MANAGING ENGINEERING AND TECHNOLOGY BASED ORGANIZATIONS

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INTRODUCTION

Basic management practices appear similar across different kinds of industries and organizations. Looking closer, Research & Development organizations show some unique characteristics and the management of such organizations therefore also involves some unique challenges. One is simply the need to make room for innovation and manage technology cycles. Another is the need to maintain both structure and agility in New Product Development, which may appear contradictive. Also, the basic operational characteristics of *innovation* and *new product development* are different and therefore require different approaches in management.

R&D managers need to strike a balance between such opposite aspects as e.g. learning and teaching, creativity and conformance, people and process focus and guide organizational transitions between these different modes of operation. Another example of this is the shift from feature engineering to value engineering that typically occurs during the life cycle of a product.

Latent needs, requirements for future products and services and emerging market and technology developments are present as largely tacit knowledge inside and outside the firm.

Leading innovation occurs when firms are able to turn this emerging, tacit knowledge into new products and services and successfully bring these to market ahead of competition. This is not particularly easy and that in turn is why only a few firms can truly call themselves leading innovators.

Like other organizations, R&D organizations need to perform. In general, organizational performance involves characteristics such as productivity, effectiveness and efficiency. In knowledge organizations, and particularly in R&D, these characteristics don't always directly translate into performance measurements or into items that can be easily accounted for.

R&D managers must therefore pay particular attention to organizational performance management and do what all managers need to do – find ways to maximize the return on all assets they control.

THE NEED TO INNOVATE

Two capabilities seem to be of particular importance for companies that wish to be truly innovative - the ability to *recognize great ideas* and *see game changing opportunities*. But if an idea is really great, why wouldn't it be recognized? And if a significant new opportunity presents itself, why wouldn't it be vigorously pursued? One reason could be that ideas and opportunities are not initially seen at their full potential and therefore appear too tiny compared with current business.

Another reason for not recognizing breakthrough opportunities might be that most traditional investment cases work best with new core business products and services in existing or slowly developing markets. The reason simply being that more (and more accurate) information is available for estimates. Still, companies need to keep looking for innovation opportunities. And they need to look in three directions.

When companies look forward, they not only try to imagine the possibilities of the future, but they also build confidence in the face of uncertainty and stimulate more creative contributions.

When companies look around themselves, they may see new needs and growing incongruities and may find new ways to create value through existing or emerging technologies.

When companies look deeply at themselves, they discover their true core competences and may find new ways of being innovative and making breakthroughs happen.

In doing so, it is not the *need* to innovate that is new. It's rather the rate and precision at which innovation must happen that is of prime concern.

The following reasons seem to be the most common why a firm may need to increase its innovation effort:

- The firm's growth targets require new products, services or markets
- The portion of the firm's business from new products or services is too small
- The return on new product or service development is insufficient
- The firm is not sufficiently competitive in existing markets and technologies
- The firm is not proactively engaging emerging technologies and markets
- Future scenarios indicate significant threats to the firm's position in the market

There may also be additional conditions indicating or predicting weak performance:

- The firm is losing reputation as a leading innovator
- The firm is losing critical or cutting edge knowledge
- The firm is not attracting new top talent in research & development

If left unaddressed, conditions like the ones above inevitably translate to an innovation gap that can be expressed as a future loss of revenue or putting additional revenues at risk. It's obvious that the R&D organization plays a key role in securing a firm's future competitive market position.

MODERN R&D

Firms are often viewed through their legal and organizational frameworks or through their product and service offerings and traditional management practices focus on the capacity to execute. Equally important views, however, include strategy, business recipe, organizational competence and knowledge base as well as capacities for innovation, learning and change.

Building such capacities, or intangible assets, is of prime importance in managing the R&D enterprise and to a large extent determines its performance.

Today most new product development (NPD) organizations have established a set of standard practices. This basically involves managing explicit customer requirements and applying investment analysis and risk management techniques to product and project portfolios as well as the use of a defined work methodology to manage individual projects.

This approach, however, does not quite guarantee that innovation will be successful. Latent needs, requirements for future products and services and emerging market and technology developments are present as largely tacit knowledge inside and outside the firm.

Contemporary NPD organizations therefore need to add the <u>a</u>cquisition, <u>c</u>reation, <u>t</u>ransfer and <u>s</u>haring (acts) of knowledge to their standard R&D practices. This implies not only the introduction of Knowledge Management (KM) technologies, but also an increased need for understanding human capital and social engineering issues and a process design philosophy that recognizes workflows on the organizational level as well as the crucial role and activity of the individual knowledge worker.

Overall, like any other organization, the R&D organization needs a productive work environment and an effective system of management.

MANAGEMENT SYSTEM

Fig 1 - The MENTOR framework: Turning a knowledge based strategy into a high performance operation

The main purpose of a Management System is to introduce structure and method in the discipline of management.

MENTOR (managing engineering and technology based organizations) is a framework for turning a knowledge-based strategy into a high performance operation, specifically designed for contemporary R&D organizations. Figure 1 shows the main components of the framework.

Strategic Management involves those management systems and activities which enable an organization to consistently act with strategic intent, e.g.

• Focusing effort
• Creating organizational alignment
• Looking for early warning signs
• Navigating through inflections (change)
• Closing innovation gaps

In addition to being forward looking, strategy must involve intent, objective and deliberate choice. Making wise choices requires that information,

knowledge and competitive intelligence feed into the strategic management process.

As a consequence, strategy not only asks for a vision or a future wanted position, but must continuously answer basic questions like what is happening, why is it happening, how should we position ourselves and what capabilities do we therefore need to preserve or develop?

Given that both vendors and customers operate in complex organizations dealing with complex products deployed in complex environments, the importance of using some level of *systems thinking* and some degree of *scenario planning* needs to be emphasized.

A broad and close relationship between the Market and R&D functions of an enterprise is critically important for innovation and most commonly used macro indicators for product development success include market share, market share growth and time to market/new products.

Even though management is rarely practiced as a systems discipline it is helpful to view various management activities as part of a bigger system.

Most enterprises are held together both by legal construction and by strategy. Interpreting strategy into annual goals and allocating resources to the pursuit of these goals are key responsibilities of management. In times of change and uncertainty, these tasks become particularly challenging and in such circumstances it would be important to focus on communication, information, knowledge and intelligence related activities. As such activities are typically people rather than process centric, effective managers must add human capital management and social engineering to their skill set.

International quality standards like e.g. ISO 9001 require that elements of management systems be documented. The purpose of this is twofold - it requires the system to be specified and it allows for independent assessments.

It's important to keep in mind that the management system, in addition to defining the operational structure, is not a set of documents but a set of practices (some of which may need to be documented).

Fig 2 - The MENTOR framework: General structure of a Management System

One of management's responsibilities is to assess its own effectiveness.
As indicated in figure 2, one aspect of this is to perform *management reviews*. These are focusing on assessing the suitability and effectiveness of the management *system* by answering the following questions:

- *Is the system designed to meet the needs of the organization (complying with the chosen standard/specification/expectation)?*
- *Is the system doing the job?*

A set of key business indicators are often used to determine the performance of a management system. The original idea with the balanced scorecard (BSC) concept was to provide management with a *balanced* view of the operation involving both financial as well as non-financial issues.
The BSC has been widely used in management for a long time. That doesn't mean that all score cards have been well designed. In fact, applying the BSC as a management method involves a number of considerations as outlined below.

A well balanced scorecard includes:

- intuitive and actionable goals
- actions, not just expected outcomes
- non-arbitrary and non-conflicting targets
- critical success factors to reach strategic goals
- competitive information and industry benchmarks
- financial/non-financial areas
- leading/lagging indicators
- hard/soft measures
- strategic targets
- stretch goals

At the same time, a BSC that is too complicated risks being less used where it is most needed – in senior management. It would be wise to conduct reviews with the help of a skilled facilitator.

Nevertheless, the implementation of a world-class balanced scorecard involves more than just documenting various indicators and targets.

It also requires a strategic management function and a performance measurement system as well as capacities for innovation, learning and change. Building such capacities, or intangible assets, is of prime importance in managing the R&D enterprise and to a large extent determines its performance.

JUDGING R&D PERFORMANCE

Fig 3 - The MENTOR framework: NPD functional architecture

R&D performance is an interesting, but complex, issue. There are three perspectives on performance – how to measure (or judge), how to manage and how to account for R&D. One single measure of R&D performance is rarely feasible. Multiple measures are certainly better and also increase the ability to take appropriate action on various outcomes.

Judging the performance of the enterprise shown in figure 3, and therefore the effectiveness of its design, would have to include questions like

- *How good are we at complex problem solving?*
- *How well do we manage knowledge and information?*
- *What level of expertise do we have in project management?*

Answers to such questions can then be used to guide efforts involved in e.g. determining the scope and staffing of a project office, the use of communities of practice for collaboration and knowledge sharing or the introduction of a coaching and mentoring program for project managers. In this way a mission centric approach will help build appreciation of knowledge. It will also increase the understanding of the role of knowledge in the business and the flow of knowledge in the business process.

The previously often used stage gate model for new product development was basically designed for controlled execution and management oversight of medium to large projects, but is generally weak in addressing organizational learning, speed and agility. The basic stage gate model therefore needs to be complemented by mechanisms for learning and knowledge sharing, collaboration, design thinking and fast execution. After all, it's not getting projects through internal gates that matter most, but rather winning in the marketplace.

The organizational value of investments in human and social capital depends on the value of satisfying specific related needs. This means one would have to estimate the benefits associated with e.g.

- finding information
- getting access to expertise
- learning in key disciplines
- increased collaboration
- improved knowledge sharing

This is not a particularly easy task, but it can be facilitated by having a structure in place that shows how the intangible assets of an enterprise support the ultimate creation of value – the enterprise fulfilling its mission.

A well performing enterprise is one that plans well *and* executes well. The increased importance of intangible assets has impacted not only how companies are being valued, but also how their organizational performance platforms are engineered.

Modern enterprises should carefully examine their strategic management framework as well as their business process design from new perspectives. The strategic management function must identify how different components contribute to a knowledge based strategy and high performance operations in the product development environment.
Managers must therefore equip themselves with a wide range of knowledge and skills and be aware of what actually drives not only the business but also the organizational performance of the enterprise for which they are responsible.

The high performance R&D organization is:

- Resource, knowledge and expertise enabled
- People focused and socially engineered
- Technology savvy and information rich
- Cost conscious and quality minded
- Competent and motivated
- Agile and responsive
- Delivery committed

Execution of key disciplines, while drawing on these capabilities, will determine the overall performance of the organization.

Many organizations simply account for R&D as cost and judge performance accordingly – i.e. as cost efficiency. Others try to look at productivity or profitability and judge performance as output over input or as return on effort. The basic challenge lies in the nature of the function. The development of new products and services is fundamentally different from producing or delivering existing ones.

The general notion of good performance involves the delivery of products and services with quality, on time and within budget.

Charging work at an hourly rate may encourage the production of more hours, impairing performance but improving revenues. Conversely, R&D can stay within budget by simply cutting back on content or deferring projects, thus improving cost efficiency but impairing revenues (and reputation).

Innovation management surveys repeatedly confirm that many organizations continue to struggle with managing and measuring innovation. Executives typically indicate that the most commonly applied innovation measurements are revenue, profitability and customer satisfaction, none of which are particularly innovation specific.

Of course, some firms have added more innovation specific indicators, adopting a balanced set of innovation metrics covering *input*, *process* and *output*:

- Number of new ideas
- Business Unit investments in innovation
- R&D % of sales
- Idea to decision time
- Decision to launch time
- Total projected NPV
- Patents granted
- New product launches
- New product sales and profits % of total
- Innovation ROI

Unless they make a special effort to engineer their metrics for innovation, companies typically use what's most easily obtained from their R&D organizations or what's already being tracked by accounting and by customer or sponsor surveys.

Also, not many companies use highly sophisticated metrics or statistical methods in the area of innovation performance – and to some extent rightfully so. After all, and despite the need for good metrics, it's probably more important to *do* innovation than to measure it.

ORGANIZATIONAL DEVELOPMENT

The purpose of organizational development is to ensure that the resources and capabilities of an enterprise are developed, organized and managed in an efficient way and in support of strategy and business objectives.

A *knowledge organization* is simply an organization that performs knowledge work, whereas a *knowledge based organization* effectively integrates knowledge with its strategy. A *learning organization* is one that undertakes transformational change and significant improvement in response to new challenges.

Improvement can be viewed either as part of strategy or as a necessity in case capabilities to address a given business challenge are not present.

Improvements directed towards product development capability must be closely aligned with the needs of core disciplines such as e.g. project management and software engineering.

One should keep in mind though that it is not really improvement activities per se that are important, but a *sustainable high performance*.

At any rate the notion of improvement is sound and must not be ignored.

After all, it is *innovation* and *improvement* that take an enterprise beyond business as usual and therefore improvement needs to be an active and clearly visible component in organizational development.

An improving enterprise is one that continuously creates advantage. An improving enterprise is one that is aware of choice and understands the impacts of its decisions. An improving enterprise is one that participates in the shaping of its own future. There is certainly no shortage of industry experience to draw from nor is there any lack of concepts to choose from. There is, however, always a risk to end up developing the *technology* of improvement and managing improvement *projects* while losing sight of improvement itself.

R&D organizations must show excellent performance on existing technology management responsibilities, focus on cost & efficiency and be creative and innovative to secure future earning potential – all at the same time.

Performance excellence is the result of an interrelated effort involving people, process, technology and content. Effective R&D organizations usually exhibit the following characteristics:

- Understanding the Business Environment
- Maintaining a reasonable Planning Horizon
- Managing Product and Project Portfolios
- Focusing Innovation Efforts
- Managing Resources
- Continuously assessing business cases and project risks

In addition, effort must also be made to build and leverage human capital and establish close relations between the Market and R&D functions through:

- Open and effective communication
- Mutual understanding of the respective areas
- Agreements regarding the "rules of the game"

Rules of the game would typically include e.g. how customer commitments are made, how risk is managed and how changes are made to project content. This requires a good connection between the R&D and Marketing functions within the company.

In particular, R&D and Marketing could engage in knowledge exchanges and joint learning activities with the following objectives guiding the effort:

- Increase the quality and precision of market offerings
- Accelerate the uptake of new product and technology knowledge in market operations
- Help broaden and deepen the knowledge of markets, products, customers and competition throughout the organization
- Enrich the customer dialogue and facilitate the sharing of market knowledge and competitive insight between key accounts
- Improve the efficiency and effectiveness of marketing as a business process through organizational learning and the sharing of good practice

Effective sharing of best practice should be controlled by a vetting process involving *recognized expertise*. Vetting tries to answer the following questions:

- *What constitutes best practice?*
- *Which practice is the best?*
- *What specifically makes this practice the best?*
- *Is this practice most suitable for sharing?*
- *What conditions must exist for effective sharing of this practice?*
- *What actions are necessary if the required conditions are not present?*

It is worth noting that in areas where efficiency is the prime concern, standardization of practice may be a good way. However if learning and innovation are important considerations, standardizing ways of working could actually become an obstacle to improvement.

It is wise for managers to exercise some caution. What has worked in similar situations in the past may very well work again. But only if the current situation actually *is* similar. And if past successful outcomes occurred because of the way situations were managed and not for other reasons or under circumstances that cannot be replicated.

Abductive reasoning is persuasive. But it's not always the fault of managers that managerial thinking sometimes goes wrong. Organizations should make sure that decision makers have timely access to the knowledge and expertise they need. That's a good reason for learning how to work with knowledge.

Creating collaborative knowledge sharing environments to leverage tacit knowledge and digital assets is critical in deploying effective Knowledge Management (KM) solutions. In addition, these solutions must be integrated with key business processes to ensure the creation of additional organizational value. In fact, it's when knowledge challenges generally held beliefs and when expertise challenges authority, that companies are put to the test – whether they can learn and change or whether they cannot.

Possibly the most striking characteristic of the learning organization is that so few actually exist. Organizational learning is about fundamental capability and long-term business performance, which are difficult to keep on the business agenda in times of rapid change and financial challenges.

The most common reason for organizational learning deficiency is simply lack of time. Project deadlines and customer commitments take precedence over reflection and learning. There is a mutually dependent relationship between learning and improvement such that they are both in certain respects a prerequisite for one another. If e.g. 100% of lead time improvement is allocated back to lead time capability, there may be no reduction in the probability of being late in product development or no improvement in product quality.
Organizations that are highly streamlined, optimized for efficiency and heavy on processes usually have a bigger difficulty with learning and change than organizations with the opposite characteristics.
Maintaining the right balance is a difficult challenge. Being aware of the issue is at least a first step towards finding the best way forward.

As the underlying purpose of R&D is to create future business, it follows that the capacity and competence of the R&D organization is critically important to any firm that is concerned about its future.

The competence of an organization is largely defined by its performance and comes not only from the experience, knowledge and skills of its people but also from structural components such as information, processes, methods and tools. Competence is thus a *complex and dynamic capability* that can only be observed in action, rather than some sort of "substance" that is present to a larger or lesser extent in the organization.

Obviously organizational competence must rely on individual competence but also requires conditions, which allow and encourage people to perform.

Organizations in which fear dominates the psychological landscape or where behavior is strongly politically driven are not very likely to demonstrate superior performance.

Also, an organization focusing on developing new technologies in a turbulent business environment should not be judged by the same criteria as one that is involved in the continual improvement of an existing product line in a stable business environment.

An organization should certainly be aware of its own weaknesses and make effort to improve. In order to excel it must, however, primarily draw on its strengths.

At any rate, the competence of an organization should be viewed as a *demonstrated capability*, which can be interpreted into *expected performance*. Competence is therefore a major part of an organization's overall value proposition.

SMART R&D

New Product Development (NPD) is a complex, high value undertaking with significant uncertainty and risk involved. Expertise is obviously an important enterprise asset that needs to be engaged and brought to bear on key product and technology issues. Experts and master practitioners thus play important roles in high-performing technology firms.

At the same time, managing creativity, learning and expertise has remained a challenge also to organizations which have adopted traditional Knowledge Management practices. Many have continued to experience less than expected returns on their knowledge assets. Valuable as it is, like tacit knowledge, expertise is also intangible and volatile.

With a proper understanding of expertise and expert behaviour, NPD organizations will be better equipped to make deliberate use of their expert resources. Conversely, with insufficient or less utilized expertise, organizations may be under-performing in key disciplines and ultimately fail to deliver on their mandates.

As knowledge and expertise are different in nature, organizations need to go beyond traditional Knowledge Management practices and find ways to also learn, use and retain deep domain expertise.

Domain expertise is acquired through deliberate practice, i.e. professional work involving self-observation, feedback, reflection, learning and improvement. Learning expertise thus involves not only the accumulation of knowledge through study and experience, but also the development of meta-cognitive skills. Deliberate practice leading to domain expertise typically also includes a repeated involvement with new challenges and complex problems. Individual performance improvement as a function of time may of course vary and talent plays a role as well in the pursuit of expertise.

The need for deliberate practice suggests that expertise develops in learning organizations. Firms therefore need to create and maintain conditions conducive to the development and growing of professional expertise and capitalize on this opportunity by also applying the necessary organizational learning techniques. This implies that "Smart R&D" organizations should not only master technology, but also need to develop their social engineering skills. Experts not only need to deepen and grow their own expertise, but also need to build and maintain productive relationships with managers, practitioners and other experts.

With the help of appropriate measures, organizations will be able to orchestrate a *productive interplay* between creativity, expertise and management – the most important organizational characteristic of well performing, innovative enterprises.

ABOUT THE AUTHOR

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