Implementing High-Technology Intelligence at National Level Organizations: An Action Research Study

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Abstract

Technology intelligence(TI) activities are those activities which support decision-making of technological and general management concerns by timely preparation of relevant information on technological facts and trends by means of collection, analysis and dissemination. Thus, TI is one of the important and critical processes of management of technology that includes technology forecasting, monitoring and assessment concepts. Implementation of TI activities at national level organizations results in a system for high- technology decision makers which provides them not only a general view of relevant technologies but also the important trends of such technologies so they can make proper decisions for technology acquisitions .No models have not been developed for implementation of high technology intelligence in developing countries based on their different context so far .The main purpose of this research is to develop a model for designing roadmap for implementing high-technology systems at national level organizations in developing countries. The following project process is characterized as an oscillation between information accumulation, discourse, and practical action i.e action research. First based on literature review six dimensions of technology intelligence including management of intelligence processes , goals and Startegies, structures and human resourses, tools, cycles were conceptualized .By a conceptual framework relationships of the main dimensions and their sub dimensions were presented .Structured and semi structured interviews ,expert workshops were performed to design the appropriate roadmap model including different layers ,connection of layers and critical milestones based on the theoretical framework. For evaluation, the model was customized for a national level high technology based organization (action planning) and then implemented .Based on action results the model was corrected and revised .As conclusion a conceptual framework for roadmap designing was recommended.

Keywords: Technology Intelligence, High technology, National level organizations, Developing countries, Roadmap

Introduction

Technology intelligence(TI) activities are those activities which support decision-making of technological and general management concerns by timely preparation of relevant information on technological facts and trends by means of collection, analysis and dissemination (Savioz, 2004) .Thus TI is one of the important and critical processes of management of technology that includes technology forecasting ,monitoring and assessment concepts (Byungun, 2008).Studies have shown that in the 1970s and 1980s only a few companies approached the technology intelligence process in a systematic way and quite often these approaches failed (Balachandra, 1980; Currill, 1972; Granstrand, 1984; Quinn, 1985). Nevertheless, in the last few years, there is a growing interest in a systematic approach to technology intelligence in many technology intensive companies (Lichtenthaler, 2003) and its application in different technological fields is widely accepted (Behkami & Daim, 2012; Dereli & Altun, 2013).

The interpretation of the term technology intelligence is multi-faceted (Klavans, 1997; Lichtenthaler, 2003). Additional terms used are technology forecasting (Porter et al., 1991; Martino, 1992) and competitive technical intelligence (Brockhoff, 1991; Lang, 1994; Ashton & Stacey, 1995; McDonald & Richardson, 1997).Calof and Smith (2010) have proposed the term "strategic intelligence and foresight on technology" for application of technology intelligence in governmental technology policy making. Furthermore, most authors distinguish between an undirected perspective of technology intelligence,the so-called scanning, and a directed perspective, the so-called monitoring (Peiffer, 1992; Ashton et al., 1991).

As in Lichtenthaler (2003), technology intelligence is understood as a task, which is independent from the way that it is performed. The goal of technology intelligence is to exploit potential opportunities and to defend against potential threats, through prompt delivery of relevant information about technological trends in the environment of the organization. Technology intelligence encompasses the activities related to the collection, analysis and communication of relevant information on technological trends to support technological and more general decisions of the organization. According to this definition, technology intelligence includes the observation and analysis of individual competitors as well as universities and start- up companies.

To identify technological opportunities and threats in a firm's environment, many companies have established technology intelligence processes, which are directed at becoming aware of technological trends in time (Alencar et al., 2007; Utterback & Burack, 1975; Balachandra, 1980). Furthermore, technology intelligence fulfills additional roles, such as organizational learning (Lichtenthaler, 2007; Karaoz & Albeni, 2005; Gerybadze, 1994). Because of the growing acquisition of external technology, many technology-based companies have systematized their search processes by building up additional technology acquisition intelligence activities (Tschirky, 1994; Huston & Sakkab, 2006).Technology intelligence, the observation and evaluation of technological trends,is therefore one of the core processes of technology management (Tschirky, 1994). Studies have shown, however, that in the past many technology intelligence approaches failed (Lichtenthaler, 2003; Quinn, 1985; Ransley, 1996).

Early work on technology intelligence has primarily suggested establishing a centralized technology intelligence unit, but recent works have shown that technology intelligence processes require more complex solutions ((Majidfar & Salami, 2010; Lichtenthaler, 2007; Laursen & Salter, 2006; Linstone, 1997). In particular,technology intelligence activities comprise informal and project-based organizational mechanisms in addition to formal rganizational structures (Gerybadze, 1994; Brockhoff, 1991). To arrive at a comprehensive view of managing TI, three complementary organizational mechanisms may indeed co-exist within any given firm. First,firms may rely on structural organization, i.e., particular organizational structures for coordinating intelligence tasks (Brockhoff, 1991; Makadok & Barney, 2001; Bartlett & Ghoshal, 1998) . Second, a firm may use project-based organization, which refers to temporary projects for coordinating intelligence activities (Slater & Narver, 2000; (Hedlund & Rolander, 1990; Galbraith, 1993). Third, different intelligence tasks may be carried out informally (Galbraith, 1993; Maltz & Kohli, 1996; Martinez & Jarillo, 1991) .

Several empirical studies have shown that in practice TI is pursued in a systemic way, a "casual" way, or a mixture of both (Savioz, 2004). However, in order to be able to discuss different elements of TI, one can describe a Technology Intelligence system (without specifying the degree of systematization). A management system can be visualized along the lines of Porter's (Porter M., 1985) value chain. Since there is value creation throughout the TI process – i.e. need formulation, collection, analysis,dissemination, and application of relevant information – these activities can be interpreted as primary or direct activities of value creation. The value lies in improvements in decision-making; that is, when the quality (of content and timing) of information is improved in order to reduce uncertainty (Savioz, 2001). Supporting or indirect activities enable the primary activities (Savioz, 2004).

Implementation of TI activities at national level organizations results in a system for high-technology decision makers which provides them not only a general view of relevant technologies but also the important trends of such technologies so they can make proper decisions for technology acquisitions.No models have not been developed for implementation of high technology intelligence in developing countries based on their different context so far .The main purpose of this research is to develop a model for designing roadmap and principle guidelines for implementing high-technology systems at national level organizations in developing countries. We show how EHS, a national level high technology based organization in Iran, has implemented technology intelligence processes by a roadmap model.

Methodology
Action research
The process of action research (AR) focuses on the practical situation. First, the problem must be defined and the target of the practical change discussed. This is the basis of the cooperation between researcher and practitioner (Kemmis & McTaggart, 2000). The following project process is characterized as an oscillation between information accumulation, discourse, and practical action. The information is the basis for the discourse (Moser, 1977). Action research is very applicable when praxis problems require change (Mayring, 2002).

The main characteristics of action research are summarized as follows (Coghlan, 1994; Argyris et al., 1985; Gummeson, 2000; McDonagh & Coghlan, 2001):

The process of action research started by praxis problems.
Action research takes action.
Action research is discourse-oriented.
Action research is embedded in the field.
The researcher is an agent of change.
Action research is mainly based on a dialectical theory.

Every AR project has the character of a panel experiment which concentrates on two main points: the intended changes of the practice and the cooperation process between researcher and researched object (Coughlan & Coughlan, 2002). At the beginning there is always a practical problem which has to be solved in a special target way. This is the crucial factor for the design of the process flow depending on the existing circumstances (Mayring, 2002).Because of different conditions (communication, background, problem understanding and interests) for participants in the process, pre-decisions about the following cooperation have to be checked (investigation) before starting with the active part of the project (entry).

Subsequently, the variables will be collected, evaluated, and prepared along with the structures and processes accessed (data collection, data feedback and diagnostic). These are the basis of the interpretation and the understanding within the scope of the discourse process to find expedient action recommendations. As a next step, the development of specific action tasks, the determination of responsibilities, and the definition of the evaluation approach (action planning) is needed to implement the changing strategies (implementation). At the end of the process, the results and changes achieved have to be measured and analyzed (Sievers, 1979).

Research Methods Used
Research methods of AR can be characterized into three categories (Kotzab et al., 2005): the creation of situations, the acquisition of existing action, and the refurbishment of determinants and processes of operations of the contemporaries. For the first category, research methods are used which construct situations that lead to actions as main sources of information for a project. Here, two minimum conditions exist: the results of the analysis have to be discussed with concerned people (feedback),and the researcher has to be honest and is not allowed to cheat on the researched object by means of the research methods (threat to reliability). In the context of

the project, none of these methods were used because a special situation already existed and actions could be derived from it, so there was no need to create a new situation.

For the next category, the acquisition of existing action, it is important to acquire natural performance or rather to belay aspects of this natural performance on the basis of interviews. Here, it is important to acquire own appraisals and evaluations of the respondents. Their decision making and responsibility is assumed. Different methods belong to this category, and some of them were included into the project.

Structured or rather unstructured observations took place the entire time, including during the workshops and project team meetings. For the understanding of the structures and processes, non-standardized interviews were conducted with different departments of the organization, combined with surveys of experts. Protocols were made for documentation of the process for each meeting, work shop etc., and there was a process reflection with fixation in written form afterwards.

For the refurbishment of determinants and processes of operations of the contemporaries as the third category, it is no longer possible to generate data from a direct observation and interviews; experiences and knowledge are second hand. The analysis concentrates on representational references which serve as an explanation for human behavior. References can be differentiated into two dimensions. The local dimension includes information about parallel events elsewhere and the temporal dimension covers events from the past. Research methods of this category are: analyses of literature, analyses of sources, and analyses of documents, which all played a main role in the context of the project for the refurbishment of the scientific foundations and concepts, and achieving an overview of the structures and processes of the organization. The analysis of content played a role in the composition of individual points of views in the protocols.

Outline of the Research Project

The research project was a collective project between the University of Allameh Tabatabii Management school (research team of four people) and a national level high technology based organization abbreviated as EHS. Both partners worked together at the same level in different constellations. Along with a reunion of all parties thereto (workshops), also there were informal meetings for the core project team consisting of people from the organization side and the research team.

The output of the technology intelligence process for EHS would be a set of technology intelligence profiles on new disruptive high technologies of interest to EHS. Acquisition of these technologies and/or co-development with EHS could lead to competitive advantage by facilitating the generation of new intellectual property, start-up companies with new business models,or joint ventures.

Overall, the project was made up research activities along a time period of fourteen months:

preliminary analysis (literature review),

ten preliminary, discourse and evaluation workshops

review of the current intelligence structures (internal interviews)

Structured and semi structured interviews and expert panels were performed to design the appropriate roadmap model including different layers ,connection of layers and critical milestones based on the literature and theoretical framework.

The preliminary analysis took place before the discourse-oriented main part of the project started. Main topics for these enquiries were: (1) the main dimensions or variables discussed in technology intelligence scientific literature (2) challenges for management of technology intelligence implementation in national level organizations including planning, executing and evaluation phases, and (3) best practice and negative examples of other companies and industries from different regions of the world. Based on this analysis, an overview of the current research status for technology intelligence in national level organizations was established as the starting point for the first internal workshop.

The ten workshops were used to congregate all relevant people involved in the project. The first workshop familiarized the participants with the topic, and the results of the preliminary analysis were shown. In every workshop the current statuses of the ongoing research were discussed, and further actions were determined. Each person took part in the decision process, and together the design and the used research methods were chosen to develop a realizable implementation concept by using the

Know-how of the practitioners to ensure feasibility of the developed solution.

The review of the current situation of the organization was initiated to understand the organization's sourcing structures and processes and to identify weak points related to technology intelligence implementation general process.

The overall intelligence system implementation comprises four different phases: design, implementation, application and evaluation. Therefore, eight interviews with experts of the respective organization departments were carried out. These statements were collected and analyzed to identify possibilities and needs for changes. From them, different solutions could be generated as norm strategies, and were discussed at the other workshops to identify a suitable solution.

Results and Analysis

All three parts of AR were taken into account in the research project. The first part, the collection of information, took place during the preliminary and attendant analysis, including studies about the main dimensions and sub dimensions of technology intelligence, challenges for implementing TI in national level organizations, as well as the exploration of the best practical examples and organizations. On the other hand, information about the own situation of the organization, and existing structures were gathered via expert interviews with the organization's departments.

Based on scientific literature review, main dimensions of TI with sub domains could be categorized as (Table 1):

1-   *TI management* processes: the general management functions of a TI system are to designing(or planning), implementation, development and application of the system.

2-   *TI goals and strategies*: this dimension consists of TI mission ,goals and strategies which interact with the information needs, but there also is a direct link to the business mission and strategy.

Klavans (1997) lists the objectives of TI as:

a) To provide early warning of external technical developments or company moves,

b) To evaluate new product, process, or collaboration prospects created by external technical activities,

c) To anticipate and understand S&T related shifts or trends in the competitive environment for organizational planning.

3-   *TI structures and human resourses*: this dimension describes the arrangement of different elements of TI and the role of people involved.

4-   *TI tools*: TI tools include collection and analysis methods (for example,patent analysis,trend extrapolation and scenario analysis) and enabling infrastructure (for example, like IT infrastructure).

5-   *TI Cycles*: Value is created throughout the TI cycles – i.e. planning & direction(need formulation), collection, processing, analysis, dissemination.

6-TI Metrics: Metrics are used to measure the outputs of TI systems

A conceptual model was then developed for displaying the interaction of main dimensions of TI system (Figure 1).In this model two rings are considered. Inner ring consist of TI cycle as the basis of system's value creation.Outer ring includes other dimensions of TI system as enablers.

The second part, the discourse, was the central instance of the scientific process for the critical question about the sense of norms and facts. As a next step, the development of specific action tasks, the determination of responsibilities, and the definition of the evaluation approach (action planning) was planned to implement the changing strategies (implementation) through three workshops. As a result of the practical actions, a framework of roadmap for implementing technology intelligence was designed regarding dimensions and sub dimensions of TI systems. Five layers and related sub layers and activities were planned (Table 2). During the period of nine months the planned roadmap was implemented in EHS organization .The results of action was assessed through four other Action workshops .Evaluation of the situation, analysis of weak points, formulation of possible objective dimensions and options for solution strategies was also discussed during these workshops.

For the evaluation, after completion of action course, a new classification set of roadmap layers and sub layers was established (Table 3) through two workshops. Four new layers of roadmap under the main category called "technology intelligence systems" was related to previous layers, including TI management, Culture enhancement & empowerment, Intelligence Methods & Tools Development , Intelligence Cycles/Activities/Projects/Initiatives. Other four new layers was also designed based on the strategy map of organization consist of products, impact on other organization processes, strategic objectives of organization and stakeholders expectations. These layers were categorized as "outcomes". The connection of layers and sub layers was redesigned (fig 2). Furthermore, new responsibilities and tasks in the context of job descriptions were distributed to several people. We now have some fundamental changes for the organization's technology intelligence operations directly originating from the project.

Table 1. Main Dimensions and sub-dimensions of technolohy intelligence

Dimensions	Subdimensions	References
Technology Intelligence Management Processes	General Processes	(Ashton & Klavans, 1997)
	Design	(Ulrich & Probst, 1988)
	Implementation	(Baisch, 2000)
	Project-Based Implementation	(Krystek & Müller-Stewens, 1993)
	Development	(Rapoport, 1988)
	Design,Implementation, Development & Application	(McDonald & Richardson, 1997)
Technology Intelligence Goals & Strategies	Linkage between TI mission and Business mission & Strategy	(Jennings & Lumpkin, 1992; Hambrick, 1982)
	Dual strategy (long term & short term) for TI	(Abell, 1999)
	Interactive technology control system	(Jung & Tschirky, 2002)
	TI Goals	(Ashton & Klavans, 1997; (Reger et al., 1998; Lang, 1994)
	Linkage between	(Yasai-Ardekani & Nystrom, 1996; Smeltzer et

	organization's size and TI mission and strategies	al.,1988; Beal, 2000; Mohan-Neill, 1995; Lyles et al., 1993; Matthews & Scott, 1995)
Technology Intelligence Structures & Human Resources	Formal structures	(Lichtenthaler & Tschirky, 2001)
	Coordination of TI activities: Structural, Informal, Hybrid	(Lichtenthaler & Tschirky, 2001; (Lichtenthaler, 2000; Lichtenthaler, 2004)
	Industry-wide systems	(Hassid et al., 1997; Krystek & Müller-Stewens, 1993)
	People roles in TI system	(Lichtenthaler, 2000; Krystek & Müller-Stewens, 1993; Jakobiak & Dou, 1992; Kobe, 2001)
Technology Intelligence Tools	TI Methodes	(Lichtenthaler, 2000)
	Technical Infrastructures	(Savioz, 2004)
Technology Intelligence Cycles	2 steps: identification & observation and assessment	(Peiffer, 1992)
	5 steps collection, analysis, dissemination and application.	(Ashton et al., 1991; Ashton et al., 1994))
	2 steps :Conveyance, convergence	(Lichtenthaler, 2000)
	5 steps :Planning & Direction, Collection, Processing, Analysis, Dissemination	(Herring, 1997)
	6 steps: coordinate, search, filter, analyse, document, disseminate	(Kerr et al., 2006)
Technology Intelligence system metrics	Timeliness,Right scope,Clarity	(Schwartz & Mayne, 2005)
	relevance, timeliness and accuracy	(Delone & McLean, 1992)
	content, accuracy and timeliness	(Doll & Torkzadeh, 1988)
	Intrinsic,Contextual,Representational,Accessibility	(Lee et al, 2002)
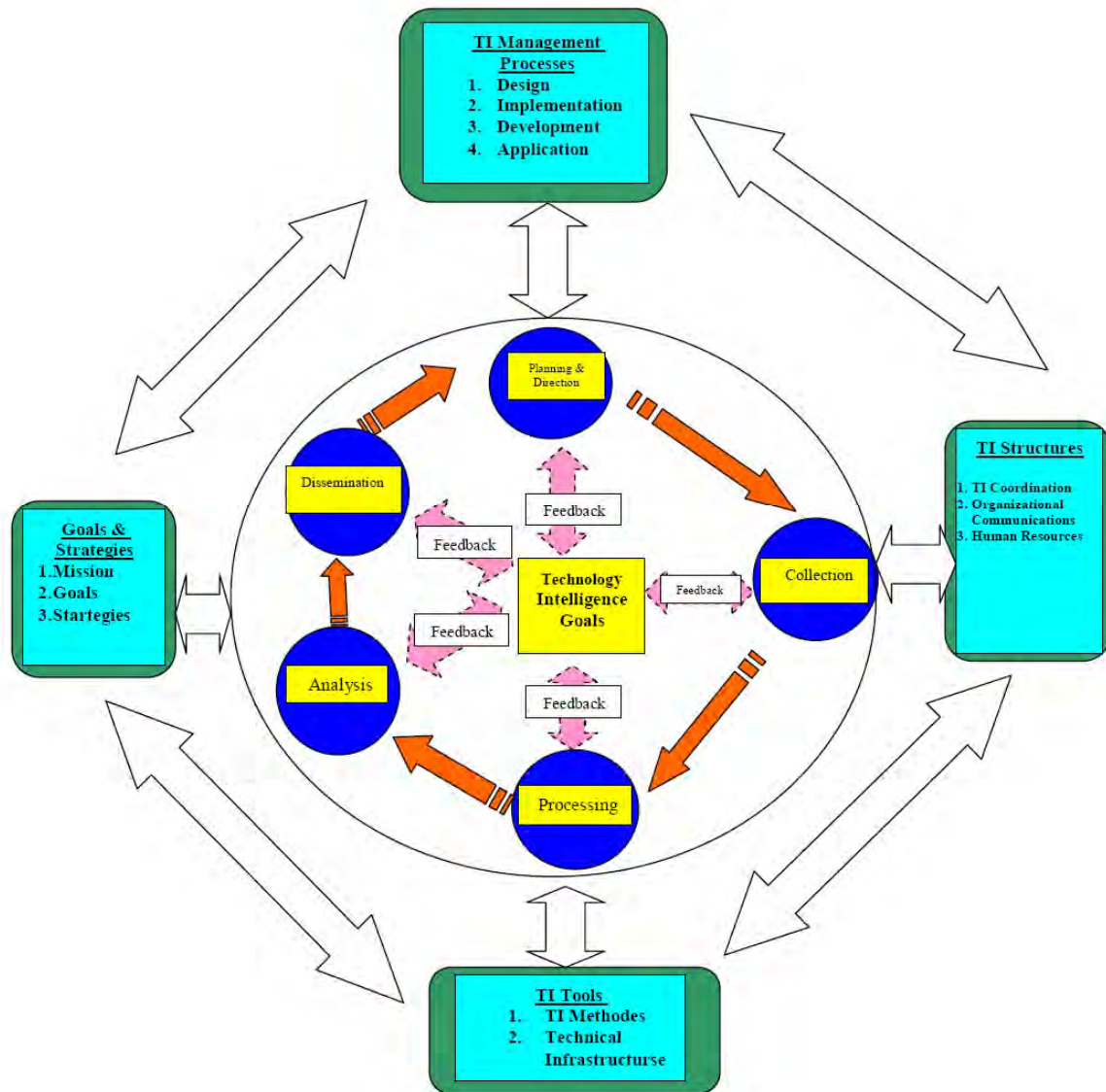
Figure 1. A conceptual model of technology intelligence dimensions and their interactions

Conclusion

The inquiry subject of this paper aims at implementing technology intelligence by a roadmap model reflecting the conceptualized dimensions of such a system based on scientific literature. It describes a successful implementation of the AR methodology on the subject of technology intelligence, especially with regard to participatory research and theory generation. Oscillation between information accumulation, discourse and practical action is the core of a successful action research project.

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Table 2. Preliminary Roadmap Generic Framework

Layer No.	Related Dimensions	Layers	Sublayers	Direct Connections with other Layers
1	Management of intelligence processes	TI Management	Planning Structure Design Implementation Coordination Developement	Lower :2,3,4
2	Technology Intelligence Metrics	TI Metrics	Process Control	Upper:1 Lower:6
3	Technology Intelligence Goals & Strategies	TI Strategies	Setting Goals Strategic directions	Upper:1 Lower:4,5,6
4	Technology Intelligence Structures & Human Resources	TI Structures	Identifying informal structures Setting a Centralized unit Education,Training	Upper:4,3 Lower:5,6
5	Technology Intelligence tools	TI Tools & Methodes Developement	Infrastructure Development Methodes Development Software tools Developement	Upper:1 Lower:6
6	Technology Intelligence Cycles	TI Cycles	Adhoc Projects	Upper:2,3,4,5

Table 3.Roadmap Generic Model after Implementation and Evaluation phase

Related Dimensions	New Layers	Previous Layers
Management of intelligence processes	TI Management	TI Management
Technology Intelligence Metrics		TI Management
Technology Intelligence Goals & Strategies		TI Strategies
Technology Intelligence Structures & Human Resources	Culture Enhancement & Empowerment	TI Structures
Technology Intelligence tools	Intelligence Methods & Tools Development	TI Tools
Technology Intelligence Cycles	Intelligence Cycles/Activities/Projects/Initiatives	TI Cycles
Organization Startegy Map	Products	-
Organization Processes Map	Impact on other organiztion processes	-
Organization Strategy Plan	Strategic Objectives of Organization	-
Organization Strategy Plan	Stakeholders Expectations	-
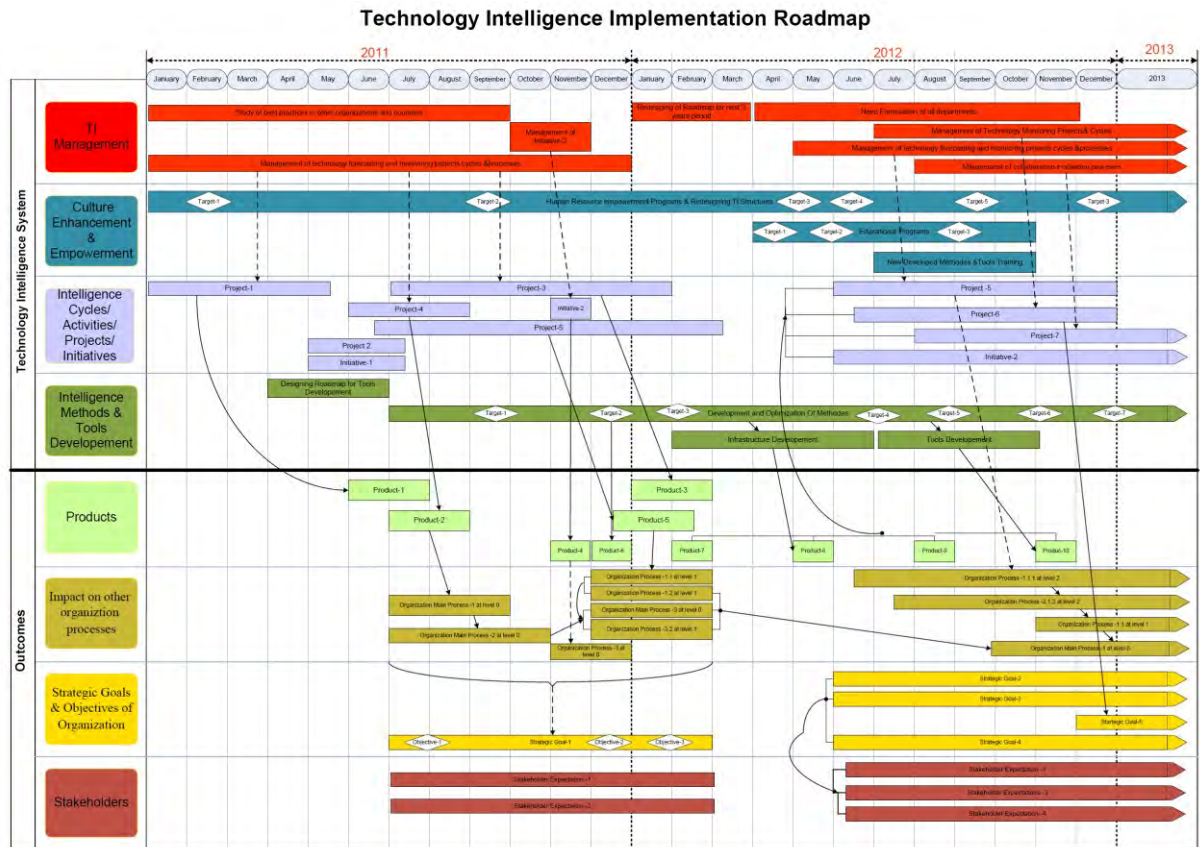
Figure 2. Technology intelligence implementation roadmap model customized for a high technology based national level organization

A roadmap model for implementing technology intelligence activities in national level organizations was presented in this paper together with its theoretical concepts. This roadmap framework is composed of two main categories, namely: technology intelligence system and outcomes. This framework provides the linkage between the strategic plan and the intelligence activities of a organisation To implement technology intelligence system within an organisational context, In order to run the technology intelligence system, Four layers of roadmap under the main category "technology intelligence systems", were named as TI management, Culture enhancement & empowerment, Intelligence Methods & Tools Development and Intelligence Cycles/Activities/Projects/Initiatives layers .Other four layers based on the strategy map of organization (outcomes) consist of products, impact on other organization processes, strategic objectives of organization and stakeholders expectations. This paper has indicated that it is possible to apply action research as an applicable methodology for empirical research in the context of technology intelligence. In this context the function of the project researchers showed similarities to a consulting activity in the field of business management. The researchers have to try to keep a kind of impartiality towards the researched object, although there is a certain dependency on the organization. It is also important to power the discourse process between all participants at all times because the praxis often has time restraints and does not care for too much reflection.

Acknowledgments

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