STRATEGY BUILDING MODEL FOR TECHNOLOGY BASED ORGANIZATIONS: A TECHNICAL APPROACH

B. Balaji Srinivasan B.E, M.B.A., (PhD)

Head, Faculty of Management Studies
SCSVMV University, Kanchipuram,
Tamil Nadu, India.

Prof. Dr. K. P. V. Ramana Kumar M.Sc, M.B.A., PhD

Dean, Faculty of Management Studies
SCSVMV University, Kanchipuram,
Tamil Nadu, India.

ABSTRACT

In general, firms execute various pieces of their technology strategy- R&D, New Product Development, or value chain configurations – in two modes. In one mode, a firm implements its strategy all by itself, relying on its own internal value chain and organizations. In the second mode which is collaborative, a firm executes its strategy with the help of others. In recent years, the effectiveness of strategies framed by various knowledge based organizations started to decline due to the pressures of time compression and the potential interest in technology integration. The present paper overcomes the above limitations and describes technology strategy model, which can be applied to any technology based organizations for its success.

Keywords*: Technology Management, Technology Strategy, Technology Strategy Model, Validity Test and Managerial Implications.*

Introduction:

The two words management and technology carry the burden of several different meanings. The combination of the two words presents additional complexities. Some people view management of technology as a means of managing engineering. Other category of people view the management of technology as managing information, managing research, managing development, managing manufacturing operations or managing functional activities without concern for the total spectrum activities that encompass the business concept to commercialisation process. In many ways management of technology is not a new field. The beginning of technology management can be traced to year 1950, which was a period characterised by plentiful resources to R&D. In 1987, the National Research Council defined management technology as "Management of Technology links engineering, science & management disciplines to plan, to develop and to implement technological capabilities to shape and accomplish the strategic and operational goals of an Organisation". In a simple way, as per Gayner "The Management of Technology can be best described as the process of integrating the business unit resources and available infrastructure in the fulfilment of its defined purpose, objectives, strategies and operations". The essential criteria for the Management of Technology are the integration of technology at different phases. In the present environment, it is very difficult to find organisations that manage the technology as an integrated function. The number of phases of integration will be arbitrary and depends upon the number of functions. Each function will represent a phase. The integration of functions of the technology in Technology Management is generally a complex process. In implementing the process of Technology Management, in various phases, one has to consider three variables namely primary elements (Resources, Infrastructure & Activities), Business Issues (Management strategies & Operations) and supporting influences. It is important to note at this juncture that technology is the prime factor for consideration in the primary element category. Note that the successful use of technology depends on the availability of other resources.

Study Objectives:

1. To study the importance of technology management
2. To test the effectiveness of technology strategy model on select technology based organization
3. To verify the validity of the technology strategy model

Review of Literature:

The Technology had been defined by many researches either with science or products.

J. Fred Bucy (1983), former chairman of Texas Instruments argued "Science is the systematic pursuit of knowledge, while technology is the application of that knowledge to the production of specific goods and services. Technology is the design and manufacturing know-how to produce goods … Products… are the result

of technology but are not themselves technology; and while science is almost always the basis of technology, it also is not technology

According to the framework of P.S. Adler and A. Shenhar (1990), "the success of a technology – based company depends crucially on technological base, which is ability to exploit the technology as a core competency, to invest in future technology, to incorporate better technology in its products and services".

According to M. Hammer and J. Champy (1993), there are two processes, which are critical to technology – based firms. First, the product and process development process generates the actual output of the company and creates value for customers. Second and fueling the first, the technology development process creates next generations of technologies.

The contribution from P.S. Adler & A. Shenhar (1990) explains that, the technological base provides a framework, not only for assessment but also for implementing change and for analysing the difficulty involved.

In the context of Technology Management, creativity and innovation plays an important role in all aspects. Michale J.C. Martin (1984) in their contribution "Managing Technological Innovation and Entrepreneurship" described, creativity by thought is invention and that inventiveness is a quality usually required and always desirable in all phases of innovation process. .

The study on "Managing New Technology Adoption" by Roger A More (1992) states some of the issues related to technology adoption. Accordingly the reasons for failure of technology adoption includes the development of new technology in an explosive rate, lack of comprehension at user level, limited human capacity and financial limitations of the organisations. The study also stresses the importance of involvement of the managers in the process of the technology adoption for the success and also about the requirement of forecasting systems in the organisation to know the exact time to take up the new technology.

Stephen Bradley's research titled "Impact of Technology on Industry Structure and Competitive Strategy" (2011) has focused for several years on the impact of technology on industry structure and competitive strategy. In particular he has been studying the convergence of information technology and telecommunications and how this convergence is not only radically restructuring the telecommunications industry but numerous other industries as well. Specifically the exlposion of broadband and the integration of multimedia technology with broadband communications, IT networking, the Internet, and IP based telecommunications standards will radically transform the ways people work, shop, and are entertained; the way companies are organized; and the way entire economic environments are structured. To investigate these issues, he has organized a sequence of four research colloquia the most recent of which, entitled The Bandwidth Explosion: Living and Working in a Broadband World, took place in April of 2003. The outgrowth of this research colloquium was a book co-edited with Robert D. Austin of Harvard Business School, The Broadband Explosion: Leading Thinkers on the Promise of a Truly Interactive World, HBS Press, 2005. His most recent article, which appears in this book, is "Wi-Fi: Complement or Substitute for 3G." He is currently working on a book that examines the transformational impact of various broadband technologies on the structure of specific industries including the advertising, movie, recording, television, and telecommunications industries.

Philip Anderson et al (1991) in their study "Managing through Cycle of Technological Change" evolved at the conclusion that the changes in the technology are discontinuous. From his study he came to the conclusion that the new technology could make the present competence obsolete and may require mastering a new set of skills. He also suggested that the organisation must inculcate an ability to learn and adapt quickly to counter the impact of technological upheaval.

Prof. Dr. Alexander Gerybadze (1994) in his article "The Evolution of Industrial Research & Development" explained the various stages of evolution of research and development. According to him first generation of research and development (1950 – 1975) was input oriented and people belief on the outcome of research and development was a chance. T F was considered to be a part of project planning during this generation. The 2nd generation of research and development (1975 – 1990) is the stage of decentralisation of research and development. Alignment of research and development efforts to various business goals yields in more efficient application oriented efforts and TF was envisaged as a data gathering exercise. The 3rd generation of research and development effort has sought a balance between basic research and applications. The article also summarises the importance and various stages of technology forecasting. He concluded that the company must have an efficient intelligence system to scan emerging technologies.

Rebecca M Henderson and Kim B Clark (1990) classified the innovation into incremental innovations and radical innovations. According to them, incremental innovations represents relatively minor changes in the existing concepts (or) products. On the other hand, a radical innovation makes the need to learn visibility of new skills. The study explains the classification of innovation through two case examples of Xerox and the U.S. Automobile industry. The study concludes with recommendations on the effectiveness of architectural innovations.

Edward B. Roberts and Alan R. Fusfeld (1988) explains the six states in the innovation process in their contribution "Needed roles in the innovation processes" The six stages are Project Stage, Project Possibilities, Initiation of the Project, Execution, Outcome Evaluation and Project Transfer. The study infers that innovation as differentiated from creativity has a contrast reference to the market place because that is where the opportunity and risk for success or failure lies.

Innovation and invention are the two terms generally to be classified. Schmokler (1966) pointed out that "Every

invention is (a) A new combination of (b) Preexisting knowledge which (c) Satisfies some want. When an enterprise produces a good or service or uses a method or input that is new to it, it makes a technical change. The first enterprise to make a given technical change is presumably an initiator and its action imitation."

On the other hand, innovation is seen by Schonberger and Knod (1991) as "technological break throughs – new products, services and techniques when they occur, but is more often the result of modest, incremental, improvements to existing products, services, and operations (the "tinkerer's tool box").

In the context of Technology Management, creativity and innovation plays an important role in all aspects. Michale J.C. Martin (1984) in their contribution "Managing Technological Innovation and Entrepreneurship" described, creativity by thought is invention and that inventiveness is a quality usually required and always desirable in all phases of innovation process. The study concludes with the formulation stages of innovation.

John E. Ettlie et al (1992) enumerates the three integrating factors where the value of process innovation from new technology provides competitive advantage. The three factors are new hierarchical structure, increased coordination between design & manufacturing and greater supplier cooperation. The authors feels that a market related mechanism could also affects the flexibility of the system. The study concludes with the various factors affecting the system flexibility.

John Rennie has explained (Center of Technological innovations) some of the cases where technological innovations involve uncertainties in 1955. One of the cases he has considered was alternate energy (solar and wind, etc) and according to him this will provide another chance to protect the environment. He has given the experts projection of 50 years as the time frame when it will be able to harness the power through a process called fusion. Thus, any sector can utilize TM practices for overall efficient performance.

The study conducted by T.R. Madan Mohan et al., (1994) on "Technological Transformation in Indian Manufacturing Firms" reveals the findings in terms of the predictors and factors affecting technology adoption. According to the study, the technology planning, customer focus, trade fair, government policy and sophistication of neighbouring industrial units are found to be important predictors of Technology adoption. For technology adoption, government policies, manpower planning, production focus, technology content and openness to change are found to be most important factors. Among the above factors, the Government Policies are the most significant predictor of Technology adoption. For the study they considered the variables like extent of technology planning, customer focus, input control production focus, man power planning and development budgetary system, corporate allocation, research and development commitment, government policies, openness to change technology content and participation in trade fairs by the industries.

Methodology:

A detailed field survey was conducted in the cities of Delhi, Hyderabad, Bangalore, Chennai and Tiruchirapalli in 20 major technology based organisations & institutions through questionnaires. The purpose of the questionnaires administered is mainly to elicit the relevant information from the respondents, keeping the objectives of the study in mind. A brief discussion on the questionnaires justifying their inclusion has been made below:

The study conducted the qualitative survey on the performance and the effectiveness of the technology strategy model on 5 -point scale of measurement. The sample size for both the survey is150 comprising academicians, engineers and consultants

Sampling Design:

The type of sampling used for the study is Quota Sampling. The study used weighted average concept for the analysis.

Data Analysis and Interpretation:

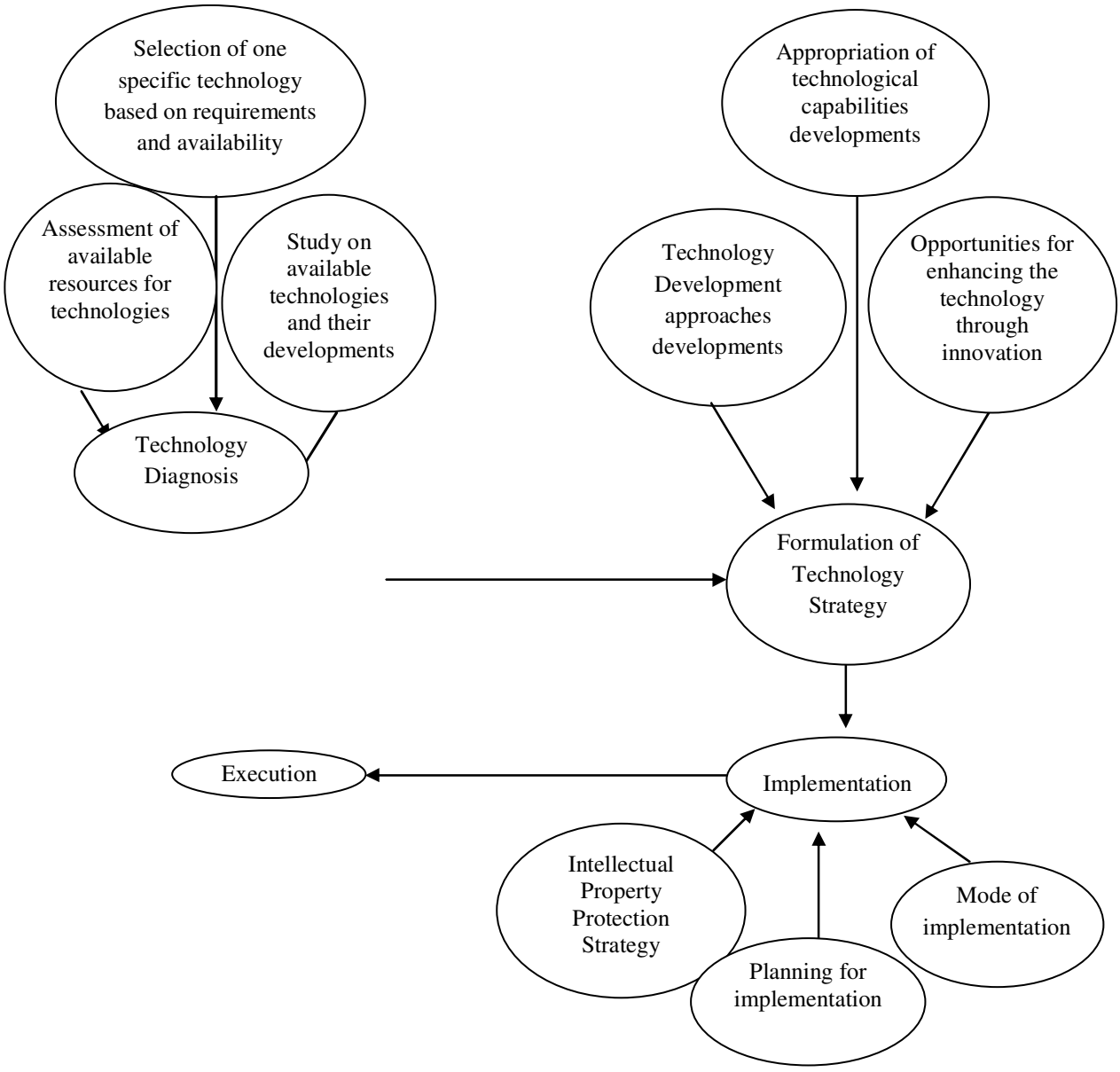
Technology Strategy Model:

Technology Strategy is a relatively new concept. After World War II, many firms pursued a path of diversification through in house Research & Development efforts. Although the concept of technology strategy was not prevalent at that time, the roots of the concept arose from the diversification of Research & Development efforts. Also, during that time many writings about the strategies used to manage Research & Development in large diversified firms (e.g. GE) evolved. These writings focused on technological innovation and attempted to categories the firms based on their innovativeness.

Technology strategy is the revealed pattern in the technology choices of firms. The choices involve the availability and usage of resources for the appropriation, maintenance, deployment and abandonment of technological capabilities. Technology strategy mainly focuses on the kinds of technologies that a firm selects for acquisition, development, deployment (or) divestment. Also, technology strategies are not confined to high technology industries. Even capacity – driven or customer driven industries require a technology strategy. The technology strategies generally embrace both the hardware and software elements of the technology.

Technology strategy will be decided at the top level of any organizations. The technology managers or chief technology officer or chief information officer plays an important role in this aspect. They provide top management with requisite intelligence and sponsor specific technology selection decisions within the organization.

Figure 1.1 Showing The Technology Strategy Model



Source: Self Designed Model

The study focuses on a simple model for organizing the process of technology strategy and tested the effectiveness of the model with specific reference to technology based organizations. The basic root path for the construction of the model lies in the writings of many research scholars and also the necessity to consider the technology as strategic issue.

In recent years, the Herring Model, developed by JanHerring, (1993) has been used to organise the technology intelligence process. The Herring Model consists of five stages namely needs assessment, planning, collection, analysis, and presentation.

Over a period of 2 decades (1960-1982), Perkin-Elmer (PE) accomplished a major transformation from a $100 million to a billion dollar corporation. This was a result of a carefully planned strategy of internal product development and well adoption of technology strategy.

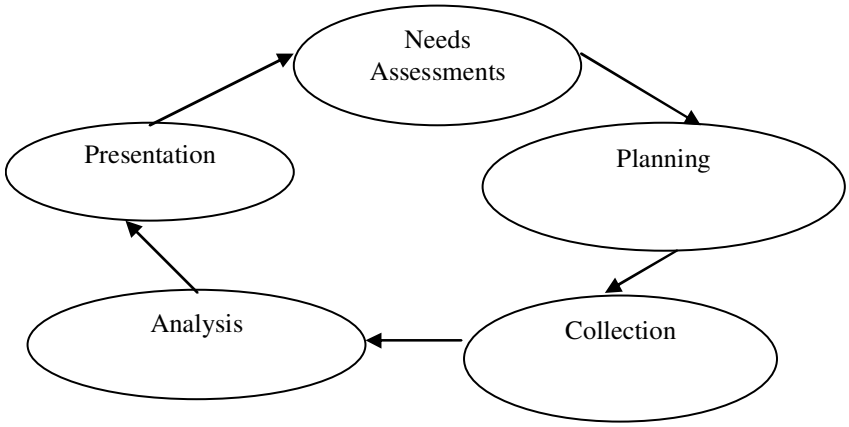
Technology Strategy is usually formulated over four stages:

a. Strategic Diagnosis
b. Formulation of Technology Strategy
c. Crafting an Implementation Approach
d. Execution

As a result, the company that resulted from a repositioning process was not only greatly expanded but also for better positioned – both strategically and technologically. The company strategy focused first on strengthening its base line operations in optical devices and avionics and then expanded into new fields, ranging from analytical instrumentation and small computers to flame sprays.

The Technology Strategy Model for the present study is developed along the lines suggested by Herring & William P.Sommers et.al. The model for technology strategy constitutes four different stages namely Technology

Fig.1.2 Showing The Herring Model



Source: Herring, Jan P "Scientific and Technical Intelligence: The Key to R&D, "Journal of Business Strategy (May/June 1993), Vol.14 (3), pp.10-12.

Diagnosis, Formulation of Technology strategy, Implementation and Execution

Technology diagnosis involves assessment of resources for technologies and assessment ,study on available technologies and their developments and selection of particular type (or) specific technology based on requirements.

Formulation of Technology Strategy:

Key objective elements involved in this stage are: -

A) Appropriation of technological capabilities
B) Technology Development Approaches and
C) Opportunities for enhancing the technology through innovation.

The necessity of appropriation of technological capabilities is

- To create fundamentally new technology
- To support existing technology and
- To alter existing technology

Accepted Criteria for Selecting Appropriate Technologies:

Some of the accepted criteria to be considered for selecting appropriate technologies are:

- It should primarily aim at meeting the basic needs of rural people; it should be capable of absorbing large labour force, preserve existing traditional jobs, low cost and require low levels of skills.
- It should be capable of using indigenous raw materials and services.
- It should provide for waste recycling and should be non-polluting.
- It should be considered with local culture.
- It should be compatible with social system.
- It should be accepted to the political systems also.

Appropriation of Technologies:

Technologies to be acquired and those technologies that need further development are translated into specific Research & Development programs.

Technology Development Approaches:

An effective management of R&D's and appropriate choice of technology development approaches are important for the success of the technological efforts. The various technology development approaches followed in Indian based technology organizations are setting up of separate in house R&D units within the corporation, cooperative R&D units, which constitutes a group of companies in a particular industrial sector and contract research approaches.

Opportunities for Enhancing the Technology Through Incremental Innovation:

Incremental innovations are small and marginal improvements brought about by Research & Development teams out of their experience while working with the specific process that give rise to the productivity resulting in low cost

Implementation Stage:

This stage can be categorized into three phases namely mode of implementation of technology, Intellectual property protection strategy and for implementation of technology planning.

Mode of Implementation:

There are two modes of implementing the technology either by going it alone (or) through collaboration. Present conditions in Indian context mainly prefers the second mode i.e. collaboration with other country in the form of mutual understanding approach in the implementation of technology. The first mode (i.e. In house Research & Development) is also preferred in India but to the least extent. The government (MNES) initiated many subsidies

Table 1.1: Showing the Effectiveness of Technology Strategy Model

Factors	No. of Respondents				
	Score 1	Score 2	Score 3	Score 4	Score 5
Degree of focusing attention on important issues, tasks and objectives	0	0	28	36	86
Level of clarity	0	5	37	51	57
Degree of consistency	5	9	36	53	47
Degree of complexity	3	28	41	34	44
Degree of relevance in the current context	8	0	27	55	60
Possibility on degree of administration	14	27	23	38	48
Degree of convenience in usage	17	23	15	67	28
Degree of effectiveness	3	8	42	79	41
Degree of rates of success	0	12	19	71	48
Degree of technical manager involvement in model implementation	0	12	15	41	82

Source: Primary Data

in the field of biomass technologies in developing indigenous technological approaches, and the percentage of this kind of development is limited in present scenario.

Intellectual Property Protection Strategy:

This phase refers to the action taken to prevent the value derived from technology choices from being dissipated by the forces of imitation (or) hold up. The protection is keenly felt in biomass gasification sub technologies since the technologies entered into the society in just two decades only and it should survive and to be developed economically and technically for better benefit of society.

Planning for implementation:

Technology choices to be implemented require proper planning and organizing. Be it in house Research & Development or collaborative mode of Research and Development, proper planning is must for the technology development in terms of processes or sub-technologies.

Execution:

During execution, operational plans are developed. Not only this, but also the human resource requirements will be properly deployed at this stage.

It is important to note that, this execution stage generally integrates the implementation process with the action-oriented plans for achievements.

The execution of technology strategy in biomass gasification technology is purely based on the output generation of electricity and the available resources in all aspects along with the issues related to the technological process adopted.

It is to be noted that, at each stage of the technology strategy model, policies (both organization and government) should be framed and implemented for the effective performance of the model.

Testing of The Technology Strategy Model:

The study tested the acceptance of the technology strategy model on Biomass Gasification Technology among 150 respondents in 5 major cities of India (Bangalore, Chennai, Tiruchirapalli, Hyderabad and Delhi). The respondents constitute academicians, engineers and consultants who are equipped with the knowledge of biomass energy technologies. The parameters of the tests are: -

- Degree of focusing attention on important issues, tasks and objectives
- Level of clarity
- Degree of consistency
- Degree of complexity
- Degree of relevance in the current context
- Possibility on degree of administration
- Degree of convenience in usage
- Degree of effectiveness
- Degree of rates of success
- Degree of technical manager involvement in model implementation

The above parameters are rated on 5-point scale with the scores as

1. Very Low
2. Low
3. Moderate
4. High and
5. Very High

The survey result on the effectiveness of technology strategy model is shown below in the table 1.1. The sample size for the survey is 500 comprising academicians, engineers and consultants having knowledge on Biomass Technologies.

Inference:

The weighted average was taken for each parameter and finally the overall parameter average was calculated. The overall performance of the model came to 79.2%, which is a measure of good significance.

Validity Test:

Validity of the technology strategy model is also tested by means of content validity method. The content validity is typically estimated by gathering a group of subject matter experts (SMEs) together to review the test items. The SMEs are asked to indicate whether or not they agree that each item is appropriately matched to the content area indicated. For the present study 20 SMEs were considered for conducting the test validity. In that 16 SMEs accepted the model and the remaining 4 SMEs (who disagree) suggested that the model can be changed from time to time based on the various external factors inclusive of the nature of resources available.

Suggestions:

Some of The Suggestions Recommended From The Present Study Are:

- In order to enable a firm to get the most from external sourcing, the firm should scan broadly, provide for continual interaction between technology managers and the environment, nurture gatekeepers and boundary spanners and technology managers and the employees of technology-based organisation.
- For the potential of technology integration to be realised, managers not only need to nurture innovation in their organisations, but they must learn to import technology from other organisations, as well.
- Technology development takes place at many levels. Basic research and applied research, development and operations should be carried out by different organizations before implementing the strategy model

Managerial Implications:

The following are the four key managerial implications in the field of management of technology with specific reference to technology based organizations in India.

- All the four stages of technology strategy model should be explicitly evaluated and implemented.
- Management of technology should focus on the resources to gain the best value for the organisation from its appropriation activities.
- External sourcing should be explicitly considered to build technological capability and speed execution.
- Management of Technology will require tapping a mix of secondary and primary data sources. Thus, maintaining access to secondary data sources and having a network of personal contacts outside the organisation are critical to the flow of timely technology information to the organisation.

Conclusion:

In today's technology based organisations, technology strategy formulation and implementation is a crucial and important factor. So, the necessity arises for all technology used organizations to have a simple model for Technology Strategy.

Technology Management is not a mystery and Technology Strategy is (must be) a synergy to the technology based organisation"

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