy and maneuver thinking as they apply to product development.

1. Complexity theory

Although the great French mathematician and physicist Henri Poincaré more than a century ago identified systems sensitive to initial conditions, which typically are associated with deterministic chaos, it was with the advent of computer simulations in the 1960´s and 1970´s, and especially agent-based simulations that everything changed (Solé and Goodwin 2000). The study of ecological and social systems, theoretical physics (non equilibrium systems) and the comparison with computer simulations, has yielded exceptionally interesting results that have not yet reached a broader audience but is beginning to cross the border to other scientific fields.

C*omplexity theory* or *complexity science* is used as a unifying name for a set of patterns found in the most different areas and for the implications of these findings. The prevalence of them makes some theoretical physicists call complexity something more basic than physics (Buchanan 2001). “It may be that the complexity sciences will emerge as the dominant force, distinct from the older competing paradigms” (Mathews et al 1999).

In social sciences, complexity science was at first used as a source for metaphors, which has a value in itself (Lissack 1997). Organizational science has had difficulties cooping with nonlinear phenomena and has treated them as if they were linear (Andersson et al 1999). The application of complexity theory to organizations is justifiable since organizations and complex systems are not different phenomena (Maguire and McKelvey 1999). Organizations are complex systems (Dooley and Van de Ven 1999).

McKelvey’s (1999) application of complexity science simulation[1] to organization science, and the view of Anderson et al (1999), highlights the importance of focusing on individual behavior instead of average behavior when analyzing complex systems. Jönsson (2004) has shown the importance of this conclusion in a large investigation at NedCar. One interpretation could perhaps be that this indicates a superiority of the

[1] Such simulations often consist of the application of a few simple rules on a large set of agents for many consecutive time steps resulting in intricate and unforeseeable patterns with striking similarities to observed phenomena in the real world.

qualitative research method and case studies over the by necessity averaging quantitative method with its use of questionnaires and suchlike.

1.1. Complexity and complex systems

One definition of complexity is as follows: *Complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties* (Mikulecky 2001). One definition/description of complex systems is: *a system that is comprised of a large number of entities that display a high level of nonlinear interactivity*. There are a number of basic observations that have been made through the examination of complex systems, primarily using computer simulation and the mathematics of non-linearity (Uden et al 2001).

- Complex systems are usually open systems (McKelvey 2004).

- Complex systems are incompressible. It is impossible to have a total account of a complex system that is less complex than the system itself without losing some of its aspects. Incompressibility is probably the single most important aspect of complex systems when considering the development of any analytical methodology, or epistemology, for making sense of such systems (Cilliers 2005, 1998).

- Complex systems consist of a large number of dynamically (and usually non-linearly) interacting non-decomposable elements (McKelvey 2004).

- The interaction in a complex system is fairly rich (McKelvey 2004) and must be such that the system cannot be reducible to two or more distinct systems (Cilliers 1998). However there can exist quasi-independent and emergent domains.

Because of this high interconnectivity between elements, it can often be difficult to associate effect with cause. We are now confronted with incredibly intricate interacting networks of cause and effect, rather than the relatively easily identifiable chains of cause and effect apparent in complicated, or linear, systems. These rich and pervasive dependencies place fundamental limitations on our abilities to develop and validate appropriate models of complex systems (Uden et al 2001).

- The interactions usually have short range and contain feedback loops (Cilliers 1998), and they may occur on several levels (Kolenda 2003).

- The behavior of the system is more determined by the nature of the interactions, than by what is contained within the components (Cilliers 2005). An example of a complicated system (but never the less illustrative), from Polyani (1958) cited in Lichtenstein (2000): “Take a watch to pieces and examine, however carefully, its separate parts in turn, and you will never come across the principles by which a watch keeps time”.

- Complex systems can have an adaptive capability to influence, almost control, its environment and re-organize its internal structure without the intervention of an external agent. Such systems are called CAS, complex adaptive systems. Often the agents making up the CAS are adapting individually, each applying their own strategy (Axelrod and Cohen 1999). Examples of CAS are free-market economies (Englehardt and Simmons 2002, Stamps 1997).

Human organizations are often considered to be CAS (Dent 2003). In several aspects, human organizations differ from other complex systems, such as bird flocks, fish schools and ant colonies. Humans have the ability to comprehend at least some of the consequences of the system. Further, humans as agents of CAS are affected by emotions such as compassion and anxiety; they are capable of prioritizing their own mental objectives over those of the group; they are aware and capable of thinking systematically, unlike most other animals and all insects; and power differences exist between agents, by which they are influenced. Consequently, these complex human systems are still more complex (Chiva-Gomez 2004).

- Complex systems operate under conditions far-from-equilibrium (McKelvey 2004).

- Complex systems have a history (Buchanan 2001, Cohen 1999, McKelvey 2004, Richardson 2005, Cilliers 2005). The system memory/history is captured at both the micro- (personal experience, personal opinions, worldview) and macroscopic (cultural, ritual, value system) levels. Therefore, system history plays an important role in defining the state of the system as wel1 as affecting system evolution (Cilliers 1998).

- Each element in the system is ignorant of the whole (McKelvey 2004).

The ignorance of the whole is not necessarily true for systems comprising human agents who might each have their own view of the system, its purpose and direction, leading to political activities. This awareness of the system's direction is the reason why complex human systems can be governed. However, attempts at governing complex systems can yield unexpected results. It was for a long time assumed that systems could be controlled, when in fact they can only be influenced (McElyea 2003). When modeling human systems it is done from an outsider perspective, but for the modeling to be useful it is important to use ones imagination in order to see what the modeled interactions are saying from within that interaction (Stacey 2002, p71).

- A complex system might react proportionately to small as well as large changes; it might also react disproportionately to both small and large changes. It might be very sensitive to initial conditions (a phenomena popularly referred to as deterministic chaos) as well as at times, be very resilient and insensitive to initial conditions (as a result of self-organization or, alternatively, anti-chaos) (Uden et al 2001, Richardson et al 2000).

- A complex system, driven to critical state, edge of chaos, has its own highest computational capacity (Langton 1990). This means that the system cannot be simulated with sufficient accuracy faster than the system itself develops. Such a system can be completely deterministic, yet completely unpredictable.

- Complex systems can show **emergence**, which are unexpected, often unpredictable characteristics of the system that are a result of interaction between the elements of the system. An example: electrochemical activity in the brain results in consciousness. Micro level interactions between individual agents and global, aggregate-level patterns and behaviors mutually reinforce each other (Linstone 1999).

- Self-synchronization leads to emergent properties and efficiencies unattainable with top-down direction (Wesensten et al 2005).

An example of such system-wide self-organization can be found in flocks of birds, where there is no single, organizing, bird leader. Nevertheless, a pattern of organization develops from local interactions among agents following simple rules. The benefit of self-organization is a structure that is fluid and sensitive to the needs of connected elements. Self-organizing behavior is disorderly only by traditional management standards, because patterns of behavior and decisions emerge rather than result from specific plans (Ashmos et al 2000):

- Complex systems show existence of a rich diversity of qualitatively different operating regimes that the system might adopt.

- At the basis for a complex system, there can be a few simple rules.

- Complex systems often have network character.

- Complex systems can be unpredictable at one level, but strikingly predictable at another (weather as opposed to climate).

1.1.1 Complex systems and power laws

Behind many phenomena in the most apart situations there lurks a power law $\mathbf{y = ax^n}$. Plotted in a log-log diagram a power law is a straight line with slope **n**. If $n < 0$ the number of occurrences are inversely proportional to the size of the occurrence; many small and few large occurrences. Some such examples are: number vs. size of movements at the stock exchange (Sornette 2001), number vs. mass of individuals in a biotope (Buchanan 2001), and number of links pointing to a website vs. number of websites (Barabási 2002).

Power laws have the following especially fantasy stimulating characteristics:

- There is no typical size; the process is scale free.

- Similar occurrences of all sizes are just as natural and are basically of the same origin if they belong to the same power law (the same exponent).

- It is impossible to predict if an occurrence that is governed by a power law will be large, small or medium, making prediction virtually impossible.

The processes are rooted in a kind of geometrical relation between the elements. How the elements influence each other over distance is important. Sometimes an element may influence many other elements and sometimes only a few. The elements are members of a network with links of varying strength (Watts 1999, Barabási 2002, Buchanan 2001).

Future development is dependant on the way we came to be here. History is baked into the present and can function as trigger points for often unthinkable chains of events.

The system may drive itself to criticality, the "edge of chaos". For example, all living species use their biotope to the limit and beyond. In nature, there is no holding back or economizing with resources, resulting in eternal crisis. Often only one species becomes extinct at a time, but about every 200 million years or so global ecosystems break down and we have mass extinction of species of exactly the same causes as when just one or two become extinct (Lewin 1999).

Big events must have important causes, that we like to think, but as we have seen, even the largest occurrences may have the smallest origins. Furthermore, many behaviors in the social world might be explained with a natural "scale-free" generating mechanism (Dooley and Van de Ven 1999).

1.1.2 Complexity thinking

The *Complexity thinking* school of thought takes hold of the fact that no real complex system is completely closed; all complex systems are more or less open, and therefore they stress the following points as limitations to our ability to know for sure (Richardson 2005):

- All boundaries are emergent and temporary (given a sufficiently long time scale), neither purely natural nor purely a function of our description, sometimes making boundary recognition and allocation problematic. Boundaries in the rigid traditional sense do not exist. The boundaries analysts infer around a system are more a feature of our need for a bounded description rather than a feature of the system itself (Uden et al 2001).

- Everything is connected to everything else – radical holism: the universe is the only true whole.

- No part can be ***fully*** understood without understanding it's relationship with the whole, the whole is reflected in every part and all models leave something out.
- Absolute knowledge of the part would require complete knowledge of the whole (the incompressibility of complex systems) – a practical absurdity and a theoretical impossibility.
- There are no real parts; all boundaries that delimit a part from its whole are temporary and often illusory: no-boundary hypothesis, all boundaries are emergent

In spite of the epistemological caveats from the complexity thinking school, for practical purposes it is useful to define boundaries and treat organizations as open complex systems, thereby disregarding the errors and approximations with such an approach (Cilliers 2005).

2. Organizations as complex systems

The field of organizational application of complexity science has emerged in the past ten years (Eoyang 2004). It is increasingly used by researchers and practitioners to improve their understanding of organizations (Chiva-Gómez 2003).

One purpose of organization science is to facilitate design, or in other words, to change and improve upon organizations. One aspect is the fit between the organization and its environment achieved through *evolution and adjustment*. Many researchers therefore study this aspect (Levinthal and Warglien 1999, Morel and Ramanujam 1999, McKelvey 1999, White et al 1997). In this regard, it is convenient to *see the organization as an organism that survives by continuous adjustment to its environment*. If the organization is an organism or a collection of organisms then *the environmental assessment must be a critical focus for long-term survival and success* (McElyea 2003).

Complexity science has been applied to the study of "the normative order, operating through informational and social influence, that guides and constrains people in collectives", which is culture (Frank and Fahrbach 1999) and can be extended to a whole society as in understanding western firms in China (Boisot and Child 1999). Some researchers try to understand the character of organizational dynamics through event time-series analysis (Dooley and Van de Ven 1999). But foremost it seems, complexity in connection with organization sciences is used for theories of change management (Higgs and Rowland 2005, Eoyang 2004, McElyea 2003, Styhre 2002, Ashmos et al 2000, Beeson and Davis 2000, Zimmerman and Hayday 1999). See table 2:1 for a comparison of traditional vs. complexity-based ideas of change management.

In the complexity view of organizational change the system is far from equilibrium, it dissipates energy (imports matter, energy and humans, (Reynolds 2004)), it is self-organizing capable of radical transformation as well as gradual evolution, and continually moving between order and disorder as well as between stability and instability.

Traditional Models of Organizational Change	**Complex Adaptive Mode of Organizational Change**
Few variables determine outcome	Innumerable variables determine outcome
The whole is equal to the sum of the parts (*reductionism*)	The whole is different from the sum of the parts (*emergence*)
Direction is determined by design and power of a few leaders	*Direction is determined by emergence and the participation of many people*
Individual or system behavior is knowable, predictable, and controllable	Individual or system behavior is unknowable unpredictable, and uncontrollable.
Causality is linear: every effect can be traced back to a specific cause	Causality is mutual; every cause is also an effect, and every effect is also a cause
Relationships are directive	Relationships are empowering
All systems are essentially the same	Each system is unique
Efficiency and reliability are measures of value	Responsiveness to the environment is the measure of value
Decisions are based on facts and data	Decisions are based on tensions and patterns
Leaders are experts and authorities	Leaders are facilitators and supporters

Table 2:1. The table shows a comparison between ideas of traditional and complex organization change, from Olson et al (2001).

Processes are *irreversible and cannot be fully controlled or planned* (Beeson and Davis 2000). Informal structures (the shadow system) self-organize and emerge and persist in a way that is remarkably robust to changes in the formal organizational structure (Anderson 1999). Organizational development practitioners should *intervene in the shadow organization* (Dent 2003), because it is here that self-organization is primarily to be found.

2.1. Organizations can be teleological

White et al (1997) propose that organizations in their evolution are formed not only by environmental selection but by the organization's own choice of path, perhaps from among several viable internal evolutionary drivers. Mikulecky (2000) claims that the system has within itself a model of its environment that it uses to influence present behavior in anticipation of future events. The organization's members take actions they feel will move towards desired futures. The organization is thus at least partially a product of human intention, as a complex creative adaptive system (Rowland 2004).

Buckle (2003) takes this idea further. Organizations are teleological, purposive, designed to achieve predetermined goals. This they do by using organizational knowledge, which includes both conscious and unconscious dimensions. There is for instance tacit knowledge, which is unconscious, but still can be highly goal directed. This duality of knowledge applies also to organizational teleology since organizational behavior unfolds in service to consciously understood teleological aims (such as corporate strategies and business plans) and also unconscious teleological aims (that are un-designed or emergent), which are subtler to detect.

Many of the intentions driving organizational behavior are publicly understood and sanctioned; others are less well understood and unsanctioned. To the degree that some purposive behaviors in organizations remain unconscious, it may detract resources from managerial objectives and confound organizational change efforts regardless of the desires of any one manger.

2.2. Self-organization and emergence

Self-organization, which is the spontaneous generation of system-wide order in a complex adaptive system, and emergence, which is the spontaneous creation of new entities or patterns in a system through self-organization, are two aspects from complexity science that are especially important for organizations. However, until recently the power and ubiquity of self-organization was not understood.

Eoyang (2004) gives a theory of self-organization in human systems. According to this theory, self-organization requires three interdependent conditions: *container, significant difference,* and *transforming exchange*. A change in one of the conditions results in a change in the other two.

Container is a name for the boundary that distinguishes a self-organizing system from its environment. There are three basic containers that each constitutes a condition that pulls individuals tighter and increases the probability for self-organization.

1. External boundary, or fence: a room, information system, membership criteria, etc constraining the agents into a shared space.

2. A central attracting force, a magnet: charismatic leader, a clear and shared vision, and a desirable resource.

3. One-to-one attractive forces, affinity-like containers: gender, ethnic identity, shared language, and trust.

Significant differences. Within a container, difference along one or several dimensions between agents establishes a potentially generative tension. These can be power, money, experience, language skills, etc.

Transforming exchange. Language is the most obvious manner of transformative exchange, but any transfer of information, energy or matter can function. The exchange becomes transforming when it affects the self-organizing processes within the agent, crossing containers from system of agents to the agent as a system.

When stable system-wide patterns are maintained for some time, the system is said to have self-organized. Internal dynamics might hold the system in a stable state by opposing change or emergence of new order.

When the parts of a system fit together to establish system-wide patterns, this is called **coherence** and is characterized by:

- Meaning is shared among agents.
- Internal tension is reduced.
- Actions of agents and sub-systems are aligned with system-wide intentionality.
- Patterns are repeated across scales and in different parts of the system.
- A minimum amount of energy of the system is dissipated through internal interactions.
- Parts of the system function in complementary ways.

Further, according to Eoyang (2004), system-wide coherent patterns are more stable than other self-organized patterns. Because of the mutually reinforcing dynamics, the effort required to change the pattern is greater than the effort to maintain it. When the system reaches a state of coherence the available energy of the system is aligned and focused on system-wide behaviors, rather than diverse and disruptive behavior of individual agents or sub-system clusters. Interventions that increase the coherence of one level of the human system increase the effectiveness of that organizational level.

	High difference	**Low difference**
High feedback	Contention Disagreement New learning Shared understanding	Singing to the choir Little new productivity Comfortable Reinforcing
Low feedback	Avoidance Fear and anxiety Individual reflection Safety	Boring Entropic Passive Quiet

2:2. The difference matrix, from (Eoyang 2004).

As an aid in understanding the degree of difference in an organization Eoyang (2004) designed a so-called difference matrix, see table 2:2. What can be gleaned is that intense development (upper left corner) goes hand in hand with disagreement and anxiety, but can also result in a shared understanding. The comfortable, reinforcing zone (upper right corner) is not very creative.

3. Order and un-order

Kurtz and Snowden (2003) in their paper give a model for organizational regimes of operation based on several years of action research into the use of narrative and complexity theory in organizational knowledge exchange, decision-making, strategy, and policy-making in among others, product development, market creation and branding. They base their analysis on what they say are three universally accepted assumptions *that they question*, which are:

The assumption of order, which states that there are underlying relationships between cause and effect in human interactions and its consequence: that it is possible to produce prescriptive and predictive models and design interventions that allow us to achieve goals.

The assumption of rational choice that states that humans will make a "rational" decision based only on minimizing pain or maximizing pleasure. Consequently, their individual and collective behavior can be managed by manipulation and by education to make those consequences evident.

The assumption of intentional capability meaning that the acquisition of capability indicates an intention to use that capability, or stated differently: that all actions are intentional and have a premeditated purpose. It is important to refute this assumption because it is only possible to consider alternative explanations for actions when one relaxes the assumption that all actions are deliberate.

Based on what we know of complex systems and its epistemological implications we could readily dispute the assumptions above, but many of us have a strong wish for order and much of our education is based on an assumption of an underlying order.

Humans are not limited to one identity. In a human complex system, we constantly flex our identities both individually and collectively. We may be child, parent, spouse, etc, and belong to shifting groups and change our behavior depending on context, something that is very difficult, if not impossible, to simulate. Further, humans are not limited to acting in accordance with predetermined rules. We are able to impose structure on our interactions as a result of collective agreement or individual acts of free will. As a result, questions of intentionality play a large role in human patterns of complexity. This also is difficult to simulate.

It is difficult to simulate true free will and complex intentionality (for example, retrospective elaboration, duplicity, groupthink, rumor, self-deception, manipulation, surprise, confusion, internal conflict, stress, changes in the meanings of previously unambiguous messages, the deliberate creation of ambiguity, inadvertent disclosure, charisma, cults, and pathologies) within a rule-based simulation.

Humans are not limited to acting on local patterns. People have a high capacity for awareness of large-scale patterns because of their ability to communicate abstract concepts through language and over large distances because of the technological infrastructure. This means that to simulate human interaction, all scales of awareness must be considered simultaneously rather than choosing one circle of influence for each agent.

Acknowledging the complexity of human organizations, but refuting computer simulations, Kurtz and Snowden (2003) create a novel distinction: that between order and, what they call un-order. Systems can be either ordered or un-ordered. In fact they say that: "…learning to recognize and appreciate the domain of un-order is liberating, because we can stop applying methods designed for order and instead focus on legitimate methods that work well in un-ordered situations". For instance in dynamic and constantly changing environments it can be possible to pattern un-order but not order.

In an ordered environment, one can rely on and act-out entrained patterns based on passed experience, in an un-ordered environment that could be fatal. These two areas are each further divided into two parts. The complex system is thus seen as comprised of four parts, where the great divide is between order and un-order, see figure 3:1.

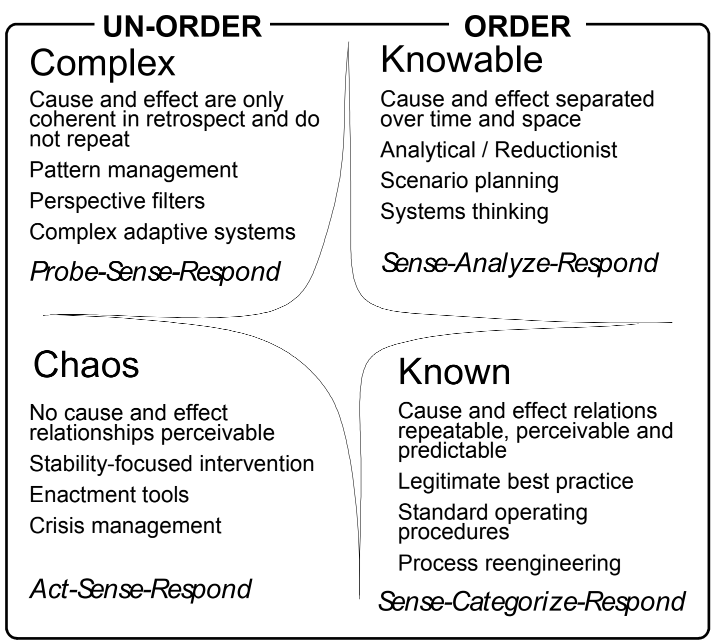

Figure 3:1. In the Cynefin framework for organizational sense making, the four fields represent domains of action in a complex system, from Kurtz and Snowden (2003).

The four corners represent the extreme values of respective domain and the four-armed figure in the middle separating the domains represent a divide or no mans land between them. Kurtz and Snowden call this the Cynefin framework and primarily use it for sense making in organizations.

It is important to note here that " known and knowable" does not refer to the knowledge of individuals but to things that are known to society or the organization.

Ordered domain: Known causes and effects. Cause and effect relationships are generally linear, empirical in nature, and not open to dispute. This is the domain of process reengineering and optimization. The focus is on efficiency, single-point forecasting and field manuals. Our decision model here is to sense incoming data, categorize that data, and then respond in accordance with predetermined practice.

Ordered domain: Knowable causes and effects. Stable cause and effect relationships exist, although they may be separated over time and space in chains that are difficult to fully understand, making them not fully known, or known only by experts. *Everything in this domain is capable of movement to the known domain.* The issue is whether we can move from the knowable to the known by ourselves. Often we cannot and instead rely on experts. *Here the entrained patterns are at their most dangerous*, as a simple error in an assumption can lead to a false conclusion that is difficult to isolate and may not be seen.

Un-ordered domain: Complex relationships. Emergent patterns can be perceived but not predicted; this phenomenon is called retrospective coherence. Structured methods that seize upon such retrospectively coherent patterns and codify them into procedures will confront only new and different patterns for which they are ill prepared. Thus, relying on expert opinions based on historically stable patterns of meaning will insufficiently prepare us to recognize and act upon unexpected patterns.

Understanding requires multiple perspectives on the nature of the system. This is the time to pay close attention, gain new perspective on the situation and think before you act. The methods of the known and knowable domains do not work here but narrative techniques are particularly powerful.

Un-ordered domain: **Chaos**. There are no perceivable relations, no visible relationships between cause and effect. There is no time to investigate change, analyze, or wait for patterns to emerge.

The domain of disorder (the area within the central four armed figure). The central domain of disorder is critical to understanding conflict among decision makers looking at the same situation from different points of view (from within different domains). Often people agree on what the extremes of the four domains mean in the context they are considering, but disagree on more subtle differences near the center of the space. As a result, individuals compete to interpret the central space based on their preference for action. The stronger the importance of the issue, the more people seem to pull it towards the domain where they feel most empowered by their individual capabilities and perspectives.

Boundaries are possibly the most important elements of sense making, and especially the crossing of boundaries. A boundary might look different depending on from what direction it is approached. Important here is awareness: of approaching the boundary, so that one can sense when change is incipient and respond before the boundary is crossed (perhaps to cross it purposefully, perhaps to avoid it), and of crossing the boundary, so that one can respond quickly to new conditions after one has arrived on the other side. It may be possible to manage the boundary and the perceptions surrounding it, so that one can, for example, put a deep-chasm boundary in place for one's adversary while maintaining a shallow-river boundary for one's own use.

There are many possible paths within the Cynefin framework, see figure 3:2.

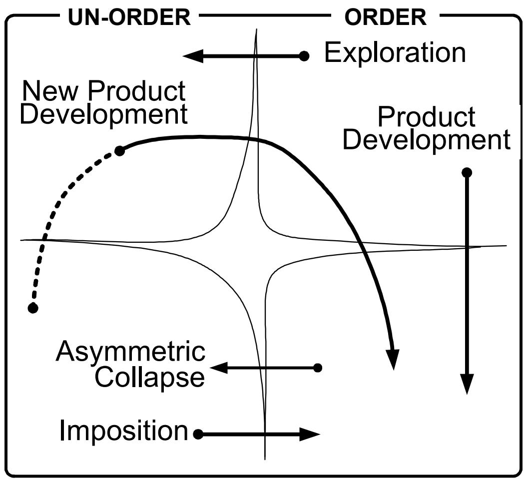

Figure 3:2. There are many pathways possible in the Cynefin framework. Modified from Kurtz and Snowden (2003).

Asymmetric collapse is movement from the known to the chaotic in a disastrous way. This mode is typical of organizations that settle in an environment and fail to observe that circumstances have changed, until it is to late. Some organizations tend to oscillate between known and chaos.

Imposition is the forceful movement of an organization from chaos to the known. This is often the result of asymmetric collapse, and typical examples are the regular reorganizations of large companies.

Exploration is movement from the knowable to the complex, that function as an opening up of possibilities by reducing or removing central control without a total disruption of connections.

Because self-organization also works on the informal system, the shadow system, which is very much intertwined with, yet constantly attempts to undermine, the legitimate hierarchy. Interactions in the shadow system are based on the free choice, preference, benefit and self-interest of the agents, yet at the same time these agents have their formal roles in the organization; these different roles are always co-creating and influencing one another (Aram and Noble 1999).

This requires careful monitoring and awareness of the shadow system. In most organizations, there is a strong and often untapped resource to be found in exploratory moves such as this. For example, informal communities, which may range from public to secret in their profile, provide a rich and fertile source of knowledge and learning that is too large and complex to be formally managed.

Product development, PD, is often thought of as only involving mechanistic adjustments and limited redesign of a product already in production. This is sometimes called reengineering. We move within the knowable and through development move the product down into the known domain.

New product development, NPD, is different. New product here means conceptually new to the design team, whereby they by necessity must go beyond an extrapolation of previous products resulting in creative activities residing in the truly complex (Rose-Anderssen et al 2005). NPD may even start in the chaotic domain, but most certainly, for a huge part resides in the complex. Consequently, NPD is difficult to manage and as has already been pointed out: established procedures may not work, historically stable patterns of meaning cannot be relied on, and expert opinions are insufficient or sometimes even false. The way to act is multiple thrusts, that is to create probes to make the patterns or potential patterns more visible before taking action. We can then sense those patterns and respond by *stabilizing those patterns that we find desirable*. Understanding requires multiple perspectives on the nature of the system.

4. Emergent knowledge process, EKP

A new product development project, performed by a geographically dispersed team, has recently been reported (Malhotra and Majchrzak 2005, 2004, Sawy and Majchrzak 2004, Markus et al 2002, Malhotra et al 2001, Majchrzak et al 2000 A, 2000 B). The authors used a multi methodological approach attending all 89 virtual meetings, sending out weekly questionnaires, studying archived data files, and performed interviews.

The studied project comprised eight people: a project team leader, concept designer, lead engineer, combustion analyst, and thermal analyst from two different geographically separated organizations in Rocketdyne, a manufacturability engineer and a CAD (Pro-Engineer) specialist from Raytheon (then Texas Instruments) located 1,000 miles away, and a stress analyst from MacNeal-Schwendler Corporation, located 100 miles away (Malhotra et al 2001). This inter-organizational virtual team[2] developed over a 10 month period, a novel rocket engine, while continuing their normal duties with their respective collocated teams, setting off only marginal time

[2] A virtual team is a group of geographically and/or organizationally dispersed coworkers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task (Majchrzak et al 2000).

for the virtual team project. The team was by all standards extremely successful (Majchrzak et al 2000 A):

> "The team succeeded at designing a thrust chamber for a new rocket engine with only 6 parts instead of the traditional hundreds, with a predicted quality rating of 9 sigma (less than 1 failure out of 10 billion) instead of the traditional 2 to 4 sigma, at a first unit cost of $50,000 instead of millions, and at a predicted production cost of $35,000 instead of millions. The team was able to achieve all of this with no member serving more than 15% of his time, within the development budget, with total engineering hours 10 times less than traditional teams, using a new collaborative technology with several partners having no history of working together. The team members achieved this success through collaboration.
>
> The team received an award for outstanding achievement from RocketCo Senior Management".

The team had an html-based collaborative communication technology tool (CT) for communication, information storage and retrieval (organized database, keywords), whiteboard, sketching, etc that was custom developed for the team. It was found however that the team made little use of the supposedly powerful organization search and retrieval mechanisms provided by the CT utility.

The reason for this was that ***the design process was so unpredictable*** (the team created over 20 different engine design concepts) that most of the members had no clue as to whether or not the knowledge they were putting into the database would be of value later on and thus those entries did not warrant attempts at categorization and organization. This was so in spite of the fact that very many entries were later referenced. When reference links were created this was regarded by the team as the most helpful feature for finding information (Majchrzak et al 2000 B). The team never came to a conclusive design of the CT tool although no less than 23 versions were created and tried during the project (Malhotra et al 2001).

One reason for this is that creative work is substantially different from routine problem solving in many ways, for instance (Malhotra et al 2001):

1. Solutions are generated in *unpredictable* ways,

2. Both the analysis and solution need to be generated *concurrently*,

3. The design process is a series of seemingly irresolvable tradeoffs, with *priorities* among tradeoffs *emerging as the design progresses* and the process gradually builds a consensus around the solution that meets these priorities,

4. Problems are often not well-specified, being understood only as they are solved,

5. Tasks cannot be easily apportioned to individuals since everybody makes an unpredictable contribution to the process (a true team effort),

6. *Expectations evolve* (rather than are found and followed) about the task, work, collaboration, context, jargon, and assumptions.

During the research of appropriate CT tools and researching how to design them Markus et al (2002) discovered that the creative new product design activities they had witnessed in the rocket engine design team, from a knowledge management point of view, belonged to a new class of problems. They dubbed this new class *emergent knowledge process*, EKP.

Emergent knowledge processes are organizational activity patterns that exhibit three characteristics in combination:

- Deliberations with no best structure or sequence
- Highly unpredictable potential users and work contexts
- Information requirements that include general, specific, and tacit knowledge distributed across experts and non-experts.

Examples of EKPs include basic research, new product development, strategic business planning, and organization design.

Process has traditionally been described in terms of structure. However in this case, increased structure is neither possible nor desirable, because it might introduce rigid, stereotyped responses where creativity and flexibility are needed. Such unstructurable processes have been referred to in terms of human sense making: building knowledge in a recursive, participatory, and evolutionary manner. Because the term *unstructured* suggests that structuring is possible and perhaps desirable, Markus et al (2002) instead elected to use the term *emergent* as a better label.

An example of an emergent process is new product development, which can be described as a series of unpredictable trial-and-error experiences in which the developer iterates recursively between problem-finding and solution evaluation.

In a later article Sawy and Majchrzak (2004) introduce the OODA-loop[3] and the necessity to increase decision speed and agility in a competitive business environment. They note that in the SLICE project the quick action-learning loops, where new designs were created from scratch each week, led to a process that was no longer able to follow a traditional product development process.

[3] For a description of the concept, see the following section on strategy.

This quick iteration on the work process allowed the team to work in a way that encouraged quick iteration on the work product. Experts were called in on the spur of the moment, with each individual contributing his perspective on the situation. People acted before they were able to fully comprehend a problem. In fact, they acted in order to understand the problem, creating only partially predicable events, making problem definitions evolve. This was a real-time emerging knowledge process.

Key to the team's success, was synergy between emergence of the work process and product, coupled with quick action-learning loops.

Few people have the capability of functioning effectively in such teams: they require deep expertise, aptitude to function well under stress, a quick ability to size a situation, the cognitive flexibility to completely adopt a new perspective, and ability to improvise as new knowledge is acquired.

5. Strategy

One consequence of the results from complexity science is that we cannot be as sure, as we previously thought, that the future could be predicted. This uncertainty is not reducible to information: *perfect information will not remove uncertainty* (Artigiani 2005, Kolenda 2003). For example, the theoretical limit to weather forecasts is 3-4 weeks and will never be exceeded (Wiin-Nielsen1999).

Very large and very small occurrences can have the same origin and it is impossible to predict, when they occur, if they will be of significance or not. The possibility to foretell the future is small and unexpected things can suddenly happen.

5.1. Planning

In an orderly world that is linear and proportional and where perfect knowledge is available, precise planning is possible, but in a complex world where order is circumstantial, any reliance on plans is rather futile.

Therefore, plans will not hold together, because the past, which plans are based on, is not an accurate compass for the future, but also because change is so pervasive that the environment can undergo profound alterations while the formal planning process is underway. But planning, never the less, is very important because (Cunha and Cuhna 2002):

1. During planning, management's discussion on possible future scenarios creates a "memory of the future" so that when circumstances unfold they are met with prepared actions (Bunker and Alban 1997).

2. A shared knowledge of plans may be used as a coordination mechanism for individual improvisation.

3. Plans can be conceived as actions unfold making economizing with scarce resources easier.

4. The planning process can yield organizational learning, shared mental models, in fact a meta-language.

The separation between the observers and the planners (between first line operators in contact with customers/users and senior management) is a source of information filtering and delay, which can be dangerous in a fast paced environment (Cunha and Cuhna 2002). The solution is to merger action with planning, resulting in a bottom-up design more efficient than any top-down design (Wesensten et al 2005) and the basis for maneuver thinking.

The application of this idea to NPD could be thought of as reliance on self-organization (bottom-up) and a probe-sense-respond mode of operation (figure 3:1), which could also be described as quick iterations or evolve/adapt and iterate (Highsmith 2004).

We must let go of the idea of the plan as a timetable, but utilize the other aspects of planning. Then to succeed, planners do not need to “know” the future. Because systems guided by rules for making rules are much more flexible than formal systems. Furthermore, if by a lively preparatory communication the organization’s members have acquired a shared understanding of proper actions and shared mental models, then they can effectively think in one another’s brains (Artigiani 2005).

5.2. Business strategy

In the business world strategies are sometimes thought out based on an analysis of circumstances, strength and weaknesses, etc, (Markides 2000), but more often than not they are created as a result of adaptation to the environment, especially for small and medium sized enterprises (Rantakyrö 2004). In later years business strategists have been looking at complexity science for metaphors and analogies (Englehardt and Simmons 2002).

The well-known case of IKEA is a good example of how a certain culture in combination with environmental necessities created a brilliant strategy. The following is from Markides (2000, p 150).

> When Ingvar Kamprad, IKEA's founder, tried to crack this market, he was shut out at every turn. Barred from selling directly at trade fairs, he resorted to taking orders there. When that was forbidden, he contacted customers directly (initiating a profitable mail-order business, which necessitated that the furniture be easy to ship). When Swedish manufacturers refused his business, Kamprad sourced from Poland, getting even better prices than before. Locked out of traditional outlets, Kamprad converted a factory into a warehouse and showroom, where explanatory tags, self-service, a colorful catalog, and the lure of instant availability—thanks to

> on-site stocking—were deliberately distinctive. In every instance, the strategy was driven as much by necessity as it was choice. . . . In hindsight, IKEA's positioning is indeed brilliant and is indeed a source of real and sustainable differentiation. The position, however, was as much a consequence of adaptability as it was of strategy. It was persistence—and experimentation under the strict discipline imposed by constrained resources—that allowed IKEA to build its furniture franchise.

Strategy has military roots. It has been found that strategies for armed forces will be most effective if they master the following concepts (Kolenda 2003):

1. *Decentralization:* create and exploit a knowledge advantage by empowerment at the appropriate levels.
2. *Complexity:* gain a complexity advantage by maximizing the number of meaningful interactions.
3. *Tempo:* sustain an intensity of operations over time with which the competition cannot cope.

5.3. Aim or purpose of strategy

> *The aim or purpose of strategy is to improve our ability to shape and adapt to unfolding circumstances, so that we (as individuals or as groups or as a culture or as a nation-state) can survive on our own terms.*
>
> *John R. Boyd*

The citation defines strategy according to USAF Col. John R Boyd, Korea veteran, creator of fighter aircrafts F15 and F16, and teacher at US Marines War College. Boyd created his theory of strategy after having studied 2500 years of human conflicts. Boyd never published his theory, but gave a number of comprehensive briefings that spread his ideas among strategists that have later published Boyd's theory (e.g. Richards 2004).

The Boyd theory was primarily conceived for international politics and military conflicts, but if we define conflict as a situation where two or more parties compete for limited resources then the theory is applicable to all human conflicts, and that makes the theory useable to us who lead organizations and develop new products.

Decisive for the outcome of a conflict is the ability to observe, orient, decide, and act, quicker than the adversary. Especially important is the ability to shift orientation swiftly. The result is generic and applies to all systems: an individual, a project group, product developing company, or a nation.

The O-O-D-A-loop of John R Boyd (figure 3:3) is not a loop in the same way as for instance Deming's wheel in quality work that is run through step-by-step, revolution after revolution. That is not how the Boyd loop works. Instead, there is a continuous

Observation-Orientation with a Decide-Act when necessary. That is, a perpetual process of ongoing activities – not a cyclic development!

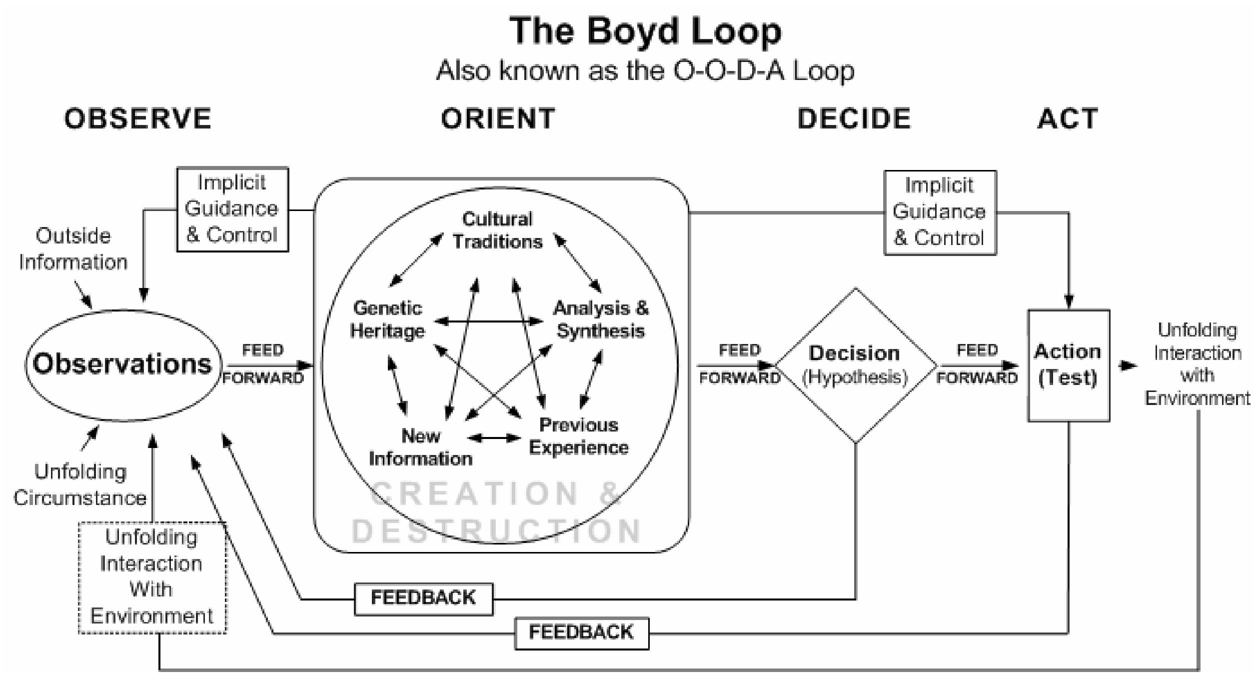

Figure 5:1. The O-O-D-A loop, also known as the Boyd loop after its creator the late John Boyd (Richards 2004).

Observe: One cannot observe without distortion, because what one observes (has the ability to observe) depends on the mental models that one possesses, how one is oriented. So your orientation decides what you observe. That for which you lack concepts/mental models cannot be observed. What we try to observe is ever changing.

Orientation is adaptation to the observed reality. What one observes depends on the orientation, which in turn depends on genetic heritage, cultural traditions, earlier experiences, new information (if you have the ability to digest it), and analysis and synthesis of the situation at hand (to see that which can not be seen with the eyes).

Creation & Destruction (figure 3:3, Orient block) stands for the fact that one must destroy, abandon, a mental model for to be able to accept a new one (for the same set of facts). It can be very hard to break old, familiar patterns; especially if they have been internalized and thereby made unconscious to us. It is here that the greatest difficulties abound.

The idea that it is constructive to be able to abandon ones ideas is not new, as strategist Yagyu Munenori (1571-1646) talked about the necessity of not allowing ones mind to tarry (Yagyu 2000, Takuan 1987), and strategist Miyamoto Musashi (ca: 1585-1645) says: “it is a matter of harboring an open, free and fluid mind” (Musashi 2001).

Discussing successful designers Lawson (1997, p 158) says: "Creative thinkers in general and designers in particular seem to have the ability to *change the direction* of their thinking thus generating more ideas".

Decide: Based on a hypothesis of reality and probable development, we make decisions that will affect the very reality that we observe.

Act: Our actions influence, alter, the observed reality and thereby what we observe and how we orient. The orientation influences action, which is the realization of the decision, since our way of action depends on the same factors as our orientation: earlier experiences, cultural traditions, etc. We are for the most part unaware of these mostly subconscious influences.

5.4. Maneuver thinking

In military affairs, it was found that a culture of maneuver thinking resulted in the most effective and efficient strategy (Richards 2004, Smedberg 1994). It was the military answer to the uncertainty and lack of trustworthy information in military operations of war. Without knowing it, the military were operating complex organizations (Artigiani 2005).

To give an understanding and "feel" for the attitude of maneuver thinking, the following description of one of the basic principles of maneuver warfare, *Auftragstaktik*[4], is given (Claesson 2001):

> *Auftragstaktik* found its definite form between the world wars. It is based on the following fairly simple hypothesis:
>
> - As no plan, and thus no orders, remain valid after contact with the enemy, and
>
> - as the very nature of combat is confusion and uncertainty, one must
>
> - develop a system of command that allows rapid changing of plans at every level to seize the fleeting opportunities that combat confusion offers, which thus means that:
>
> + command initiative must be devolved to the lowest tactical levels, and
>
> + no formal orders can be given other than by commanders who are in physical contact with troops at the point of contact; while, at the same time,
>
> + all commanders, down to section level, must react to developing combat situations in accordance with the tactical and operational INTENT, as opposed to precise orders, expressed by higher commanders two links up the chain-of-command so that
>
> + all are functioning, one might say, in harmony. And, finally,
>
> + this "harmony" is dependent on a common mobile military culture, or philosophy, that is enshrined in the army's doctrine and ingrained in the

[4] "Auftragstaktik" as a term and method was first developed in the German army in the 1800´s (Larsson and Kallenberg 2003).

> minds of all soldiers through a system of war maneuvers, Kriegspiele – staffrides and promotion values rigorously applied by the General Staff.

> This special method for planning and giving orders allows for large freedom as to the realization of orders. For instance were subordinate commanders invited to seize initiative and develop measures to be used if a tactical opportunity should arise.
>
> Such opportunities can be utilized directly without order from higher command. It was assumed that by encouraging initiatives from subordinates one would gain a greater flexibility.

Auftragstaktik relies on and thrives in a culture of initiatives at all levels, self-organization, tolerance of failure, intuitive communication and almost thinking in one another's brains. It relies on empowering professionals at the lowest possible levels, which is the most effective guarantor for excellence (Kolenda 2003).

By making good use of the ideas and philosophy behind *Auftragstaktik* in product development, it seems plausible that *speed and flexibility will increase*, which will *yield higher quality and higher performance products.*

For this tactic to work everyone must know the overall goal and have an ability to change between different kinds of work and adapt to changing circumstance. The ability to achieve "fast transients" is a core capability according to Boyd (Richards 2004).

The advantages and efficiency of maneuver thinking has been reported in the PD literature and Wesensten et al (2005) points out that abilities that facilitate *Auftragstaktik* are situational awareness, adaptability, mental agility, judgment, initiative, anticipation, planning, course-of-action determination.

Other basic concepts of maneuver thinking are (Richards 2004):

1. *Einheit:* mutual trust and cohesion based on shared experience and shared mental models are the basis for leading by mission statements and commanders intent. In NPD literature, we find that interpersonal trust is important for new product success (Akgün et al 2005) and for business success in general (Englehardt and Simmons 2002, Pech 2001).

2. *Fingerspitzengefühl:* intuitive skills based on extensive experience and deep knowledge[5] that make spontaneous improvisation possible.

3. *Schwerpunkt:* the effective focus[6] of our activities that all subordinate units shall support. It is important to be able to quickly shift focus.

There are examples of spectacular success in new product development that seem to be a result of team design (brilliant individuals) and what could be called a maneuver

[5] Compare with the importance of personal skill and aptitude found in section 3.4

[6] This appears to be similar to "leading by a vision" in DPD, section 2.4

culture (Sawy and Majchrzak 2004, Markus et al 2002). There is an emphasis on speed, the importance of time, or tempo in maneuver thinking that was brought into strategy theory by Musashi in 1643 (Musashi 2001) and which has been found in NPD to cause development personnel to make more careful decisions, and to more effectively implement new technologies and techniques (Swink 2003).

As a result of initiatives at all levels there naturally emerges, from a culture of maneuver thinking, a strategy of multiple thrust, which is in harmony with newer theories of business strategy that stress the importance of keeping a portfolio of options in progress (Englehardt and Simmons 2002).

Pech and Durden (2004) compare maneuver with attrition as bases for a business strategy and advance maneuver thinking as preferred strategic approach. In Pech and Slade (2003) there is an emphasis on action through maneuver, speed, and external focus. They distinguish between decision models R and P see figure 5:2.

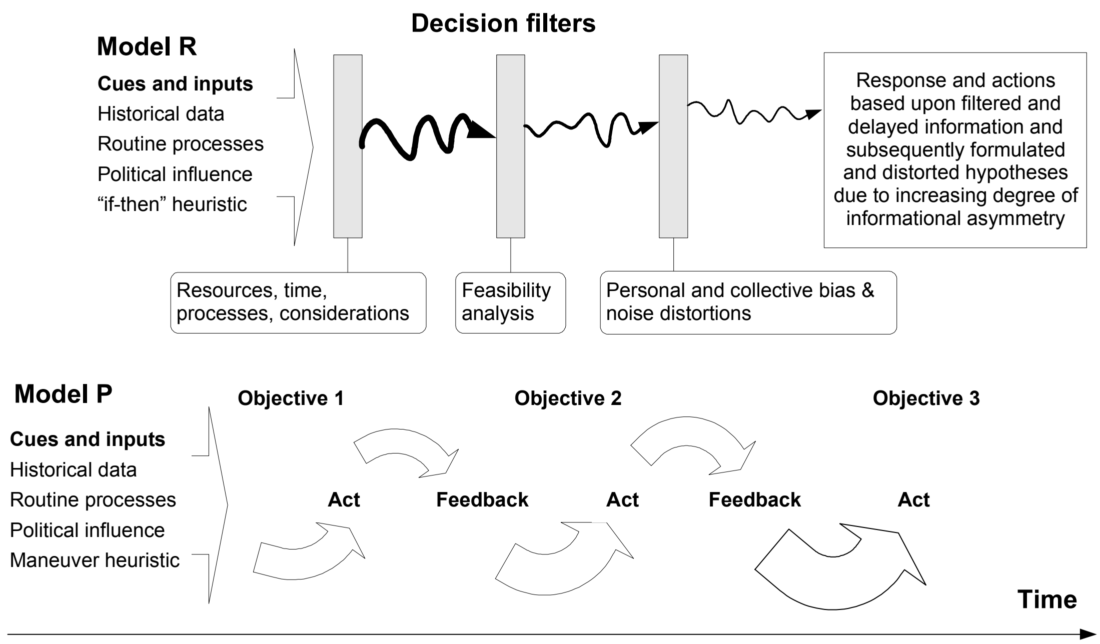

Figure 5:2. A comparison between models R (reactive) and P (proactive) (Pech and Slade 2003).

R stands for reactive and relies on tradition, historical analyses, and the “luxury” of careful planning and lengthy response and reaction times in order to attempt to shape the firms future. This is serial information processing and predicable decision making based on “if, then” calculus (Pech and Slade 2003). In such an environment, management may appear to have isolated themselves behind layers of non-porous decision filters. However, no amount of advice will help an organization to improve itself if such improvement methods expose or attack senior decision makers’ greed, ignorance, or foolishness (Pech and Durden 2004).

P stands for the preferred proactive maneuver model that relies on speed and the development and attainment of rolling objectives in order to influence and shape the future. Model P describes parallel information processing as new objectives and downstream responses to actions are processed simultaneously and in parallel rather than in a serial manner (Pech and Slade 2003).

The P-model is strikingly similar to action in the knowable and the complex quadrants (figure 3:1) of the Cynefin model by Kurtz and Snowden (2003) that is not based on maneuver thinking, but complexity theory.

Based on maneuver thinking Pech (2001) describes characteristics of an innovative organization, see table 5:1, which is profitable for PD and used in DPD.

Element	**Characteristics**
Organization structure	Small semi-autonomous units.
Employees	Well-educated and highly trained.
Culture	Open culture espousing loyalty, trust, helpfulness, an action and performance-orientation, team oriented but supportive of creative and independent thinkers, encouraging of on-going learning. An atmosphere of copetition - co-operation and competition.
Management	Supportive, guiding, facilitative, high standards, high achievement, participative and tolerant of failure.
Leadership	Dynamic, motivational, communicative, influencing.
Promotion	Based on performance and ability.
Remuneration	Innovative and based on group and individual performance.
Focus	Innovation, markets and customers, external environment.
Rules and policies	Minimal and flexible for the long-term health and prosperity of the organization.
Strategies	Flexible and two pronged. Focus on growth and market dominance by providing customer satisfaction through quality and innovation, and second, outmaneuvering the competition by getting inside their decision cycle, identifying and isolating their weaknesses, and innovating at a pace beyond the coping capacity of the competition.
Tactics	Numerous, creative, unique, unexpected, a mix of both spontaneous and well planned.
Decision making	Decentralized, well conceived. Uses competitive intelligence gathering and analysis to aid decision-making.
Learning	Continual, encouraging discovery and exploration, and on-going learning

Table 5:1. The table shows a pathway to a more innovative organization based on maneuver thinking, according to Pech (2001).

A command and control approach often creates a dangerous illusion of direct cause and effect (Maguire 1999). Ordering people about is not in line with either findings from complexity-based organizational science or maneuver thinking. Instead ‘‘complex leadership’’ involves creating the conditions that enable productive, but largely unspecified, future states. Leaders cannot control the future because in complex systems such as organizations, unpredictable (and sometimes unexplainable) internal dynamics will determine future conditions. Rather, complex leaders need to influence networks (Marion and Uhl-Bien 2001).

Leadership thus becomes a question of inspiring, guiding, and supporting committed subordinates and encouraging them to perform freely within set limits (US Marine Corps Doctrinal Publication 6, p83).

6. Synthesis

Often in PD literature methods are described/prescribed without much regard for the situation at hand or the characteristics of those that make up the system and who are expected to use the methods.

It can be argued that we have a progression from abstract and generic to concrete and special that looks like this:

Culture ➔ Strategy ➔ Plans (tactics) ➔ Work (techniques are applied)

The culture determines what strategies are possible or acceptable. Then plans are born out of accepted strategy. The plans are transformed into work. It follows that our culture, our outlook, our view of the world is important for the way we perform product development.

To illustrate, I put forth three ideas: the assumption of order and the somewhat corollary idea of man's liking for designing machines, verses the idea that the world is truly complex.

6.1. The assumption of order

There seems to be, deep ingrained in many of us, an assumption of an underlying order that constitutes the world, and thus forms a paradigm. We can see this assumption of order from earliest recorded history, and early myths such as the Book of Genesis (Eden was a garden and God was a gardener), as well as in the Babylonian myth of creation (Kurtz and Snowden 2003), in Hinduism (Ross 1973), and in the Nordic myths (Crossley-Holland 1983)

This assumption of order probably goes back at least to the dawn of agriculture (Brody 2000), when people depended on their ability to keep track of and foretell the shifting seasons.

In medieval times, there was the harmony of the spheres, and later when the heliocentric worldview became dominant, we had in the celestial mechanics of Isaac Newton, ordered motion. God was a watchmaker. Not long ago society also, was thought of as having a natural order with God on top, followed by the king, etc. Natural science itself is based on ideas of governing natural laws that are discovered by industrious scientists. Maybe it is comforting to think of the world as ordered and, perhaps, purposive.

6.2. Man's liking for designing machines

From earliest times humans seem to have had a liking for making tools and later machines to enhance the ability of the body (bows and arrows, trebuchets, windmills, waterwheels, etc) and mechanical devices to help with arithmetic operations and thereby relieving from tedious intellectual work.

If we agree that, *a machine processes input and delivers output in a predetermined, rule based and foreseeable fashion*. (There is no judgment at hand. All thinking and design has been done beforehand and laid down as rules). Then we see that also bureaucracies are machines and understand that they have been designed that way for a purpose. Bureaucracies by their rules and regulations save us from intellectual work. We eagerly remove humans' judgment by aid of a machine if it saves us from mental effort. "We use intelligence to structure our environment so that we can succeed with less intelligence" (Clark 1997, p180). Other benefits we draw from such action are the predictability and quality control that are available to organizations designed to be machines (Morgan 1998).

The organization as a machine is designed as a rational structure of jobs and activities. Its drawing is the organizational chart and employees are hired to operate the machine and everyone is expected to behave in a predetermined well-defined way. This has the advantage of letting all organization members know what is expected of them. But it also lets them know what is *not* expected of them. Initiative is discouraged because people are expected to obey orders and keep their place, not to question what they are doing. This way of organizing creates rigidity that prevents organizations from adapting and flowing with change.

> "When we talk about organization, we usually have in mind a state of orderly relations between clearly defined parts that have some determinate order. Although the image may not be explicit, we are talking about a set of mechanical relations. We talk about organizations as if they were machines, and as a consequence we tend to expect them to operate as machines: in a routinized, efficient, reliable, and predictable way" (Morgan 1998).

Machines of all kinds are a result of, and harmonize with human nature and therefore are hard to argue against in those cases where it is more efficient not to take to machines. We are so used to and like so very much to create machines that when judgment and creativity is called for, we often have a hard time leaving the machine-thinking out of it.

It is understandable if scholars in the field of product development want to design machines and undoubtedly literature is full of diagrams with rectangles and arrows describing some process thought out by some researcher. Precisely as with the designed machine-like organization, it is common in product development literature to find the opinion that before start, plans should be drawn up and subsequently followed. First, someone thinks and designs the project, team, planes, etc and then the team carries out the work.

It is worthy of note to point out that I am not trying to discredit the science of machine elements and other sciences that support engineering design. These sciences are very much about designing "machines" in the sense that the researcher designs an algorithm or schema to follow for dimensioning machine elements such as cog wheels, brakes, bolted joints, etc (e.g. Tepper and Schopf 1985, Beitz and Grote 1997).

Machines work best when there is a straightforward and well-defined task to perform and the environment is stable and predictable. They are good for producing exactly the same product time and again with precision and efficiency. But machines can only solve "old" problems since all thinking is abolished and substituted for fixed rules. This makes machines rigid, unable to adjust to changing circumstance. But to upper management this is often seen as a low price to pay for the control, and predictability, that is typical of a machine process. This false feeling of power reduces anxieties, which is especially important for authoritarian managers (Dixon 1994).

The strengths and weaknesses of machines are well matched to industrial production but less so to organizations such as product development teams or research groups, because in these cases the very nature of the work itself is opportunistic demanding flexibility and an ability to utilize fleeting opportunities. The fact that Taylorism is so favored by upper management even in these cases indicates that: "Taylorism is as much a tool for securing general control over the workplace, as it is a means of generating profit. …One of the great attractions of Taylorism rests in the power it confers on those in control" (Morgan 1998).

6.3. The world is truly complex

An understanding of the world as a complex system has several ramifications, as presented earlier in this chapter in sections 3.1-3.5, e.g.:

- It can be difficult to associate effect with cause, making prediction virtually impossible.

- System history plays an important role in defining the state of the system as well as affecting system evolution. Future development is dependent on how we came to be here.

- It was for a long time assumed that systems could be controlled, when in fact they can only be influenced.

- Self-organization leads to emergent properties and efficiencies unattainable with top-down direction.
- The system has within itself a model of its environment; it is teleological.
- Informal structures self-organize, emerge, and persist in a way that is remarkably robust to changes in the formal organization.
- Understanding requires multiple perspectives on the nature of the system. Narrative techniques are particularly powerful.
- Perfect information will not remove uncertainty.

Methods created based on an assumption of an ordered, linear world, are probably unsuitable for situations where circumstances are complex. For example, in a linear world, when a plan fails to come together, it is seen as a flaw in the plan, not as a natural consequence of how the world is constituted, which would be the natural inference based on a complexity worldview.

Previously in this chapter, I have shown how a common view has emerged from such different fields as:

- Military affaires
- Business strategy
- Complexity theory

In this common view, the world is complex with areas of relative stability or chaos. For successful action, it has been found that uncertainty and changing circumstance, so typical of product development, is best handled by agile adaptation to shifting circumstance, relying on self-organization and emergence, making use of the latest gained knowledge. Even act in order to learn, when an understanding of the problem develops concurrently with the solution. The dynamic methods, such as DPD, seem to best correspond to this description. While the static methods (SE/CE, IPD, Stage-Gate™, etc) appear to have been designed for an ordered, stable, world.

7. Design the team

In a successful team, each team member's judgment is utilized thereby realizing the inherent full capacity of the team. Further, the team is a more capable performing unit when the work is finished than it was when the work began. In other words, the team is learning. There are five simple requisites that must be in place for a team to be successful (Hackman 2002):

- A real team

- Compelling direction
- Enabling structure
- Supportive context
- Expert coaching

A real team has four features: a team task, clear boundaries, clearly specified authority to manage their own work processes, and membership stability over some time. All of these conditions are normally fulfilled in a PD project team.

Team composition has proven to be of extreme importance. How one designs the team, is said to affect team performance 40 times more than team coaching (Hackman 2002, p208).

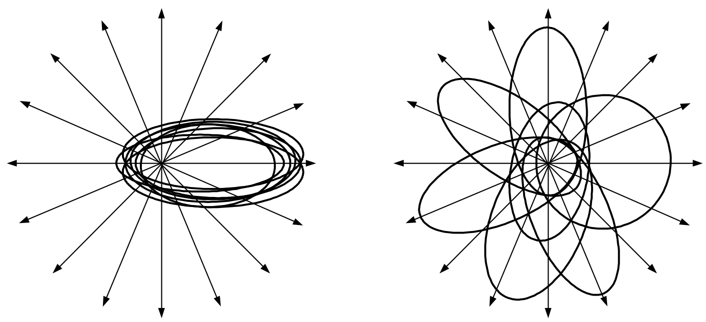

Figure 7:1. By recruiting team members who differ from each other, a stronger more competent team is formed than would be the case if all team members were look-a-likes (Pech 2001).

There is a risk of achieving to little cohesion in a group of disparate talents, and if there are personality differences, communication within the team is hampered (Sample 2004). However, in a homogeneous team there is less learning and creativity. For the specialization, typical of a good team, it is advantages to recruit team members that complement each other's competence, see figure 7:1. The combined competence is larger for such a group. A heterogeneous group performs better than a homogeneous (Pech 2001).

The compelling direction should ideally deepen the meaning or elevate our purpose in life and it should be challenging to be interesting. Such a compelling direction energizes the team. A clear direction helps orient the team and align efforts. With possibly positive consequences of the work follows engagement that foster full utilization of knowledge and skill.

An enabling structure starts with a sound project organization, with clear statements of responsibilities, code of conduct, and division of work. The team should not be too large as motivation and engagement usually is larger in small teams. A well functioning and supportive infrastructure including locations, communication equipment, computers, software, etc are all a part of an enabling structure.

Supportive context in this case means open borders, a free flow of information, and a forgiving atmosphere where mistakes are allowed if they are the result of meaningful risk taking. There should be some kind of reward system.

Expert coaching must take into account the three aspects of group interaction, found by research to enhance effectiveness, namely the amount of *effort* members apply to their collective work, the appropriateness to the task and situation of the *performance strategies* they employ in carrying out their work, and the level of *knowledge and skill* they apply to the work.

Team leader intervention mostly has either of two purposes: to minimize process losses, or to increase process gains. Intervention that addresses effort is *motivational* in character; its functions are to minimize free riding and to build shared commitment to the group and its work. Intervention that addresses performance strategy is *consultative* and intends to minimize thoughtless reliance on habitual routines and to install inventive ways of action that are aligned with task and situational requirements and opportunities. Lastly, intervention that addresses knowledge and skill is *educational* in character.

7.1. Group problems

The shadow system has already been discussed[7] where it was pointed out that informal structures (the shadow system) self-organize and emerge and persist in a way that is remarkably robust to changes in the formal organizational structure (Anderson 1999). Further, the shadow system is very much intertwined with, yet constantly attempts to undermine, the legitimate hierarchy (Kurtz and Snowden 2003).

We have also discussed[8] how an organization at least partially is a product of human intention (Rowland 2004), and that an organization besides having outspoken predetermined goals, may harbor unconscious intentions (Buckle 2003), residing in the shadow system. This is illustrated in figure 7:2, which shows how interaction between the shadow system and the individual may be "kept in the dark" and therefore invisible to management (Lindholm 1998).

Many of the intentions driving organizational behavior are publicly understood and sanctioned, this is "theory espoused" (figure 3:6). However, some purposive behavior in organizations remains unconscious and is present in "theory in use". These may detract resources from managerial objectives and obstruct organizational efforts regardless of the desires of any one manger. The more so, the less theory espoused coincides with theory in use.

[7] Section 3.2 Organizations as complex systems, section 3.3 Order and un-order
[8] Section 3.2 Organizations as complex systems

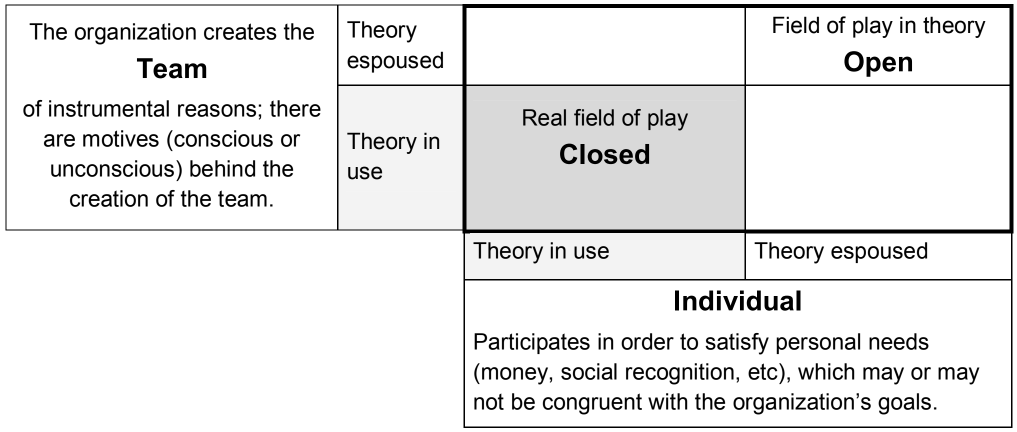

Figure 7:2. As individuals become members of an organization from their own personal reasons, there might be a conflict with the goals of the organization from Lindholm (1998).

To complicate this further we can bring in aspects from the difference matrix[9], which is unique for every difference factor that affects the organization, such as power, money, place, topic, personal style and language (Eoyang 2004).

As we can see, conditions for product development in any organization is thus truly very intricate and complex.

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