Chapter – III

RESEARCH METHODOLOGY

3.1 Introduction

Research work is basically meant to be a search for knowledge. It is, in a way, a journey to discovery. The systematic manner in which this journey is performed can be termed as Research Methodology. In the case of social sciences, it usually includes the entire gamut of the research process, including definition of the problem, review of literature concerning the problem, formulation of hypotheses to look for their proof or otherwise, collection of data, analysis of results, drawing of inference and conclusions, and making recommendations in the light of limitations of the study (Kothari, 2009).

Research methodology is one of the most important aspects of research because it spells the reason behind the research work undertaken, how it is required to progress or has progressed, and what methods, tools and techniques are to be used or have been used. Therefore, when conceptualized and articulated, it gives a fairly clear perspective of the research effort not only to the researcher but also to those evaluating or assessing it at the proposal stage or after the research has been completed.

3.2 Systems Methodology

The present thesis is essentially concerned with the application of systems science to study security management in the Indian Railway System
(IRS). It employs a variety of relevant systems tools. The rationale for utilising specific systems tools stems from the requirement of reducing the level of system complexity and arriving at a contextual Interpretive Structural Model of Security System, probable and preferred rail transport security scenarios in the future (by the year 2020), as well as exploring efficient policy initiatives and action plan that could match up to the requirements of the projected scenarios.

Further, the systems tools used are in accordance with possibilistic theory, “…..dealing with certain types of uncertainty and treatment of incomplete information, (which is) considered as an alternative to probability theory.” (Gal, 2013). Probability theory is, “…. a branch of mathematics concerned with analysis of random phenomenon.” (Encyclopedia Britannica, 2014). “The transitions from probabilistic models to possibilistic models require that random variables are replaced by fuzzy variables and that the probabilistic indicators (expected value, variance, etc.) are replaced with appropriate possibilistic indicators.” (Gal, 2013).

Systems Science, including its four components enunciated by John N. Warfield (2006), namely, Science of Description, Science of Design, Science of Complexity, and Science of Action, is ideally suited to study large scale systems like Indian Railway Security System (IRSS). It employs the methodology of Interactive Management (IM), particularly Nominal Group Technique (NGT) and Interpretive Structural Modelling (ISM), to delineate the elements of a system and decipher the contextual structural model to reduce
complexity.

In a general systems research paradigm, designing or redesigning a system requires proper identification of its elements, as well as the interactions amongst them. This generic approach is fundamental to any systems modelling design. Usually, a system design is based on contextual relationship of elements within the concerned system. However, a network of heterogeneous systems may interact with each other as a system of systems (DeLaurentis and Callaway, 2004). Accordingly, the IRSS has been conceived as embedded in the National Security System (NSS) of India. The Transport Security System of India is also, largely, a part of the National Security System and may have linkages with the Transport Security System of other countries. However, the research presented in the following chapters is the result of a select study of Indian Railways Security System (IRSS).

As described by Warfield and Cárdenas (2002), Interactive Management (IM) is a system of management that has been developed to deal with complex problems and situations. It is based on the premise that when a group of people having knowledge and /or experience about the subject matter concerning a problematic situation get together to tackle the main concerns, the collective knowledge / experience, commitment and collaborative effort result in a clearer understanding of the situation at hand. This also facilitates development of an effective action plan for achieving desired objectives.

Thus, IM is a group process exercise involving managerial functions of
intelligence, design and choice. It works best in a cooperative environment with active interaction amongst participants of the concerned group. Typically, IM process has three phases, the Planning Phase, the Workshop Phase, and the Follow-up Phase.

The domain experts, who have knowledge about a given situation, have to be identified and contacted during the planning stage. Planning is also expected to take care of the required information, infrastructure, etc. During the workshop phase, the domain experts participate under the guidance of an expert/researcher in a specially designed room to facilitate interactive communication on the given subject. The follow-up phase involves iteration, or implementation, or both.

3.2.1 Idea Engineering

Generation of ideas is an important factor for any creative effort. Mere participation of domain experts is not enough until their knowledge and experience is tapped suitably. Idea engineering is a systematic way of ensuring participation of all members of the group assigned to focus on a given problem/issue in a short time. It also prevents domination by a few participants and/or suppression of the ideas of less vocal participants.

Typically, the process of idea generation begins with presentation of a triggering question to the group of domain experts to elicit focused response. Each participant jots down his/her ideas/suggestions/views on one or more sheet(s) of paper, as required by the expert/researcher/process facilitator. Normally,
the ideas are shared and informal exchange of ideas is encouraged. In case, any new ideas are generated, they are also recorded until no more new ideas occur to the group. Finally, the ideas are listed in cogent language for further processing.

In the present study, the domain experts recorded their views to suggest solutions for improving security in the railway system after identifying the objectives and constraints of the system.

3.2.2 Nominal Group Technique

Nominal Group Technique (NGT) is concerned with a group (in name only), where participants interact through a facilitator. This technique was invented to neutralise the negative effects of group dynamics. In a normal group, either due to competition or certain behavioural attributes, some participants appear to dominate the group activity. In the process, they render relatively silent members, who may have significant contributions to make, almost ineffective in the performance of the group.

NGT is so called because it involves minimal dialogue or interaction amongst the group members. It is a structured method aimed at diffusing the influence of group members who tend to dominate the discussion, and at eliciting, response from relatively silent members. Thus, it allows each member to have a say and vote on each item. Hence, NGT involves formalized brain storming and decision making.

The NGT process begins with a triggering question requiring the group
members to respond. Initially, the participants mull over the question and work in silence for a few minutes to jot down their ideas. After the ideas are written, the participants do not exchange their lists of ideas, but present them on being asked by the facilitator, one at a time. The recording of ideas takes place on a flip chart, or a computer, with the display enabled to afford clear visibility to the entire group. Identical or overlapping ideas are pooled together, and all the ideas are clearly stated and listed.

The participants are asked to vote by selecting three most important ideas and ranking them in order of importance. The votes are recorded by the facilitator and mean values are calculated. Normally, in the case of complex problems, there is divergence amongst members of the group as to which three or five ideas may be considered as most important. This kind of divergence can be dealt with by other techniques for improving the degree of consensus among experts.

Research has proved that NGT is significantly superior to interactive group exercises like brainstorming in generating ideas, solutions to problems, etc. (Delbecq and Van de Ven, 1971). NGT was used in the present study to reduce the complexity by pruning down and prioritising the descriptive elements of security system.

3.2.3 Delphi Method

Though included as an interactive management process, Delphi method is used when face-to-face interaction is either not possible or not desirable.
Originally developed in the 1950s by the RAND Corporation in USA, it is a strongly structured survey method of capturing the views of experts about matters on which naturally unsure and incomplete knowledge is available. It is a much slower process as compared to other processes of interactive management because it requires survey in at least two or more rounds. (Sackman, 1974).

Typically, a structured questionnaire based on the subject matter under study is administered to a group of domain experts. The results obtained from the first round are presented to the same experts to review their responses in the light of collective feedback of the group concerned. The results obtained after the second round are checked to verify the level of consensus and variance. If the desired consensus is found lacking, the whole exercise is repeated until the consensus is reached.

Delphi method was used in the present study to arrive at a consensus view of domain experts on security scenario in the Indian Railways System (IRS) by the year 2020 as an intermediate step to feed another group of experts for scenario building exercise using Harva Method.

### 3.2.4 Harva Scenario Building Approach

This is an approach where knowledge and experience of the domain experts is utilised in projecting probable futuristic scenarios. Typically, the participants are divided into different groups and requested to visualise futuristic scenarios for the target year (Year 2020 in the case of the present study). It is imperative that the participants must have context specific
knowledge about the system relevant to the scenarios concerned. Usually, the process involves the following five steps (Satsangi and Gautam, 1983):

1. Present state-of-the-art of techno-economic development
2. Points of crisis and fulfilment
3. Perceived future society
4. Synthesis scenario
5. Action plan.

3.2.5 Interpretive Structural Modelling

Interpretive Structural Modelling (ISM) is a soft systems methodology based on paired comparison of system elements with respect to a given relationship to structure complex systems. The ISM process transforms unclear, poorly articulated, complex mental models of systems into visible and well-defined simpler models, which could be useful for many purposes (Satsangi, 1985). It deals with the interpretation of the embedded object by systematic iterative application of graph theory, resulting in a directed graph for the concerned complex system. Each stage of methodology may be viewed as transforming a model from one form to another, which is referred to as Model Exchange Isomorphism (MEI).

The concept of MEI has been clearly illustrated by Sage (1977) in his book titled “Methodology for Large-Scale Systems.” He explains that five MEIs are clearly identifiable. The first MEI represents the modeler’s mental image of the set of elements and their inter relationships. A pair wise comparison of the
elements in the data set leads to a reachability matrix, which implies conversion of a mental model into reachability matrix as a model. By inducing partitioning on the set of elements, the reachability matrix gets rearranged into a canonical form at the third stage of MEI. The fourth stage is concerned with the drawing of structural model based on canonical reachability matrix. At the fifth stage, the numbered elements are replaced with the description and/or keywords of the elements to facilitate interpretation.

3.2.6 Options Field Methodology

The Options Field Methodology (OFM) was invented by Warfield to derive advantage from ISM exercise for systems design. Option field method can use ISM several times with different relationships. OFM involves identification of elements, placement of elements in dimensions, sequencing of dimensions and the policy options within them, and development of profiles as alternative options for implementation (Warfield, 1981).

3.2.6 (a) Clustering

Clustering is an important part of OFM. To place policy elements into categories or dimensions, the respondents react to the relational question: “Is element A in the same category/dimension as element B?” The categories/dimensions are generally named as per the criterion on which their elements are grouped together. Similarly, dimensions are clustered as being in the same cluster or as independent dimension for consideration during option profiling.
3.2.6 (b) Option Profiling

Developing option profiles requires consideration of at least one of the policy options from each of the dimensions. However, the experts may choose a single element or more than one element from each cluster or independent dimension, depending upon their experience and knowledge. The choice may be exercised in the same sequence as ascertained in advance during clustering.

Generally, more than one profile is generated. Alternative profiles can be compared on the basis of relevant criteria to select the best policy profile for implementation (Gaur, 1996).

3.2.7 Tradeoff Analysis vis-a-vis Integrated Policy Design Scenario Combine (I-PDSC)

Tradeoff analysis refers to evaluation of alternative policy designs and arriving at suitable design for implementation. Although each method stated earlier is complete in itself, yet any of them alone or separately may be inadequate in affording a holistic analysis of large scale complex systems like IRSS. However, integrating them as a combined whole in a systematic way, harnessing the synergy resulting from such integration, is more likely to solve the objective at hand. Accordingly, an Integrated Policy Design Scenario Combine (I-PDSC) has been visualized as a process for studying IRSS.

Figure 3.1 gives an overall picture of the research design process, integrating different soft system methods of Interactive Management methodology, where the basic exercise of Content Analysis leads to two
different directions. One route leads to building of an Interpretive Structural Model by IRSS, which further leads to generation of alternative profiles and recommendation of the best profile for implementation and use. The other route leads to application of Delphi Technique followed by Harva Scenario Approach and Fuzzy Evaluation of alternative scenarios to arrive at the best possible action plan for improving efficiency and effectiveness of IRSS.

Thus, techniques like NGT, ISM, AHP and Fuzzy Dominance Analysis, along with Delphi and Harva Scenario Building exercises, have been combined to develop alternative policies and action plans, and to evaluate them before reaching a conclusive decision for recommendation, implementation and use. This research design can be used for studying any similar system to reduce complexity and improve efficiency of the system concerned.

3.3 Sample

Since IM methods require small groups for data collection, choice of participants is of great importance. Inclusion of representatives of different stakeholders of the system concerned helps in avoiding infirmities in system design.

In each of the workshops conducted for data collection, 10 to 15 domain experts participated. However, the number of participants was higher (20) for the workshop on option profiling (Appendix A).
Figure 3.1: INTEGRATED – POLICY DESIGN SCENARIO COMBINE (I-PDSC) PROCESS FOR IRSS