

Balancing Venturi and Laissez-Faire Management Styles: Insights from Fluid Mechanical Analogs

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ABSTRACT

Mobilizing distributed Organizational Intelligence involves managerial efforts whereby the generation of new tacit knowledge requires dissemination of newly codified externalized knowledge. The managerial role in the early stage of knowledge creation is to support and stimulate the process of knowledge generation and to aid the diffusion of knowledge across organizational boundaries. In contrast, the subsequent ‘harvesting’ and goal-oriented application of knowledge requires convergence of human actors (H) as carriers of distributed intelligence (DI). Optimization of the organizational performance and improved workflow efficiency is best effectuated by applying insights from fluid mechanical analogs.

Several such analogs are introduced here and these provide insight that helps to funnel tacit and explicit knowledge into tangible asset value. Three sets of managerial lessons are inferred from the analogs: (1) Social bonding between professionals needs to be stimulated because professionals with strong social bonds (S) can sustain effective workflows under relatively high pressures, while weak social bonds lead to turbulence and disruption; (2) Effective vision sharing is essential for goal-oriented and accelerated knowledge development in DI systems, and; (3) Managerial pressure may not overheat the critical limit that can be handled by resilient and strongly bonded DI networks, as this would result in disruptive turbulence even in experienced neural networks.

Keywords: Distributed Intelligence, Knowledge Flows, Organizational Learning, Strategies and Organizational Behavior, Fluid Mechanical Analogs

1. INTRODUCTION

Most contemporary models of organizational learning and organizational behavior focus on the decision-making processes [1, 2]. Further optimization of performance and workflow efficiency can be achieved by improving the process of new knowledge creation, optimizing the flow of networked cooperation, and enhancing the speed of knowledge transfer across organizational decision gates. Ultimately, this will contribute to the speed and quality of the decision-making process. The organizations that succeed in the most effective goal-oriented application of new knowledge and implementation of new solutions at the highest speed are the ones that succeed in outperforming their competitors [3].

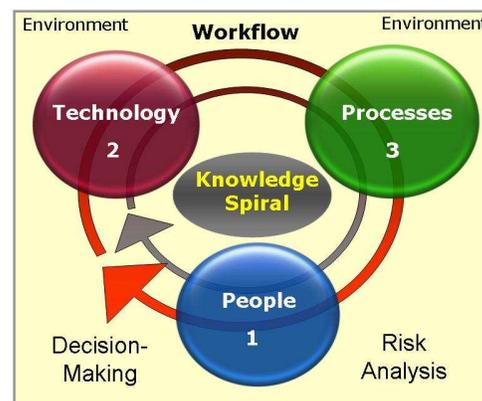


Figure 1: Knowledge is moved up the Organizational Learning Spiral - by people - ever faster, while critical decisions are made on business risks and opportunities. Smart workflow architecture helps to organize the decision-making process (from Weijermars [3]).

New insights gain momentum when a research domain is stimulated by incipient codification, growing funding for further research, and continued attention – commonly by incorporation of this knowledge in a product life-cycle - to ensure sustainable growth. For example, the oil industry represents one of the most complex engineering operations of its time, involving integrative application of 4D seismic imaging, reservoir modeling, drilling technology, facility planning and long-term geopolitical assessments for economic viability. Typically work is shared in complex cooperation agreements between multiple companies and institutions, involving public authorities, academia, and industry [4].

In such a complex business, success critically hinges on people’s ability to optimally interact, using technology and processes to complete their goals in an efficient workflow (Fig. 1). The workflow commonly requires decisions based on the assessment of goals set against the actual project status, and increasingly makes use of uncertainty quantification of risks and opportunities in a sophisticated risk analysis and decision-making protocol [5]. Organizational Intelligence is the outcome of the actions by the networked intellectual capabilities of human agents, where each contributes their distributed intelligence to the organizational brain.

This paper describes qualitatively how managerial efforts are needed for knowledge management in the broadest sense: Management of the human agents, who first generate new knowledge, then spread and enhance the distributed intelligence, to ultimate apply this knowledge in society, occurs in several organizational structures:

- Education in academia and industry to raise new human agents
- Research in physical and virtual groups that focus the distributed intelligence
- Funding to stimulate research domains & educational programs
- Peer review to ensure the quality of research & education programs
- Publication to encourage codification and distribution into the explicit knowledge domain
- Goal-oriented application (in economically viable products &

services) to provide sustainable support for the subject area

The principal focus here is on the managerial role in (1) supporting the process of new knowledge generation, and (2) harvesting and stimulating the goal-oriented application to translate that knowledge into asset value.

2. GENERATING AND CODIFYING NEW KNOWLEDGE

The organizational brain can be viewed as the networked intellectual capabilities of human agents, each contributing their distributed intelligence to the organizational brain [6-8]. The optimization of Organizational IQ requires maximizing the efficiency of the distributed intelligence [3] by speeding up the Organizational learning process. Two processes that critically contribute to rapid Organizational Learning are: (1) to accelerate the conversion of tacit knowledge into the explicit knowledge domain, and: (2) to align knowledge applications with the organizational goals by effective vision sharing.

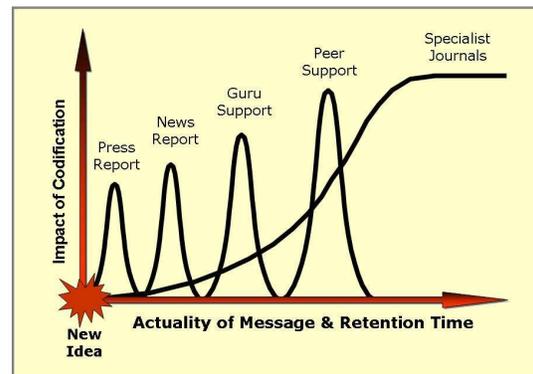


Figure 2: The impact of newly generated tacit knowledge rises when codification succeeds in gaining broad support and collaboration. Specialist journals play a role - but so do human agents – in spreading the message.

New tacit knowledge accumulates in the minds of people and effective Knowledge Management is required to accelerate the externalization of new tacit knowledge into the explicit knowledge domain (Fig. 2). Research on knowledge diffusion consistently shows that human agents

are knowledge actors that bounce around randomly (at worst) in a global playground. Senders and receivers of ideas interact at a speed determined by conjectural circumstances and prompted by high impact events. Some receivers of information only absorb, and if not transmitted, they act as knowledge sinks. But most professional interactions result in knowledge exchanges with a certain focus and future direction lead by shared values, common goals, and not the least, fuelled by infective and energetic passion. The high impact of intercultural challenges has been recently described elsewhere [9].

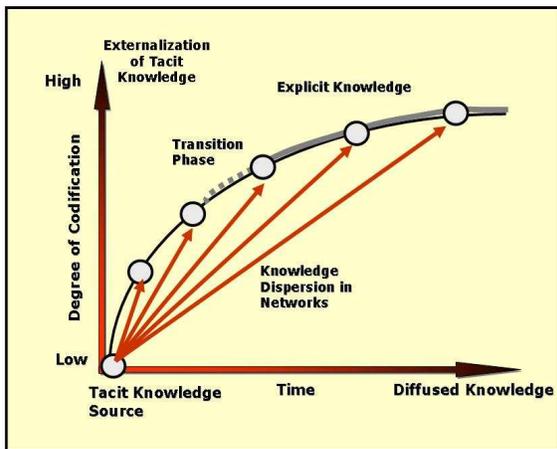


Figure 3: Tacit knowledge migrates into the explicit knowledge domain fastest by publicizing. Concepts are adopted and elaborated further in professional literature, which leads to the introduction of new jargon and further codification. The transition phase of tacit knowledge to explicit knowledge is poorly defined.

The outcome of knowledge transmission models using social networks [10] indicate that codification and distribution of knowledge follows the saturation curve as stylized in Figure 3. Populations of social networks absorb new knowledge at speeds determined by the frequency of interaction (meetings), exposure (publications, media), and aptitude of the audience (interested, knowledgeable, etc.). The degree of codification of the new knowledge increases as the number of interactions and publications increase.

Rapid release of mature tacit knowledge into the explicit knowledge domain is but one aim. Creating an environment that stimulates the development and innovation of new tacit knowledge must be another organizational goal. This can be realized by:

- Facilitating communities of practice,
- Providing personal learning experiences to support organizational learning,
- Stimulating external knowledge sharing activities (conferences),
- Rewarding innovation in annual performance reviews.

Failure to ‘grow’ new tacit knowledge leads to the loss of supply in new explicit knowledge. The filtering and prioritizing of information and knowledge is incredibly important. Thematic conferences are extremely valuable for unlocking fresh tacit knowledge and distributing it across organizational boundaries to fuse with existing explicit knowledge. Web-based learning has been heavily promoted over the past decade, but traditional knowledge transfer methods remain equally important. Cost-effective and smart choices have to be made about an array of knowledge transfer tools and methods (Fig. 4).

Place	Same	Different
Source		
Explicit	<ul style="list-style-type: none"> • Wall Charts • Proprietary Manuals • Classified Films • Logs & Photos • Classified Maps 	<ul style="list-style-type: none"> • TV & Website • PDF, PPT • CD ROM • Books & Journals • Satellite Images • Public Maps
Tacit	<ul style="list-style-type: none"> • Knowledge Fusion • Meetings • Story Telling • Mentoring • Classroom 	<ul style="list-style-type: none"> • Email • Phone • Letter • Message in Bottle • Video Conference

Figure 4: Matrix of knowledge transfer tools and methods for sharing local and remote knowledge (tacit and explicit). E-mail, phone conversations and letters are indispensable tools to share tacit knowledge between professionals in different locations. Knowledge fusion is optimum when tacit knowledge is shared in face-to-face discussions.

Ultimately, all tacit and explicit knowledge resources must be managed to support humans in decisions and in generating new business opportunities - and with the aim to enhance societal well being in a sustainable fashion.

3. MANAGING DISTRIBUTED INTELLIGENCE GOAL-ORIENTED: LESSONS FROM FLUID MECHANICAL ANALOGS

Human capital (H – following Becker [11]) and /or Social capital (S - following Burt [12]) behave like particles that migrate value across the organization towards the goals set by the program management. This value migration in an organization has been analyzed in terms of knowledge nets by Allee [13,14]. The knowledge net is primarily comprised of human agents that engage in the exchange of knowledge and value. The mobilization of human agents in the corporate brain commonly requires rewiring of the neural connections [15], adapting the individual professionals to the agreed project goals and organizational objectives. One interesting (inefficient) combination of ‘isolated genius’ (H) and ‘networked idiots’ (S) was alluded to by McKelvey [8], as a metaphor for visualizing the challenges of optimizing distributed intelligence (DI).

The human agents are viewed here as neural particles in a fluid continuum which holds the DI. In this approach, organizational efficiency

depends upon the DI alignment with the organizational goals. The fluid mechanical analogs provide some interesting insights that help managers to focus alignment of H and S from the DI resources.

Not unlike the traditional approach in fluid mechanics, the continuum assumption of human agents that generate and transmit new knowledge requires a balanced mass (fixed number of particles) and any physical change is subject to an equation of state. A small number of people (H) can only occupy a modest volume in the overall flow or workspace. They therefore cannot buffer large pressure changes, at best only steep gradients with relatively small overall pressure changes. A large number of people (H) can occupy a vast flow space and thereby can accommodate large differential pressure changes across the (work) flow tube between starting (or entry) point and target (or exit) point.

The rheology of the fluid analog is assumed here to be linear (i.e, a linear relationship exists between flow rate and pressure changes). The stream function is a concise mathematical formulation to represent the flow net as well as the transfer rate of particles across the flow field. The Venturi effect provides a useful analog for understanding how convergent knowledge flows can speed up in team projects and goal-oriented applications (Fig. 5). Although strictly mathematical formulation of fluid flow could be transposed to describe particulate flow of

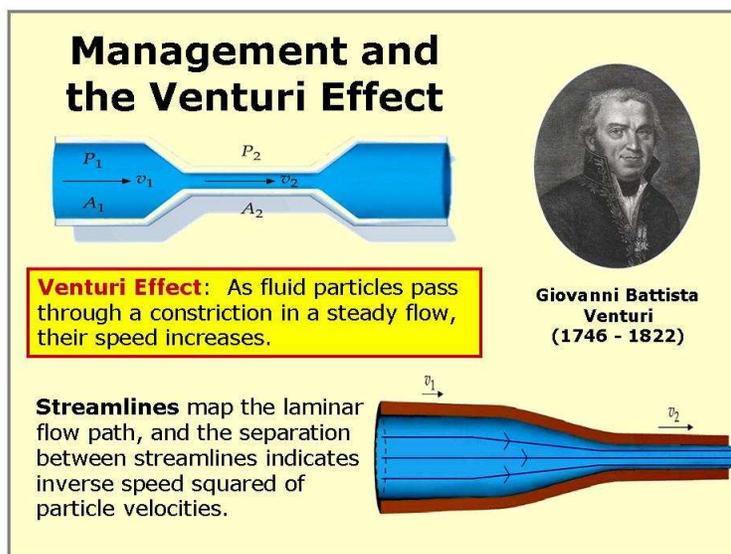


Figure 5: Giovanni Battista Venturi, early fluid mechanicist, noted fluid particles speed up as they approach flow constrictions. The flow convergence is represented by streamlines. These track particle movement paths and streamline patterns map speed changes.

knowledge across networked distributed human agents, a qualitative approach is adopted here for quick translation to practical situations.

Flowlines and particles are uniquely tied in laminar flow, and particle transfer is most efficient if inertia effects like turbulence remain suppressed (by intrinsic fluid properties like viscosity and extrinsic conditions like pressure gradients), see Figure 6.

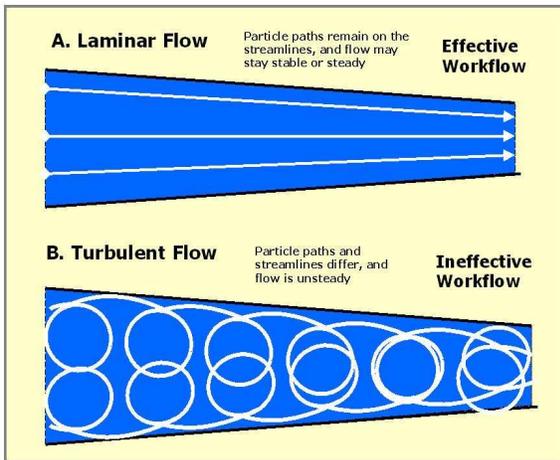


Figure 6: A. Transfer speed in corporate knowledge exchanges increases when resembling laminar fluid. B. In contrast, the transfer rate of individual particles slows when pressure gradients become steeper or particle cohesion is low to begin with.

A first set of managerial lessons from this fluid mechanical analog is as follows:

- Professionals that have strong social bonds (S) constitute a high viscosity continuum.
- They do not easily disrupt into turbulence if (work) pressure gradients become steeper.
- Laminar flow is an analog for effective workflow and efficient knowledge transfer processes (Fig. 6A).
- Professionals that have weak social bonds (S) can rapidly burst into turbulent flow even at modest pressure gradients.
- Management must provide opportunities to increase S between professionals; Turbulence leads to unexpected particle movements (Fig. 6B) and is an analog for

ineffective workflow and inefficient knowledge transfer processes.

People that become distracted by poor management directions may actually start to show shear thinning or thickening behavior, flying like ketch-up out of the flow tube if shaken beyond their critical value. Therefore it is extremely important to pay attention to the development of Social Cohesiveness in research and project teams. Factors that contribute positively are:

- Time spent together
- Severity of initiation
- Group size and skill mix
- External threats (global competition helps!)
- Previous successes
- Gender and cultural diversity
- Experience: Weathered professionals can better network with mature soft skills (high S capacity).

The role of the manager in this process of innovation in organizational learning is to avoid 'groupthink' type of impediments to new knowledge creation [16]. For people locked in groupthink, novelty is bad. But in a changing world, for a firm facing tough and changing competitors, groupthink and bureaucracy are killers. The (knowledge) manager must provide incentives that reward the externalization of new tacit knowledge into the explicit knowledge domain.

The benefit of a high S capacity work force is that they can be creative, while still accommodating steep pressure gradients in a smooth laminar workflow. Sharing the corporate vision effectively with high S-capacity professionals also accelerates the convergence onto the corporate goals. Clearly, investment in high S capacity professionals pays off in terms of rapid alignment and convergence into speedy results. Combined with mature situational leadership, whereby middle management is delegated full authority to the implement changes into operational values, organizational goals can be rapidly achieved with (H, S) capacity that is motivated and understands how to bundle the DI.

4. IMPORTANCE OF DIRECTION-SETTING BY VISION SHARING AND 'MEASURED PRESSURE'

Management has a challenging task in ensuring convergence of DI by clear vision sharing, adequate staffing and resource allocation so that all organizational units are well-equipped to meet the goals set.

A *second* set of managerial lessons can be formulated here from fluid mechanical analogs:

- Effectively managing alignment of all human agents means knowledge development accelerates as neural actors converge onto the target zone (Fig. 7A).
- In contrast, misalignment leads to divergence and slows down the knowledge development speed (Fig. 7B); this occurs when goals and directions are unclear or when boundary conditions and fluid bonding (S) change across the flow space.

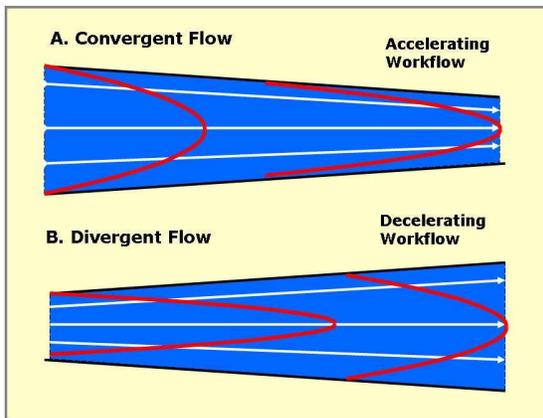


Figure 7: A. Particle speed progressively increases in convergent flows, as streamlines home in on the 'target zone'. B. In contrast, particle speed drops steeply in divergent flows, and streamlines fan away from - and disperse over- the 'target zone'. The curved potential planes show the velocity profiles in A and B.

A knowledge manager can energize the DI in the organizational workspace to reach the agreed goals by:

- Increasing (S) between the DI agents.
- Applying pressure gradients that can be handled without disruptive turbulence.
- Making sure that convergence occurs by clear vision sharing.

What should be avoided is this:

- Professionals that become distracted by poor management directions may actually slow down by insufficient focus on the goals.

A *third* set of rules derived from fluid mechanical analogs concerns managerial pressure limits:

- If workflow is represented by a convection cell with buoyancy pressures induced by a temperature gradient, laminar flow can be maintained if S is high and ΔT below a critical value (Fig. 8A).
- Turning up the heat beyond a critical value in a previously laminar convection cell results in turbulent flow (Fig. 8B). Heat transfer is effective initially, but fluid particles start to lose cohesion.
- Laminar flow can be restored by lowering heat gradients, so that fluid particles return to steady flow paths.
- Professionals that have a strong social bond (S) represent a high viscosity continuum.
- But even resilient and strong bonded professional networks disrupt into turbulence if (work) pressure gradients become too steep.
- Management must avoid applying pressure gradients that cannot be handled without undue and disruptive turbulence.

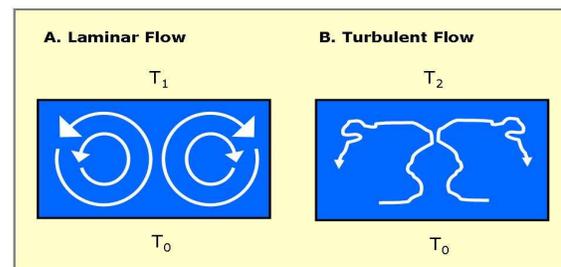


Figure 8: A. Laminar flow circulation occurs (and can be restored) by lowering heat gradients across fluid volumes heated from below. B. Turning up the heat beyond a critical value results in turbulent flow. Early work by the author focussed on physical modeling of thermal convection [17, 18].

5. BALANCING ‘VENTURI’ TYPE AND ‘LAISSEZ-FAIRE’ TYPE KNOWLEDGE MANAGEMENT

The Venturi effect indicates that divergent flow decelerates particle transfer and convergent flow speed up transfer rates (Figs. 5 & 7). ‘Venturi’ type management is defined here principally as managerial efforts that consciously use the Venturi pressure and flow speed relationship to focus the goal-oriented application of freshly generated, as well as cured, knowledge. It remains important in this approach to safeguard against a situation where an overly goal-oriented organizational focus impedes the creation of new knowledge that is needed to stay competitive. New knowledge development means effective organizational learning occurs and this in turn improves the Organizational Intelligence. Senior leaders and other functions that should maximize the corporate value-adding capacity tend to focus on goal-oriented application of explicit knowledge. They are often excellent at directing cross-functional application of existing knowledge and the finding of new business opportunities. This is a sub-optimal situation, because the best practice of today can never be the best practice solution for the problems of tomorrow. The focus on new applications areas is much needed, but should not go at the expense of efforts on the development of new knowledge potential.

Organizations that have a strong performance driven focus may run the risk that new knowledge sources remain isolated, neglected or underused, because attention is away from fundamental thinking and knowledge creation. The DI in the corporate brain must feel free - but must also be actively stimulated and receive support - to rewire and change their synaptic links. This is important and crucial when searching for innovation and new solutions, and divergence and turbulence in can play an important role in these processes. On the one hand, it is true that a corporate brain would learn less if it remains frozen in strong links. On the other hand, it is also true that there is a constant tension between the generation of useful new insights and the need for goal-oriented application of this knowledge in an efficient workflow.

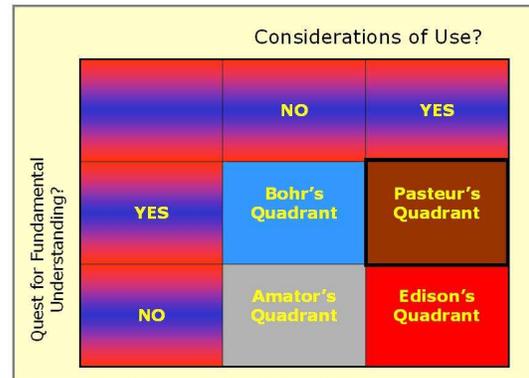


Figure 9: Organizational Learning needs to provide for infusions of fresh, use-inspired knowledge. The Stokes matrix shows Pasteur-type knowledge development is best suited for immediate business application, while still pursuing a quest for fundamental understanding. In contrast, Bohr-type research is least suitable for immediate business application, because it requires further work before translation into a commercial application (e.g. nuclear plants) becomes possible.

This is best illustrated by the well-known Stokes matrix [19], which maps Bohr/Pasteur versus Edison-type knowledge processes (Fig. 9). “Heavy investment in pure, curiosity-driven basic science will by itself not guarantee the technology required to compete in the world economy and meet a full spectrum of other societal needs,” according to Stokes [19] - who also argued it is impossible to draw a sharp line between basic and applied research. He elected Pasteur as the example of a scientist whose work encompassed both ‘pure’ and ‘applied’ science and therefore could not be located on the classical one-dimensional basic-applied spectrum. Pasteur-type knowledge development is best suited for immediate business application – combined with a practical need and drive for fundamental understanding. Edison-type knowledge application exemplifies the skillful translation of available knowledge into commercial products. In contrast, Bohr-type research is least suitable for immediate commercial application, because it requires further work before translation into business applications (e.g. nuclear plants) becomes possible.

Goal-oriented application of knowledge is not counter to creating new knowledge, the two views can be - and need to remain - connected as subsequent (and parallel) stages in the business workflow. The two views can be elegantly addressed and combined using the metaphors introduced here. Loosening the managerial reins of goal-oriented functions and business operations is one way to give room to human agents that then can then pour energy into novelty development with an entrepreneurial spirit. The complexity science view, highlighted in two recent books [20, 21], is that new efficiency is created and initiated by self-organizing DI, especially in a loose environment. Perhaps this could be characterized as a 'Laissez-Faire' type of management, as opposed to the 'Venturi' type of management.

A strong vision in combination with top/down control tends to negate the power and effectiveness of the DI self-organization process, according to one reviewer of this paper. Indeed, if top-down control is too strong - an inherent danger in Venturi type management - people may become passive and dependent [22]. But we should also keep in mind that effective top-down vision-sharing means both the adoption of a shared vision **and** the delegation of leadership to help realize the organizational vision and associated goals. The idea of DI is to get the people who are younger, - and more recently trained, closer to new technologies and changing markets, and closer to customers' tastes - involved in creating the relevant new directions, strategies, and objectives. This may even provide a positive impulse for adjustments of the corporate vision.

The Laissez-Faire style associated with a complexity leadership philosophy, rightly considers that DI itself creates new order between the 1st and 2nd critical values when flow transits from steady flow to turbulence. Self-organization is known to be pre-eminent in the fertile region where novelty is created [23]. While this may give rise to new off-spin companies, keeping a proper balance between core business goals that remain proactively fuelled by innovation and new ideas remains important. Modern management should know how to utilize the benefits of Venturi style and Complexity Leadership philosophies.

6. CONCLUSIONS AND RECOMMENDATIONS

Globalization and effective communication between professionals across political boundaries and cultures means the dispersion and competitive application of new knowledge occurs ever faster, provided effective cooperation can be realized. Distributed Intelligence principally resides in four organizational entities: academia, industry, government and NGOs. All these organizations need to develop organizational intelligence to stay competitive and organizational learning is the process to develop the organizational brain. The DI embodies the human capital asset that fuels the innovation process and moves organizations competitively forward. Active knowledge management is required, whereby a tedious balance needs to be kept between the goal-oriented applying of knowledge in 'Venturi' type management versus a 'Laissez-Faire' management style.

Society benefits from optimizing the management of knowledge processes by eliciting new knowledge and the eventual funneling of distributed intelligence networks. Enhanced efficiency results in faster knowledge creation, and more goal-oriented use of the dispersed knowledge. The advent of effective internet communication has lowered political barriers to Academic Globalization. Academic institutions and their affiliated individuals now represent a stronger and stronger bonded network (S) of human agents (H) in a global DI network.

Distributed intelligence benefits from strategic direction-setting that aligns human agents with organizational goals in knowledge networks, supported by skillful managerial vision sharing. The fluid mechanical analogs outlined here can help the managerial optimization of the knowledge generation and knowledge distribution process, as well as the goal-oriented application processes. Analogical thinking is a useful input for logical thinking, while the use of metaphors, is one of the most fruitful ways for generating new ideas, new perspectives and new hypothesis that can be further tested by empirical studies and experiments.

Meanwhile, young leadership needs to be developed and dedicated training is required to

instruct new leaders into effective knowledge management. Delft University of Technology has developed a unique Executive Master program for aspiring leaders in the Oil & Gas business, which includes personal skills development, strategy thinking and direction-setting for effective leadership. The ideas put forward here have been developed for the goal-oriented mind of engineers that need to fuse their detailed technical expertise with integrative management skills. More information on the Delft and Energy Delta's Executive Master program is found in dedicated publications on the program philosophy [24, 5] and at the following website: <http://www.energydelta.nl>

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7. REFERENCES

- [1] G. Allison and Ph. Zelikov, **Essence of Decision** (Explaining the Cuban Missile Crisis), Addison Wesley, 1999.
- [2] R. Axelrod, **The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration**. Princeton, N.J.; Princeton University Press, 1997.
- [3] R. Weijermars, **Building Corporate IQ**, Amsterdam, Alboran Science Publishing, 2008.
- [4] R. Weijermars, “**Intelligent Decision-Making in the Petroleum Value Cycle**”, *Petroleum Africa Monthly*, October, 2004, pp. 70-72.
- [5] C.F.M., Bos, “**Optimizing the Value Chain of the Upstream Oil & Gas Industry – Why we need a new approach to training.**” *Petroleum Africa Monthly*, August, 2004, pp. 52-58.
- [6] M. Masuch and M. Warglien, **Artificial Intelligence in Organization and Management Theory**, Amsterdam, The Netherlands: Elsevier Science, 1992.
- [7] L. Argote, **Organizational Learning: Creating, Retaining and Transferring Knowledge**, Norwell, MA: Kluwer, 1999.
- [8] B. McKelvey, “**Emergent Strategy via Complexity Leadership: Using Complexity science & adaptive tension to build distributed intelligence, in Complexity and Leadership**”, Volume I: Conceptual Foundations, pp 225-68 , 2008, see ref [21].
- [9] R. Weijermars, V. De Jong and K. Van der Kooi, “**Cultural challenges in oil and gas industry management**”, *World Oil*, vol 229, no. 4, 2008, pp. 223-228.
- [10] J.-P. Cointet and C. Roth, “How realistic should knowledge diffusion models be?”, **Journal of Artificial Societies and Social Simulations**, 10(3), 2007, pp. 1-13.
- [11] G.S. Becker, **Human Capital**, 2nd ed. Chicago, IL: University of Chicago Press, 1975.
- [12] R.S. Burt, **Structural Holes: The Social Structure of Competition**, Cambridge, MA: Harvard University Press, 1992.
- [13] V. Allee, **The Knowledge Evolution: Expanding Organizational Intelligence**, Butterworth-Heinemann, 1997.
- [14] V. Allee, **The Future of Knowledge: Increasing Prosperity through Value Networks**, Butterworth-Heinemann, 2003.
- [15] D. Zohar, **Rewiring the Corporate Brain**, San Francisco, CA: Berrett-Koehler, 1997.
- [16] I. Janis, **Groupthink: Psychological Studies of Policy Decisions and Fiascoes**. Houghton Mifflin, 1983.
- [17] R. Weijermars, “**Convection experiments in high Prandtl number silicones**”, *Tectonophysics*, vol. 154, 1988, p. 71-123.
- [18] R. Weijermars, “**New laboratory method for analyzing deformation and displacement inside creeping fluid: Examples from Stokes flow and a thermal plume,**” *Journal of Geophysical Research*, vol. 93, 1988, p. 2,179-2,190.
- [19] D. E. Stokes, **Pasteur’s quadrant: Basic science and technological innovation**, Washington DC, *Brookings Institution Press*, 1997.
- [20] J.K. Hazy, J. Goldstein & B. Lichtenstein (eds). **Complex Systems Leadership Theory**. Mansfield, MA: ISCE Publishers, 2007.
- [21] M.Uhl-Bien & R. Marion (Eds.), **Complexity & Leadership, Volume I: Conceptual Foundations**. Information Publishing Associates, 2008.
- [22] C. Argyris, **Personality and Organization**, New York: Harper Collins, 1957.
- [23] L.K.Comfort , “**Self-Organization in Complex Systems**”, *J. Public. Adm. Res. Theory*, vol 4, 1994, p. 393-410
- [24] A.J. Berkhout, C. F. M. Bos, P.K. Currie, and R. Weijermars, “**Executive Education for Oil and Gas Professionals**”, *SPE Talent & Technology*, Vol.2, No. 1, 2008, pp. 6-9.