Strategic knowledge management in aerospace industries: a case study

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Abstract
Purpose – The objective of this paper is to develop a model for planning and establishment of knowledge management (KM) strategy in one of the Iranian Sub-stream Aerospace Industries Organization to improve company's performance.
Design/methodology/approach – This research tries to use multi-method approach by integrating balanced score card, which is a renowned strategic management approach, and Nonaka and colleagues' knowledge creation process (socialization, externalization, combination, and internalization model), which is a well-known knowledge creation and conversion model, being adopted as the foundations of strategic knowledge management model (SKMM).
Findings – The analytical approach identifies eight issues as critical success factors of the knowledge strategy map in this case study. The overall results from the case study are positive as well, thus reflecting the appropriateness of the suggested SKMM model.
Research limitations/implications – SKMM can be used to help forward the plan, establishment and evaluation of KM strategies and initiatives. This helps to ensure that the essential issues are covered during design and implementation phases of KM strategies.
Originality/value – This paper further provides an integrated perspective of KM metrics in high-tech industries including the aerospace industry. It gives valuable information and guidelines that hopefully will help leaders to consider important issues during performance measurement of KM strategies in organizations.

Keywords Knowledge management, Strategic planning, Aerospace industry, Iran

Paper type Case study

Introduction

"Knowledge is power", particularly in the current era. No matter what you name it as cooperation, decision support, knowledge management (KM) or some other thing – that is the fundamental principle which supports nowadays' corporate strategies (Jafari *et al.*, 2009). There are various definitions about KM in the literature. Quintas *et al.* (1997) state that:

> Knowledge management is the process of continually managing knowledge of all kinds to meet existing and emerging needs, to identify and exploit existing and acquired knowledge assets and to develop new opportunities.

There are various models for management of knowledge and intellectual capital (IC) (Mertins *et al.*, 2003; Nonaka and Takeuchi, 1995; Wiig, 1997). But, they have some shortcomings in describing the way KM can be established in real world. In other words, they show an extremely general manner while they have inadequate tools for effective KM strategy development (Tat and Hase, 2007).

In addition to contributions to the economic and national pride of any country, the aerospace industry manufactures high-value-added artifacts and works as a knowledge base for other industries. KM in aerospace systems, can be found in communities and groups, that are acting diverse functions in design and development activities (Holm, 2005). Recently, aerospace firms are characterized by complicated technology equipped with expensive machinery and a large number of experts. Consequently, practical know-how should be totally precise. Like other corporations, majority of aerospace firms are trying to outsource more and focus on their own core competencies. Therefore, it seems that KM is in the center of attention in most of these companies (Jafari *et al.*, 2007a). It is striking that, providing an environment which promotes organizational learning and encourages positive changes towards it has been reported as core component in knowledge-intensive organizations (Akhavan *et al.*, 2006; Lin and Kuo, 2007).

Aerospace Industries Organization (AIO) is a serious component of Iran industrial core, since it employs a large number of highly paid, highly skilled workers in knowledge-intensive jobs. AIO have a valuable source of knowledge, product, and process technologies and complicated manufacturing. Design and development of products in AIO rely on the productive use of a lot of employees who have combinations of education, skills, and experience. Having said that, AIO can be categorized as a knowledge-intensive organization. From past ten years, Iran has been seeking a master plan to capture the space by launching national satellites. AIO leaders have faith in KM to prevent them from reiterating their mistakes. Also, they believe that it can help them to learn from their achievements and grasp their vision about capturing the space. Considering aforementioned reasons, a KM program has been initiated in various sub-stream companies of AIO. In this way, one of the most important aims of this study is to provide an explanation about strategic management of knowledge in such a knowledge-intensive organization.

Despite the fact that too much literature has been published about KM as a whole, and many recommendations exist about linkage between KM, corporate strategy and organizational performance (Bontis *et al.*, 1999; Bose, 2004), not enough

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theory can be found about the influences of measurement on KM. Although there are many KM cases, a considerable number of them has been unsuccessful at effective management of knowledge (Choo and Bontis, 2002). Lacking a descriptive measurement report about KM programs, leaders cannot make sure about their effectiveness and obstacles to their progress. So, directors seek ways to assess the influences of KM attempts on firm's performance. It is necessary to use acceptable universal measures in order to express the outcomes of KM and to persuade directors about its value. Despite advancement of KM measurement approaches during these years, it is necessary to pay more attention to this subject and try to develop and standardize these methods (Bose, 2004; Mertins *et al.*, 2003).

It is time to define the core research question which is:

RQ1. In which way a corporation can establish a KM strategy to advance firm's performance?

Useful knowledge strategy can assist aerospace industry in collecting key knowledge, enhancing firm intelligence and improving its core competencies. So, a KM strategy was scheduled in one of the Iran Sub-stream Aerospace Industries Organization (SAIO). This paper is to discuss management of knowledge strategy in one of the SAIO. Core objectives of this research are:

- Developing a model for planning and implementing KM strategy in combination with balanced scorecard (BSC) approach (Kaplan and Norton, 1992) and socialization, externalization, combination, and internalization (SECI) model (Nonaka and Takeuchi, 1995).
- Implementation and analysis of the developed model in one of the SAIO.

Knowledge management

It is time to identify the differences between data, information and knowledge. Data are raw happenings, with no meaning. Information can be considered as data with given meaning via relational link and context. Knowledge can be seen as information with direction for action on the basis of insight and experience (Lillrank, 2002). Considering the differences between data, information and knowledge, this paper takes ideas from Polanyi (1966) to define tacit and explicit knowledge. Tacit knowledge is related to individuals' private skills, backdrop, and learning characteristics, and so it is difficult to record. Explicit knowledge denotes knowledge which can be easily articulated, transmitted, and documented. We define KM as a collection of organizational activities which assists forward identification, catch, organization, storage, transfer, application, and measurement of knowledge and speeds up knowledge creation with respect to organizational strategy.

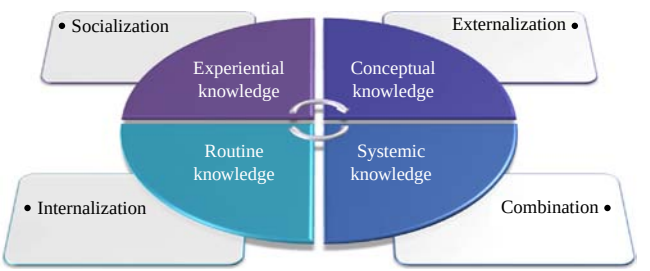
Management science is well-known due to its fashions and fads. Some researchers believe that KM can be seen like other management fads (Wilson, 2002; Ponzi and Koenig, 2002). Also some others emphasized that KM will never be a fad just in the circumstance that it can be correctly supported (Jain, 2009; Laycock, 2005). Also, some authors have criticized KM and/or suggested new directions for research. For instance, Wilson's (2002) perspective about KM just turns around hard features of KM like information management. In contrast with Wilson, some authors like Hildreth and Kimble (2002) argue that communities of practices (COPs) can be used to tackle this problem. Also, Nonaka and Konno (1998) recommend an impressive equivalent concept namely Ba.

Knowledge strategy includes considerations about the future knowledge needs and a plan for filling the gaps between current knowledge and required knowledge. Knowledge needs here may refer to the knowledge resources and desired knowledge for organization. There are different KM strategies such as: knowledge creation, knowledge transfer, knowledge protection, knowledge strategy as business strategy, intellectual asset management strategy and personal knowledge strategy (Bloodgood and Salisbury, 2001; Wiig, 1997). Each of these strategies above has its own advantage and disadvantage, but the knowledge creation strategy is the perquisite of the others. Knowledge creation acts like a vital armor in the globalized economy. In other words, it seems that knowledge creating is the most significant determinant of organizational efficiency degree (Nonaka *et al.*, 2000, 2005; Song, 2008). Because of this enormous consideration, knowledge creation is at the center of attention, and plenty of academic models have been conducted in accordance with it. So, we pursue this notion and are in agreement with SECI model about knowledge creation process (Nonaka, 1991). This model has been repeatedly utilized in various academic and practical situations (Chou, 2005).

Nonaka, in collaboration with some authors developed a comprehensive model to demonstrate process of knowledge creation in organizations in the early 1990s. The SECI model was initially presented in Nonaka (1991). But it was modified and developed for an extensive usage in his book in Nonaka and Takeuchi (1995). This model represents a dynamic interaction between two types of knowledge (i.e. tacit and explicit) in a spiral process, which helps knowledge to be improved by the way of interaction between individuals, groups, and organizations. In other words, cooperation between individuals and groups inside an encouraging organizational background creates knowledge and develops its value. A bit later, Nonaka and Konno (1998) also recommended the necessity to construct a suitable space where knowledge creation and transfer take place, namely Ba.

From Nonaka's viewpoint, knowledge is created and developed in a nonstop cycle of SECI (Figure 1). Socialization refers to creation of novel tacit knowledge by way of shared experiences. Instances of such a knowledge are skills and shared mental models. The outcome of such a process is named "experiential knowledge". Externalization refers to conversion of tacit knowledge into explicit one, so-called "conceptual knowledge". Examples are models, hypotheses, concepts, analogies or metaphors. Combination refers to

Figure 1 The SECI process



Source: Adapted from Nonaka *et al.* (2000)

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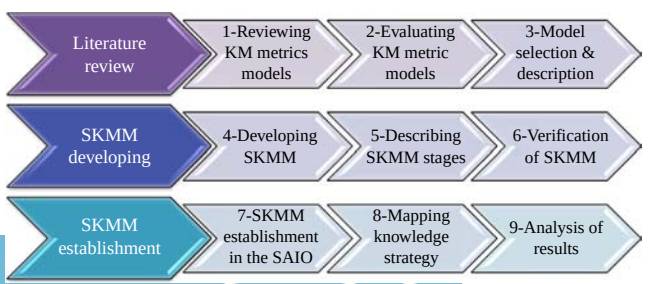
conversion of explicit knowledge into more organized and complicated collection of explicit knowledge, so-called "systemic knowledge". Samples are classifying, linking, adding and sorting explicit knowledge. And finally, internalization refers to changing explicit knowledge into tacit knowledge of individuals. Internalization creates "routine knowledge". Exercise, training and learning by doing are essential to adopt explicit knowledge. The SECI model, while widely used, has also been criticized. For instance, Hildreth and Kimble (2002) claim: "the flaw in Nonaka's spiral of knowledge is in the tacit-explicit stage." Some authors (Teece, 1998) believe that this is not a trouble and have a certain opinion that tacit knowledge is only hard to articulate. This paper tries to strengthen the impact of the knowledge creation theory and concentrates on social viewpoint of knowledge that simply exists in Nonaka SECI model.

Research methodology

Each research has its characteristics that help researcher to select an appropriate methodology. Based on the points discussed above, the authors' recent researches on KM (Akhavan *et al.*, 2006; Jafari *et al.*, 2007a, b), the research framework of this study has been developed on three main stages as shown in Figure 2.

In this way, at the first stage of this research, some measurement approaches and categories of KM and IC will be introduced. Then, we will focus on scorecard (SC) category based on its advantages among the other measurement approaches. The BSC method seems good for usage in the rest of research, so in the second stage the strategic KM model will be developed by integrating BSC with the SECI model. Note that in this model we want to replace the traditional four BSC perspectives with the four dimensions of the SECI model. The developed model is too complicated and so, it needs to describe in an explanatory manner. Also, we try to discuss verification of the proposed model, and seek to indicate the suitability of the model for the SAIO. In this way, a questionnaire will be designed to evaluate beliefs of AIO experts about basic elements of the proposed model. In the third stage, the proposed model will be implemented in the SAIO in a six-month period, and we seek to analyze the outcomes of its implementation. Finally, the results of research will be concluded in the end part and further studies will be proposed for all KM interesting organizations.

Figure 2 Research framework



Performance measurement methods for KM strategies

KM literature represents an extensive spectrum of KM measurement tools. Fairchild (2002) reviewed KM measurement methods and talked about the employment of BSC to define a relationship between KM utilization and IT strategy. Mitri (2003) noticed the difficulty level of tacit knowledge evaluation and its performance in education centers, and developed a decision support system for evaluation of tacit knowledge in a KM context. Smits and de Moor (2004) proposed an extensive approach to identify performance indices for KM in COPs. They provided an approach for measuring performance of COPs within a KM program. Hong-bing and Lei (2007) introduced a set of input/output measures for efficiency analysis of KM for project-based firms using data envelopment analysis (DEA) method. Chen *et al.* (2008) developed a method for appraising KM performance based on linguistic variables and fuzzy sets theory.

Knowledge evaluation approaches consist of a variety of methods and models for recognition, categorization and assessment of organizations' knowledge. Especially, IC can be used as a major notion to examine organizational knowledge assets. There are also a variety of methods and tools for evaluating IC. In the well-known categorization recommended by Sveiby (2001-2005), the available approaches to assess IC divide into four taxonomies including market capitalization methods (MCM), return on assets (ROA), SC and direct intellectual capital (DIC) Methods. MCM approaches are used to financially appraise the overall value of intangible resources. These methods evaluate IC in general, usually by way of the gap between the book and market value of the organization. ROA tools, assess the intangible assets by means of typical financial indices on the organizational level similar to the first group. The SC methods try to represent intangibles by way of non-financial indices. DIC models, likewise assess various IC taxonomies distinctly by means of financial measures (Sveiby, 2001, 2001-2005).

The monetary-based approaches like MCM and ROA are suitable for comparisons among firms in the same industry. In other words, these methods can be used to represent the monetary value of IC. In addition, since they are based on accepted accounting regulations, they are simply adopted between accounting practitioners. Their problematic condition is that by transforming anything into monetary values, the results will be superficial. Strength points of the SC and DIC tools refer to their abilities to represent a better inclusive depiction of organizational status than monetary-based measures. Furthermore, these approaches can be simply implemented at all levels of organizations while they represent more precise picture than financial indices. A variety of organizations including private, public, non-profit and non-governmental organizations, and also internal sections of organizations have found these methods useful. Their weaknesses refer to their contextual measures which change for every company and every intention, and this issue makes comparisons a little hard. Also, their emersion refers to a few years ago, and so they cannot be simply accepted by directors and practitioners who get used to analyze all performances financially (Sveiby, 2001-2005). Table I shows the comparisons between the explained four categories.

In addition to considerable advantages of SC methods which are shown in Table I, there are other considerations to adopt BSC for assessing KM strategy. First, BSC is a progressively

Table I Intellectual capital assessment approaches

Direct IC	Market capitalization	Return on assets	SC methods	Criterion
✓	X	✓	X	Ability to monetary appraisal (Sveiby, 2001-2005)
✓	X	✓	X	Ability to compare similar companies (Sveiby, 2001-2005)
X	✓	X	✓	Insensitivity to interest rate (Sveiby, 2001-2005)
✓	X	X	✓	Ability to use on any organizational level (Sveiby, 2001-2005)
✓	X	X	✓	Ability to represent knowledge status (Sveiby, 2001-2005)
✓	X	X	✓	Applicability for non-profit firms (Bose, 2004; Salterio and Webb, 2003)
X	X	X	✓	Being user friendly and flexible (Sveiby, 2001-2005; Groene *et al.*, 2009; Steele, 2001)
X	X	X	✓	Being popular (Bose, 2004; Salterio and Webb, 2003)

well-liked method for assessing organizational performance, and also it is broadly accepted in KM literature (Bose, 2004; Salterio and Webb, 2003). Second, BSC can be customized to carry out specific organizational strategic objectives (Groene *et al.*, 2009; Steele, 2001). Third, since BSC was presented in the early 1990s, numerous firms have been using it for systematically performance enhancement (Bose, 2004; Salterio and Webb, 2003). Fourth, BSC has been frequently incorporated in the other performance approaches, that can help us to use their experiences (Smits and de Moor, 2004; Groene *et al.*, 2009). Fifth, the resemblances between KM and BSC, make authors like Petty and Guthrie (2000) and Bontis *et al.* (1999), and another ones recommend that BSC must be an essential part of IC.

In the early 1990s, the BSC was just a performance assessment method (Kaplan and Norton, 1992). Then it upgraded to a strategy implementation approach in Kaplan and Norton (1996, 1997). At last, it raised to a higher standard which was a strategy management method (Kaplan and Norton, 2001, 2004). In other words, first, the concentration was on the basis of measure developments in four perspectives. These perspectives include "internal business processes", "customer", "financial", and "learning and growth". Then BSC progressively advanced and became a strategic management approach directed towards depicting "the process for transforming intangible assets into tangible customer and financial outcomes" providing "a framework for describing and managing strategy in the knowledge economy" (Kaplan and Norton, 2001). A standard BSC approach has stages like what comes after (Mountain State Group, 2005; Niven, 2003):

1 *Preparation evaluation.* Recognizing requirements and resources, and also verifying commitment of management.
2 *Programming.* Assigning workgroup's leader and participators; performing an examination about organization's mission, vision and strategy; allocating objectives to perspectives; creating strategy map; recognizing indices and taking collective agreement about the indices; and building execution program.
3 *Execution.* Entering objectives/critical success factors (CSFs) and indices into system by way of training or software; creating SCs; determining warning levels and criteria, data integration regulations; describing report templates; bringing in data; and producing reports.
4 *Incorporation.* Merging BSC with other supportive processes; communicating with personnel; assigning and empowering responsible persons for data gathering; explaining BSC aims; updating strategy; upgrading reporting system; and conducting some modifications to reward system.
5 *Routine function.* Upgrading data; analyzing and reporting in a regular process; upgrading measures; evaluating outcomes; preparing and distributing outcomes; and modifying process.

Developing SKMM

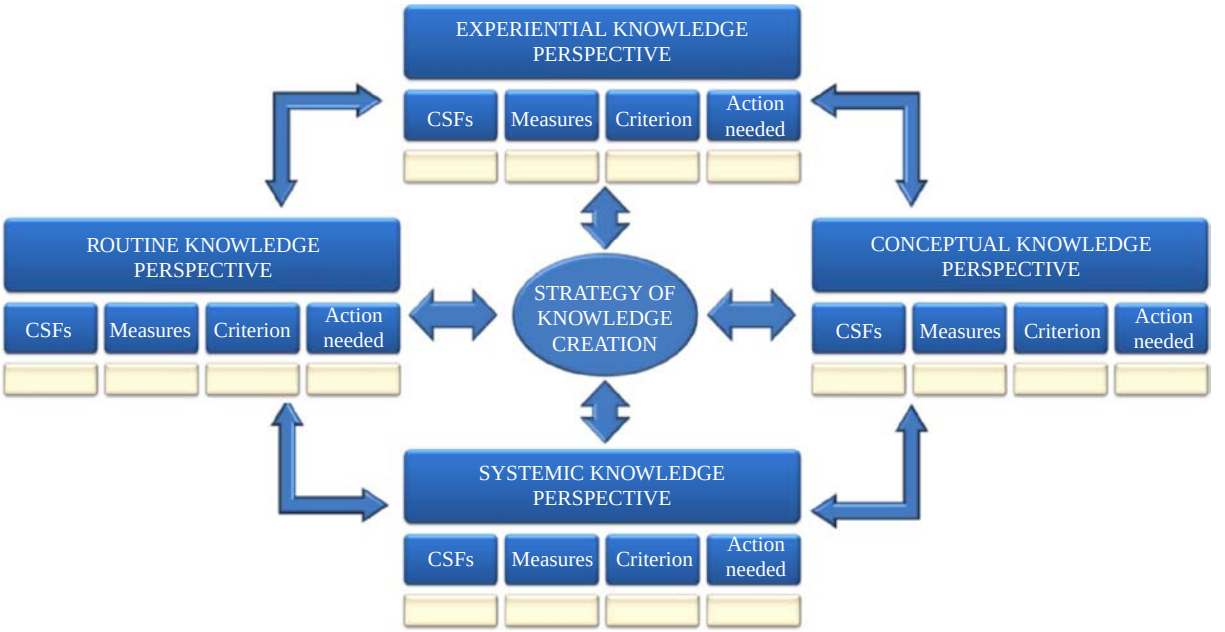
Explicit and tacit are two types of knowledge. Resemblance can be found between tacit knowledge and human capital. Also, there are similarities between explicit knowledge and structural capital. Experiential and routine knowledge are the main components of human capital. It is striking that, both of them are sub-classes of tacit knowledge. As well, systemic and conceptual knowledge are the major parts of structural capital. This and that together are instances of explicit knowledge. Structural capital includes intangible assets ready for use while personnel exit the organization like internal process/systems knowledge, procedures, knowledge bases, etc. Therefore, for setting up knowledge creation strategy, it is needed to expand knowledge in its whole dimensions, containing: routine, systemic, conceptual, and experiential knowledge (Smits and de Moor, 2004).

In this paper, authors have applied the four dimensions of SECI model instead of BSC terms for development of the new approach for measuring performance of knowledge creation strategies as shown in Figure 3. In the following, the activities of each stage of strategic knowledge management model (SKMM) will be defined (Kaplan and Norton, 1996; Mountain State Group, 2005; Niven, 2003).

Preparation evaluation

Includes recognizing requirements, identifying resources and verifying commitment of management. The first domain must think over is recognizing the necessity for establishing a SKMM. Some evaluations about existing performance indices can assist to recognize troublesome domains. There are some other issues which must be taken into account including existing resources in connection with available information technology infrastructure, proficiency and time of personnel, and cost of professional aid if necessary. Eventually, an important subject to consider is to make sure about the powerful commitment of management. It is obvious that, establishment of every performance enhancement process will denote change. Lacking a perfect management commitment, almost certainly all endeavors for alteration will be unsuccessful. SKMM establishment can cause important cultural alteration.

Figure 3 Strategic knowledge management model



Programming

Consists of assigning leader and participators for SKMM workgroup; performing an evaluation about mission, vision and strategy; allocating objectives/CSFs to SKMM perspectives, creating KM strategy map, recognizing indices and taking collective agreement about KM indices; and building execution program. While the SKMM workgroup is identified, an examination about the vision, mission, objectives, and strategies (include process or functional strategies) must be done. When the strategic plan is developed, KM strategy is checked to decide how it can make ready for the four SKMM perspectives. Maybe, a number of corporations find it necessary to supplement some other perspectives. However, we preferred to concentrate on these four perspectives. For instance, two comprehensive objectives "increase in internal systematic knowledge" and "increase in external systematic knowledge", can be categorized to fit in systemic knowledge perspective.

Taking KM strategy into account, then it is necessary to recognize CSFs of KM strategy and build a strategy map of KM. Rockart (1979) defined CSFs as "the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organization". A KM strategy map depicts how a corporation generates knowledge and represents CFSs in every KM perspective. A KM strategy map shows a chain of CSFs in order to achieve organizational KM strategy. It prepares an illustrative picture which displays the cause and effect relationship among different KM CSFs. The quantity of CSFs in a KM strategy map does not follow any strict and fixed standard. But it seems that fewer CSFs are usually better (Mountain State Group, 2005). According to Niven's (2003) suggestion, a limited number of CSFs especially more than ten and less than 20, seems good for a BSC process establishment.

Appropriate CSFs can give accurate explanation of the intention. A good selection can delineate for what reason the CSFs are essential, and also can explain in what way the CSFs join in the cause and effect chain. In addition, succinct CSFs can explain the particular objects an organization is supposed to do well to implement its KM strategy. Action verbs like raise, decrease, enhance, obtain, and those of the same type, are frequently used to describe CSFs. After formal approval of CSFs, and subsequent to KM strategy mapping, the following questions should be answered (Mountain State Group, 2005):

- Have all the essential components been considered? Does the KM strategy map show a sufficient cause and effect reasoning?
- Have all the components set up rationally? Does the reasoning seem abstractly logical?
- Do the CSFs guide us to successful implementation of the KM strategy?
- Is there a balance in our attempts to attain the KM strategy?

Akhavan *et al.* (2006) and Jafari *et al.* (2007a) by examining various references, identified some critical dimensions that can be used in selecting KM CSFs as showed in Table II.

With no KM strategy map, it is really hard to explain KM strategy modifications. Figure 4 is a diagrammatical depiction to illustrate how a KM strategy map can be built. Every organization should first consider its KM objectives and strategy, and then create a suitable map. After the creation of map, it is time to identify particular indices which can be utilized to follow achievement of KM CSFs. A SKMM is supposed to contain a mixture of lead and lag indices. Lag indices measure the outcomes of process, when lead indices measure improvement in the direction of the process (Mountain State Group, 2005).

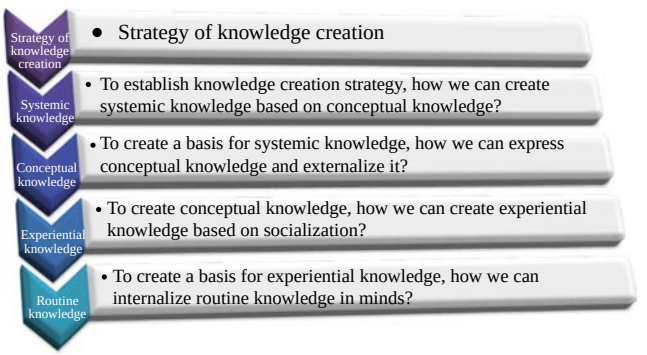
The fundamental purpose in choosing particular indices for a SC is detection of the indicators which are best suited for the KM strategy. After the indicator selection, the SKMM workgroup had to expend time to purify the indicators, allocate responsible persons, and determine data necessities. In this stage, it seems fine to collect personnel opinions about the suitability, feasibility, and rationality of the indicators (Mountain State Group, 2005).

Table II KM CSFs

Experiential knowledge	Conceptual knowledge	Routine knowledge	Systemic knowledge
Internal interactions	Specialized meetings and seminars	Specialized training man-hours	Internal systemic knowledge
External interactions	Communities of practice	Number of experience years	External systemic knowledge
Trust and organizational culture	Knowledge sharing	Utilization of knowledge repository	Knowledge repositories
Employee's involvement and understanding – awareness	Risk-taking climate in the organization	Employees training and educations	Knowledge architecture
Support and commitment of CEO (leadership)	Flexible and dynamic organizational structure	Continuous learning	KM systems
Benchmarking	Integration of KM and current systems	Job enrichment	Knowledge structure
Team working		Job security	IT infrastructure
Collaboration and communication		Human resources management and motivation	Systematic approach to KM

Sources: Adapted from Akhavan *et al.* (2006); Jafari *et al.* (2007b)

Figure 4 Knowledge creation strategy map



After general agreement on the indicators, SKMM workgroup should try to set up targets for the indicators. A lot of KM indicators are available for organizations to choose. Considering four SKMM perspectives, these indicators may be like those in Table III. Indicators must be selected for each of the perspectives agreed upon. Owing to time-consuming nature of data gathering for each measure, it is necessary to reduce the number of measures to less crucial ones which have the following characteristics (Mountain State Group, 2005):

- connected with the organizational KM strategy;
- not difficult to understand;
- can be joined together in an action and reaction chain;
- can be upgraded regularly;
- draw a factual depiction of the process which you are trying to control; and
- reachable, measurable, and practical.

Table IV is an easy way to evaluate if your indicators are fine nominees for a SKMM establishment. Table IV can be also supposed as a work sheet for evaluating the appropriateness of selected KM measures. So, you should assign a score between 1 and 10 for each item listed in Table IV. Then, the sum of scores for each measure should be calculated. Finally measures with the best scores can be selected for each CSF. The scores of measures for each CSF could be between 5 and 50. As mentioned before, if ever consensus on the indices has been obtained, the SKMM workgroup can establish targets for the indicators.

Providing a program for SKMM implementation is final step in the programming stage. This program must represent activity costs, anticipated milestones, risk assessment, a declaration of IT, SKMM components, and obvious recognition allocated persons. Also, the program must show in what way the SKMM data is exchanged all over the firm and how critiques of personnel can be acquired and incorporated. The program should represent the foundation for the execution and incorporation endeavors.

Execution

An obviously well-made program must determine organization's information technology infrastructure, and also its abilities and restrictions. For better data collection, it is necessary to make required modifications in your IT infrastructure based on risk assessment outcomes. Purchasing a BSC software package is a choice for organizations which are preparing for the execution stage. A number of packages can be found with the purpose of BSC which can support the whole process. A list consisting of 15 different BSC packages can be found at 2GC Company's web site (www.2gc.co.uk/). Also, applications of MS Office software like Access and Excel can really help those organizations which do not have enough budget for purchasing standard BSC software packages.

A SC is a table which illustrates perspectives, CSFs, measures, targets, warning points, and initiatives or actions needed. A good SC should help users to identify information integration regulations, design diagrams and reports, and bring in past data. Various reports should be provided for different organizational audiences. For instance, it is best to present all information about SKMM perspectives in a graphical report for management level. Personnel report should contain any information connected with knowledge processes like knowledge creation and knowledge sharing. Reports for board of directorates are more concise than the manager's report. It is obvious that, the SKMM workgroup has a responsibility to help different departments and groups to define their reports and SCs (Mountain State Group, 2005). An illustrative report for top manager of SAIO can be seen in Figure 6.

Incorporation

It seems that communicating is the most important feature of the incorporation stage. In this stage, all participants in SKMM workgroup and the whole managers and personnel

Table III Sample measures for SKMM

Experiential knowledge	Routine knowledge	Systemic knowledge	Conceptual knowledge
Direct communication links	Investment in training	Number of bytes of project documents	Number of bytes of project meetings records
Non-assigned working time	Training expense/administrative expense	Number of registered experiences of personnel in knowledge repository	Percentage of hours assigned to project meetings
Regulated socialization	Training expense/employee	Number of patents	Number of specialized seminars or workshops
Investment in IT	Average age of employees	Number of ISI journals articles	Number of ideas collected from suggestion box
Length of relationship	Average age of full-time or permanent employees	Number of scientific conferences or journals articles	New processes suggested
Partner satisfaction index	Percentage of company managers with advanced degree	Number of new products	R&D invested in basic research
Customer satisfaction index	Percentage of employees with advanced degrees	Number of patents field	R&D invested in product design
Customer retention	Employee turnover	Savings from implemented employee suggestions	Investments in new product design
Number of customers	Frequency of use of knowledge repository or knowledge base	Average age of company patents	R&D resources/total resources
Customer lost	Number of training man-hours	Ratio of new products	
Average duration of customer relationship	Average duration of employment	Number of new solutions	
Customer visits to the company	Educational investment	Patents pending	
Days spent visiting customer	Share of training hours	Number of processes changed	
Service expense/customer	Number of part-time employees		
IT literacy of customers	Hours of training/employee		
Network capability/employee			
Relationship investment/customer			
Direct communications to customer/year			
New markets development investments			
Contribution in projects			

Sources: Adapted from CMA (1999); Roos *et al.* (1998); Bose (2004); Smits and de Moor (2004)

Table IV A template for measure selection

			Scores (assign a grade between 1 and 10 for each item)					
Dimensions	**CSFs**	**Measures/ indicators**	**Coordination with strategy**	**Coordination with the CSF**	**Measurability**	**Accessibility**	**Specific and intelligible**	**Sum of scores**
Systemic knowledge	CSF 1-1	Measure1-1-1						
	⋮	...						
Conceptual knowledge	CSF 2-1	Measure2-1-1						
	⋮	...						
Experiential knowledge	CSF 3-1	Measure3-1-1						
	⋮	...						
Routine knowledge	CSF 4-1	Measure4-1-1						
	⋮	...						

Source: Adapted from Niven (2003)

should be aware of the SKMM process. All responsibilities for collecting, entering and evaluating the data, and producing the reports should be communicated through this stage. It is best to prepare worksheet for each measure and submit it to related data collector. This process can help organizations to find those reports and indices that are not helpful. It is highly recommended that all levels create their own SCs according to the KM CSFs and indicators they may affect. This means "cascading" which is the process of creating arranged SCs in every part of a firm. The act of cascading permits all the personnel to contribute to firm's KM objectives (Mountain State Group, 2005).

Routine function

This stage is a continuous process and consists of regular data inputting, information evaluation, and reporting by way of standard procedures. Also some other regular functions such as overall outcome evaluation and modification of the whole process take place during this stage. Considering the existence of a lot of data, the cause and effect relationships can be easily

assessed to decide whether indicators are truly joined to the determined KM strategy. Also, it is required to review CSFs to make sure about their logical relationships in the cause and effect diagram, and also to make sure that they are supporting the KM strategy. It is noteworthy that, the purification process must conduct for the SKMM process continuously during its life (Mountain State Group, 2005).

SKMM verification

Before implementation of SKMM, each of its five stages was introduced in a descriptive manner with enough templates and cases. Then, a questionnaire was designed to verify the proposed model by AIO experts' judgments. The participants in this survey were members of the AIO including managers, senior experts and effective staff in decision making who were involved in KM efforts. It is important to say that this survey was to identify the opinions of AIO experts about SKMM and verify the basic elements of model. For confirming this default, nine questions were configured and placed in the questionnaire. After a pre-test of questionnaire, the questionnaire with a guideline was sent to the experts via e-mail. The number of questionnaires sent out was 71; the number returned true questionnaires was 42, which showed a return rate of 59.15 percent of the total sent out. After a reliability analysis of the questionnaire and confirming it, since the distribution of the collected data was not normal, the Binomial non-parametric test was used to determine the difference between agree and disagree results. In this case, based on test results most of the participants reached consensus on the model. The ratio expressing strongly agree and agree on questions was over 70 percent, showing significant consensus. This representative sample expressed the opinion that "almost all of the basic elements of SKMM were verified".

SKMM establishment in the SAIO

This research will be continued by the explanations about the establishment of strategic KM process as the preliminary steps of KM program in the SAIO based on SKMM. The SAIO has a matrix organizational structure which consists of four design functions which collaborate to access the SAIO missions. The SAIO is project-based and its products are the drawings and documents of design and development projects. Usually, newcomers who enter the SAIO, before tossing into maelstrom of projects, are expected to pass some precede training and have a three-month internship in the SAIO. A top-level designer is appointed as administrator of new employees. New employees will be selected for projects only after confirmation of the administrative designer. Number of personnel of the SAIO is 175 by now and from this, 55 members are supportive staff and the others are technical knowledge workers of the SAIO. Note that, a project control department also helps design functions for better initiation, planning, execution, control, and finalization of the SAIO projects.

KM initiatives at AIO and the SAIO

Before evaluating the establishment of SKMM at the SAIO, it is necessary to get more familiar with KM initiatives both at AIO and at the SAIO. Considering knowledge and its holders (i.e. human capital) as the most expensive organizational properties, and also taking the short life of technology into account in today's economy, AIO directives realized that they should try to sustain their knowledge assets inside. Individuals' experience in combination with technical know-how can help AIO personnel to try for approaching the wish of capturing the space. Considering AIO as a knowledge-intensive organization, and also considering a huge sum of knowledge in it, the AIO leaders conclude to plan and implement a KM process all over the organization. AIO was considered as a significant park of research in Iran and endeavors were concentrated on making the organization less central. In the new organizational structure, there are various process and improvement workgroups which can collaborate easily with each other all over the organization. Nowadays, each of AIO's sub-stream companies (i.e. SAIOs), has its specific and unique research and development (R&D) department. Sharing of knowledge was defined as a fundamental characteristic of these research centers. Each of these R&D departments was equipped with a KM division to organize knowledge and assist forward knowledge transfer within the organization (Jafari *et al.*, 2007a, b).

In addition to AIO's concerns about KM, there were some other worries in the SAIO. The SAIO has numerous specialists and experts in various scientific subjects such as aerodynamics, propulsion, avionics, guidance and control, thermal, satellite, etc. A large problem of the SAIO was losing the knowledge workers. This problem was considerable because the average years of the technical employees were less than seven years. In this way, KM initiatives were started in 2006 in the SAIO. First of all, a "KM department" was organized in the SAIO by integrating three different sections, including: library, public relations office, and training and education office, and a CKO was appointed in order to supervise it.

Usually, new managerial systems cause some opposition versus change in personnel. The same event took place against the KM in some design functions. In this way, the KM department planned and held some introductive seminars and forums about the KM. Several issues like SAIO's knowledge-based feature, mission requirements, significance of knowledge and KM in SAIO and human developmental programs for the future were discussed in these forums. Several pamphlets and brochures were advertized in order to promote personnel and directors awareness about KM and its influences in different aerospace organizations all over the world. These forums and meetings helped SAIO to accept alterations and to adopt KM as a new process.

Then, organizational process map was modified to adapt with the new process. A number of organizational procedures and instructions were updated and some new instructions were added to existing organizational regulations. Afterwards, an experts' network was shaped in the SAIO and knowledge portal was established. The characteristics and experience fields of all technical employees are recorded in this portal. This portal also contains some features for receiving lessons learned and experiences from all members, and for reviewing them. Progressively, various knowledge committees in different knowledge areas formed in the SAIO. Example of knowledge committees were aerodynamics, avionics, adaptor and satellite, ground equipments, tele-command, etc. It is striking that, these committees have a close relationship with the higher level committees in the AIO. In order to acquire the SAIO's knowledge, project meetings and specialized seminars of projects are planned in project schedules, and they occur during or at the end of projects phases.

Scientific and practical relationships with some Iranian top-ranked universities were started to facilitate

intra-organizational collaboration. Each knowledge committee has at least one academic member from the universities who has an active role in the meetings. One of the most important roles of the academic members is their cooperation in defining various PhD and master's theses in collaboration with the other members of the committees.

In addition to aforementioned initiatives, a comprehensive document management system (DMS) has been established in the SAIO. Different templates for documentation were designed and spread over the SAIO. In order to increase the volume of knowledge repositories of the SAIO, the knowledge creation strategy is selected for the SAIO. This section is to discuss management of knowledge creation strategy in the SAIO. Following steps are an example of how one organization can establish a SKMM process.

Preparation evaluation

For this, two sessions were held with chief executive officer (CEO) achieve his commitment within the SKMM establishment. In these two sessions, preliminaries of SKMM process were presented to him and resources needed were explored. Another seminar was held for the department managers to introduce preliminaries of SKMM model. After ensuring the commitment of the CEO and department managers, an examination of preparation was done based on the subsequent worksheet (Table V).

This worksheet was utilized to evaluate if the SAIO can be an appropriate nominee for a SKMM establishment. The succeeding worksheet can be seen as an instance for using it in real world. Scores in the second column can be assigned by SKMM workgroup after evaluation of organization's current situation. The weight column can be scored after Pairwise Comparisons (Saaty, 1980). As stated by Niven (2003) a sum of total scores 5.5 will lead to further attention about weak domains which have marks less than five. Usually, after "management commitment", "availability of organizational strategy" and "availability of resources" are two domains which have highest priority before SKMM establishment. Note that there was a pre-defined strategy about launching Iranian satellites to capture the space, and also IT infrastructure was adequately good for the SKMM establishment.

Programming

A five-person-workgroup was selected, while the workgroup leader was CKO and the active members were four persons from the KM department. Then a review was conducted about the strategy of the SAIO. Afterwards, knowledge functional strategy defined as: "creating systemic knowledge for developing SAIO's products and services" which was a knowledge creation strategy. Subsequently, a meeting was held between CEO, department managers, and SKMM workgroup. The intention of this meeting was to make some decisions about CSFs based on Brainstorming. In this meeting, all the CSFs in Table II were introduced to the participants. Then, participants were invited to express their beliefs about each of the CSFs. Finally after 2 hours discussions, from all CSFs in Table II, eight CSFs were extracted and assigned to the four perspectives of SKMM and a knowledge strategy map was created as shown in Figure 5.

It is noteworthy that, SKMM workgroup approach in selecting CSFs was a social viewpoint of knowledge. As a result, most of the CSFs were in connection with social activities.

Following the development of the KM strategy map, some appropriate measures from Table III were entered into the worksheet shown in Table IV and sent to the CEO and department managers in order to assign scores to the measures. After collection of the worksheets, by calculating each measure final score, 11 measures were extracted as shown in Table VI. Once consensus on the measures obtained, SKMM workgroup proposed targets for the measures and released them to CEO and department managers in order to confirm them. After some interactions between SKMM workgroup and managers, the targets for the measures were identified as depicted in Table VI.

The last activity in the programming phase was development of a plan for implementation. This plan can be seen as a base for the execution and incorporation endeavors that will be happen. Table VII shows the execution or implementation program for the SAIO.

Execution

Based on SKMM execution program, top-level SCs were designed for each SKMM perspective by SKMM workgroup, and the initiatives for each CSF and measure were defined. Then the top-level SCs were submitted to all the departments. In this stage, all departments were obliged to cascade the SCs to all of their sub-departments. Through cascading the top-level SCs, any section of departments defined their own SCs in cooperation with SKMM workgroup and their department manager. Top-level SCs for all the SKMM perspectives can be seen in Tables VIII-XI.

Note that, Microsoft Excel was selected for SKMM establishment in the SAIO. Subsequently, in accordance with defined SCs, the reporting templates were made by SKMM workgroup in Microsoft excel format, and were sent to all departments. For instance, a report template for the management report has been shown in Figure 6.

Incorporation

It must be said that before implementing SKMM process in the SAIO, there was a systematic approach for process management in the SAIO based on ISO 9001:2000 Quality Management standard. Hence, key and supportive processes had previously been defined, and so they were measured and managed periodically in each month based on process owners' reports. So, it was clear to integrate SKMM process with the process management system as a new supportive or managerial process. In this way, new process map for the SAIO was generated and the new process (i.e. SKMM process) was clearly defined and documented according to ISO 9001 requirements. Then the quality manual of quality management system was modified in

Table V SKMM preparation evaluation worksheet

Area	Score (out of 10)	Weight	Total scores
Commitment of management	9	0.3	2.7
Availability of organizational strategy	5	0.25	1.25
Need for KM strategy establishment	9	0.15	1.35
Availability of resources	6	0.15	0.9
Participant's support	4	0.1	0.4
Data availability	3	0.05	0.15
Sum		1	6.75

Source: Adapted from Niven (2003)

Figure 5 SAIO KM strategy map

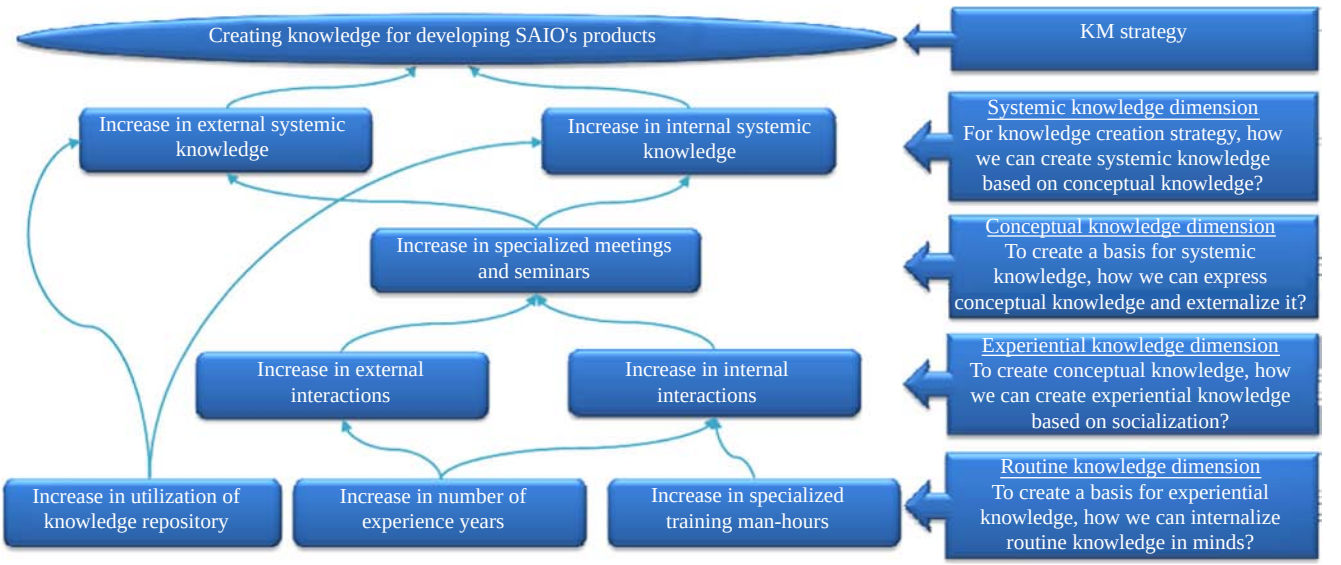


Table VI Nominated measures for the SAIO

Perspective	CSF/objective	Measure	Criteria/target
Systemic knowledge	Increase in internal systemic knowledge	Number of mega bytes of project documents	Incremental trend
		Number of registered experiences	Incremental trend
	Increase in external systemic knowledge	Number of registered patents	Incremental trend
		Number of accepted scientific articles	Incremental trend
Conceptual knowledge	Increase in specialized meetings and seminars	Number of specialized seminars	Incremental trend
		Number of mega bytes of project meetings records	Incremental trend
Experiential knowledge	Increase in internal interactions	Percentage of working time without meetings	Greater than or equal to 70 percent
	Increase in external interactions	Social interactions per employee	Greater than or equal to four man-month
		Contribution in projects per employee	Greater than or equal to two projects
Routine knowledge	Increase in specialized training man-hours	Average cascade-training man-hours	Incremental trend
	Increase in number of experience years	Average months of employee experiences	Greater or equal to 96 months
	Increase in utilization of knowledge repository	Frequencies of utilization of knowledge repository	Incremental trend

order to contain the new process. The next activity in this phase was to define who is responsible for collecting, inputting and analyzing data, generating reports, and communicating the results with stakeholders.

In this way, in contribution with the department managers, responsible persons were selected for gathering, inputting, and analyzing data; then data gathering templates were sent to them. An example of data gathering template has shown in Figure 7. As previously mentioned, the most significant feature of the Incorporation stage is communication. In this way, some technical orientation seminars were implemented for the responsible persons in each department, and objectives, activities, and executing tasks of SKMM were clearly described. In the next movement, some introductory seminars were presented for the other personnel, and in these seminars enough guidelines were given to them. In this case, it is stated that the "start time for monitoring SKMM process and data gathering is April 1, 2007."

Routine function

Data gathering was started from April 1, 2007 in the SAIO and the first SKMM report was made at April 30, 2007. CKO was responsible for integrating the reports, preparing CEO's report, and making decisions about rewarding policies for departments with best practices. Data gathering, data reporting and analysis of results continued regularly within a

Table VII SKMM execution program for the SAIO

Phase	Activities	Responsible person/ department	Cooperator person/ department	Start time	End time
Execution	Generating top-level SCs and initiatives for each perspective	SKMM workgroup	Design functions	January 1, 2007	January 21, 2007
	Generating sub-level SCs and initiatives for each section	Design functions	SKMM workgroup	January 1, 2007	January 21, 2007
	Defining the format of charts and reports and entering strategy, objectives and measures in software	SKMM workgroup	Design functions	January 22, 2007	February 6, 2007
Incorporation	Integrating BSC with the other processes	SKMM workgroup	–	February 7, 2007	February 14, 2007
	Assigning responsible persons for collecting, analysis and reporting	SKMM workgroup	–	February 15, 2007	February 28, 2007
	Describing the goals of SKMM to responsible persons	SKMM workgroup	–	March 1, 2006	March 10, 2007
	Describing the goals of SKMM to the other personnel	SKMM workgroup	–	March 11, 2007	March 31, 2007
Operation/ modification	Data collection	Design functions	SKMM workgroup	April 1, 2007	September 30, 2007
	Data analysis and corrective actions	Design functions	SKMM workgroup	April 1, 2007	September 30, 2007
	Reporting to related responsible person/department	SKMM workgroup	Design functions	April 1, 2007	September 30, 2007
	Overall review to assure alignment of system with KM strategy	SKMM workgroup	Design functions	October 1, 2007	October 14, 2007

Table VIII Systemic knowledge SC for the SAIO

CSF	Measure	Criteria	Initiatives
Increase in internal systemic knowledge	Number of mega bytes of project documents	Incremental trend	All persons and departments must document reports of all phases of projects based on documentation templates
	Number of registered experiences	Incremental trend	All persons and departments must send their experiences in projects to knowledge portals and follow it up to register them
Increase in external systemic knowledge	Number of registered patents	Incremental trend	All persons and departments must send their patents to Iranian defense patent (IDP) and follow it up until registration
	Number of accepted scientific articles	Incremental trend	All persons and departments must document their case studies in projects in scientific articles and send them to scientific journals and conferences and follow it up until acceptance received

Table IX Conceptual knowledge SC for the SAIO

CSF	Measure	Criteria	Initiatives
Increase in specialized meetings and seminars	Number of specialized seminars	Incremental trend	All departments must present the outputs of all phases of projects in specialized seminars after coordination with the CKO
	Number of mega bytes of project meetings records	Incremental trend	All departments, according to progress of projects and before accomplishment of project phases, must contribute to specialized meetings with the project members, after coordination with the CKO All departments must document the outputs of these sessions in meeting's elaborative minutes and send them to the CKO

Table X Experiential knowledge SC for the SAIO

CSF	Measure	Criteria	Initiatives
Increase in internal interactions	Percentage of working time without meetings	Greater than or equal to 70 percent	All departments make a balance for personnel time, qua at least 70 percent of personnel time not used for meetings
Increase in external interactions	Social interactions per employee	Greater than or equal to four man-month	All departments must dispatch their personnel for attending in the professional interaction such as seminars and conferences
	Contribution in projects per employee	Greater than or equal to two projects	All persons must contribute to at least two projects at the same time. All departments and persons must be aware of this situation

Table XI Routine knowledge SC for the SAIO

CSF	Measure	Criteria	Initiatives
Increase in specialized training man-hours	Average cascade-training man-hours	Incremental trend	All departments must consider some times for the experienced personnel to train the others All experienced personnel must fulfill the training ability form and send it to the chief knowledge office. Then they must train each other based on CKO scheduled program
Increase in number of experience years	Average months of employee experiences	Greater or equal to 96 months	All departments must adjust their average months of employee experience equal or above the pre-defined level. So they must protect the experienced personnel from lay-off
Increase in utilization of knowledge repository	Frequencies of utilization of knowledge repository	Incremental trend	All departments must consider some times for employees to refer to the knowledge portal and learn new concepts All personnel must use the knowledge portal to learn new concepts and use them in their activities

routine process up to September 31, 2007. For instance, Figure 6 shows a management report after six months of the starting time of the routine function phase in the SAIO. After six months from the starting time of the routine function phase, it was necessary to review the established process according to the KM strategy. So, we paid some attention to Figure 6 as an overall picture of the SKMM process performance.

In order to analyze the results, we can assess the outputs from a down-top view. In this case, it is so clear that two out of three measures of routine knowledge, all the three measures of experiential knowledge, all the two measures of conceptual knowledge and all the four measures of systemic knowledge, approximately had an incremental trend. As a result, it seems that, approximately all the CSFs had positive effects on the SKMM perspectives and therefore had positive effect on knowledge creating strategy.

Approximately, all the trends show well-defined cause and effect relationships between the CSFs. But in some cases these relationships had illogical behaviors. For instance, "increase in utilization of knowledge repository" and "increase in internal systemic knowledge" showed opposite behaviors; also behaviors of the "increase in utilization of knowledge repository" and "increase in internal systemic knowledge" were not suitable.

SAIO' portal started with a collection of searchable best practices, plus a section for field guides, project reports, and presentations. It was linked to all IT applications and the DMS software of the SAIO. Portal usage statistics indicated a relatively small number of users. The workgroup understood that a corrective action should be done to increase the portal usage within the SAIO. Instead of counting on omniscience, the workgroup directed a web survey to be familiar with employees' need. Also, this survey was to prepare a guide for amendments needed to the portal. Based on the survey, we realized that the portal had not been well kept. For instance, permission updates had really bad status. In other words, permissions had not been updated for many permission owners after their movements to new place. Besides, lacking an appropriate taxonomy, search terms had not been commonly attached while the search engine was working. In other words, the search engine performance was not suitable.

Furthermore, the SKMM workgroup conducted an examination about the folder structure of portal. The workgroup recognized that almost all of the folders needed five or more mouse clicks. In this way, it was necessary to remove the out of date content, modify the structure of folders to a more rational arrangement. Also some other changes were necessary. Examples were adjustment of posting permissions, and also developing appropriate taxonomy to enhance the search engine performance. The SKMM workgroup defined an objective to create a novel structure for the portal with the following attributes:

- Ability to approach objects by maximum four mouse clicks.
- Ability to prepare more than one search avenue for approaching objects.
- Ability to allocate alias or hyperlink for documents in new "topic-based" subfolders for easier access to the functional folder which contains the document.
- Ability to add alias names to appropriate "topic" folders, after posting new objects to departmental folders.

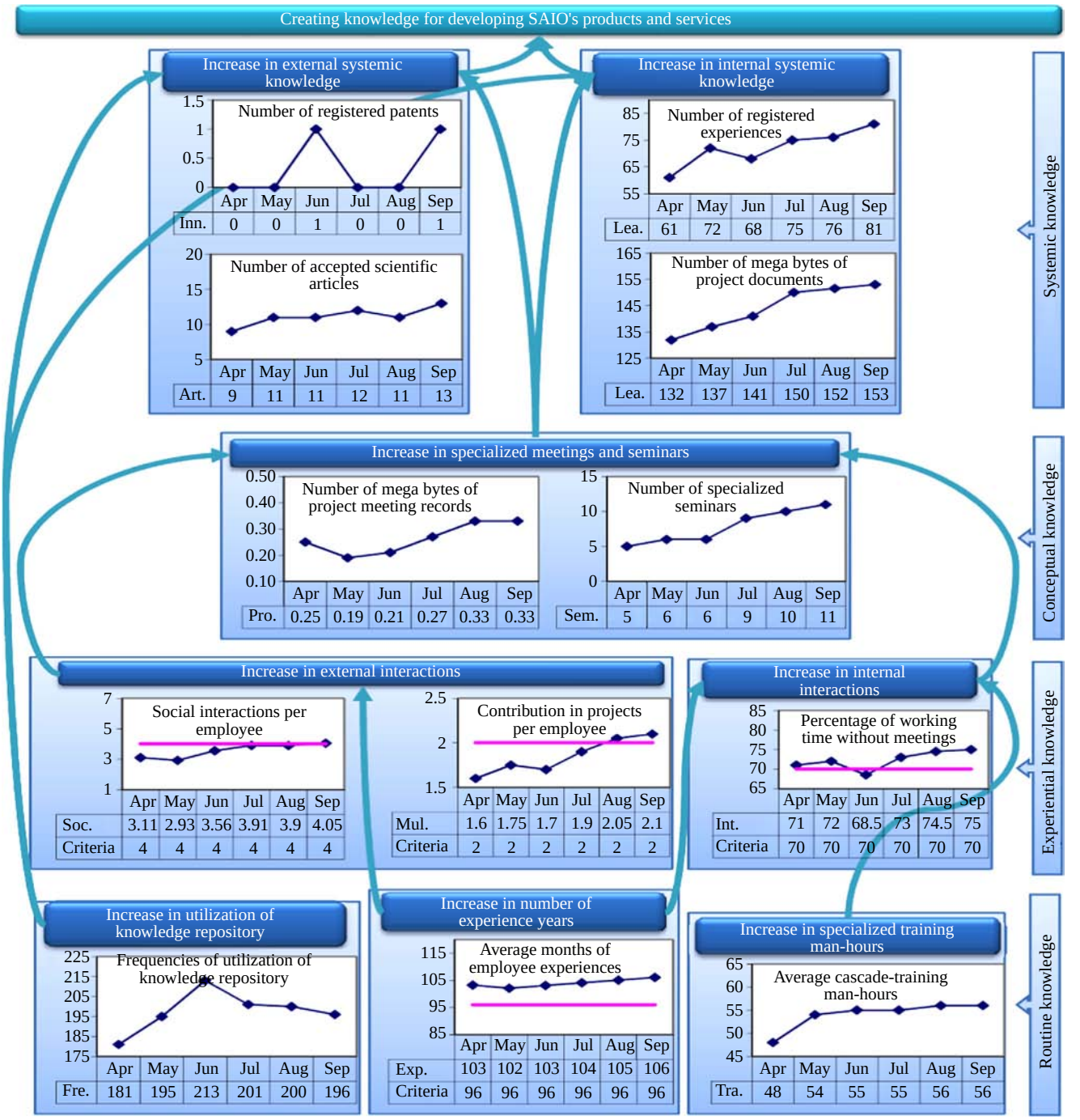
According to above discussions, SKMM workgroup decided to maintain current CSFs, knowledge strategy map and measures for the next period.

Conclusion

Considering plenty of papers, books, and web sites about the KM concerns and influences of KM on organizational success, it seems that KM is transforming from a managerial tool to an essential weapon for today's world. Importance of KM has resulted in developing some models and approaches for assessment of KM initiatives and strategies in various organizations. For a reasonable assessment, it is necessary to have quantitative methods.

This research tried to develop and represent a method for planning, establishment and control of KM strategies. Though SKMM is not proven all around the world, it can prepare a basis for quantitative performance assessment of KM strategy and initiatives in organizations. This method prepares a variety of tools by which an organization can assess its KM strategy outcomes along with the effects of its particular KM initiatives in accordance with the organization's performance. This method makes directors and leaders capable of assessing their corporation's KM strategy. It seems that, the model has helpful effects on managers' decisions about selecting appropriate KM initiatives. Although we tried to represent the SKMM

Figure 6 SKMM management report for the SAIO



establishment in an Iranian sub-stream aerospace industry, its capabilities make it useful for any other business and industry case that needs a KM strategy assessment tool.

In spite of model's capabilities, it really requires extra study to verify its analytical and practical status. Apart from model's validity, it needs additional formulation and modification for utilization at national level. By way of further study, SKMM's advantages and strengths can be illustrated, and then it can be utilized in a lot of business and industry cases.

An important research that should be considered is to evaluate cause and effect relationships between the variables in the model by using system dynamic tools (Forrester, 1958). In this way, different scenarios can be simulated and evaluated based on adjusting different variables in the model. System dynamics is a good simulation tool which can help to roughly predict the future behavior of the system. Usually, system dynamics begins from a situation that requires a solution, a problem that should to be comprehended in a good manner. Another important consideration for future research is to compare KM efficiencies of various departments and knowledge committees. This comparison can be done by using an efficiency evaluation method like DEA (Charnes

Figure 7 A sample data collection template for the SAIO

Measure name: Number of registered experiences

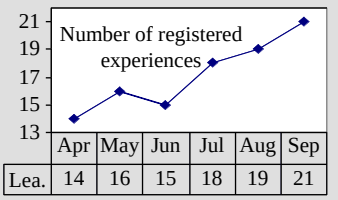
Measure definition: Number of experiences in projects that send to knowledge portal and registered by knowledge management office after peer reviewing and accepting by the specialized expert team

Responsible person/department: Design function A | Measurement period: each month

Related perspective: Systemic knowledge perspective | Related CSF: Increase in internal systemic knowledge

No.	Measurement period	Target/criteria	Measured value	Result Ok	Result Nok	Improvement action needed
1	April	Incremental trend	14	--	--	
2	May	Greater than 14	16	✓		
3	June	Greater than 16	15		✓	Go to consideration (hint 1)
4	July	Greater than 16	18	✓		
5	August	Greater than 18	19	✓		
6	September	Greater than 19	21	✓		

Graphical representation



Consideration

Hint 1: Section 1 of the design function A received a warning because of its weak performance in sending and registering new experiences in knowledge portal

et al., 1978). DEA is a Linear Programming tool by which decision makers can assess relative efficiencies of various decision-making units in a particular set of members.

One domain for further research is to evaluate customers' impact on SKMM. Another area can be examining the impact of organizational extent on SKMM endeavors. A strategic alignment between SKMM and organizational strategy seems a good issue for future studies.

The impacts of the establishment of SKMM on organizational performance can be addressed as a subject for further research.

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