CHAPTER-2
CHAPTER-2
SYSTEM DESIGN METHODOLOGY

2.1 Identification of the Problem

In the context of Indian business, as far as management of information is concerned, certain important changes has taken place in the recent past, which forced the decision makers to rethink about the said area. We may present certain issues, which have forced the corporate decision makers to think about more systematic information management:

- Market is facing the experience of the world without having periphery. This is due to the drastic change in information technology. Customer is getting access of world market sitting at his or her home. So the expectation level of customer is getting a major shift.

- Changes of economic and political scenario by the influence of foreign institutional investments, fluctuations of the international market, changes in the world political situation etc. generate high level of risk and uncertainty in terms of the formulation of the strategy.

- Existence of the toughest competition within and outside the country

- Changes in social structure, ethical values and loyalty lead to uncertainty about mapping consumer mind.

2.1.1 Choice of Port as a Focal Point of Study

As far as information management of port is concerned, it is one of the oldest activities of our country primarily engaged in business of bulk cargo handling
through its various docks. Engineering and shipping industries have grown as natural ancillaries in Port. It maintains a huge inventory for smooth operations in various departments with continuous replenishment and procurements of various items including spares and oil for its own fleet. Port has an age-old manual system for inventory operations, loading of cargo into the ships etc. It has hardly any information system for decision-making and now need for an on-line computer based system has become critical for improvising the operations in the areas of materials management, traffic management as well as finance management. Till date no such complete work has been done in this field. This work has an aim to systematically explore the various functional management areas and integrate them from a business and innovative perspective. In fact we have to develop the system from scratch within the existing framework.

2.1.2 Sub Problem Wise Discussion for Research Design

Port is having various functional management areas like materials management, traffic management, finance management, estate management, marine management etc.. Out of those functional management areas most of the areas are general in nature and common to all business organizations. Therefore emphasis has been given to those areas which are specific to port management system. Keeping this view in mind we have taken only materials management, traffic management and finance management as the scope of our study.

In these functional subsystems, there are two decision-making areas. One is subjective ‘decision making’ area and the other is objective ‘decision taking’ area. In the former one, the information system that we are going to design will provide necessary information on the time. On the basis of that information the decision makers will make decision. Here the information requirement is similar to that of
other business organizations. This area includes procurement of materials, issue and stock management, receipt of the materials, disposal of scrap, settlement of bills of the suppliers, purchasing and establishment, vessel master information, recovery of bills, revenue collection, budgeting etc. which we have discussed in detail in their respective chapters. Preparation of a tool that will aid in faster decision-making is the main objective behind development of such information system.

The later one falls under objective ‘decision taking’ area, where we will give inputs to the interactive system and the information system will take the decision and will give output to the users. Here we have got a very port specific problem named as Container Loading Problem (CLP), Cargo Unloading Problem and Pilot Utilization for which we will develop information system. The basic objective behind developing such systems is without much wasting of time and with the help of the full proof system the decision-taking problem will be solved. Consequently it will maximize the generation of revenue from the loading solution and minimize the transportation cost from the unloading and pilot utilization solution.

2.1.3 Type of Research

The type of research work that we have undertaken is exploratory or formulative in nature. The reason behind its formulating nature is due to no previous work has been carried in this context. The main purpose of such studies is formulating a problem for more precise investigation or of developing the working hypothesis from an operational point of view. The discovery of ideas and insights is the crucial point of such studies. This type of research design is appropriate for studies that must be flexible enough to provide opportunity for considering different aspects of a problem under study as is in our case. Therefore the need for hypothesis testing is not there in view of its formulating nature. Inherent flexibility in research design is there because
the research problem is altered into one with more precise meaning in such studies. This fact may changes in the research procedure for gathering relevant data. Here we have done a survey using unstructured interview schedule for the collection of data and as such no fixed decisions were there regarding the operational procedure (see Kothari, 2004). Experience survey is one method to accumulate data from the respondents for such studies. It is the survey of decision-making people who have practical experience with the problem to be studied. The purpose of such a survey is to obtain insight into the relationships between variables and new ideas relating to the research problem (see Thakur, 2003). For our survey we have selected as respondents and interviewed those people of port who are competent and can contribute new ideas to ensure a depiction of varied types of experience. For that we prepared an unstructured interview schedule for the systematic questioning of informants. At the same time interview must ensure flexibility in the sense that the respondents should be permitted to raise issues and questions which we have not considered previously. Generally these types of interview are likely to be long may last for few hours. This will also give an opportunity to the respondents for doing some advance thinking over the various issues involved so that at the time of interview they may be able to contribute effectively (see Gupta, 2005). This survey provides information about the practical possibilities for doing such types of research.

In our study we have considered three functional management areas of port. The first area is materials management. Here we have got a very interesting and port specific problem called as Container Loading Problem (CLP) that falls under objective ‘decision taking’ area under CLP where the users will give inputs to the interactive system and the information system will take the decision and give output to the users regarding container loading. For the development of the solution of such
a problem no specific methodology is there in the literature. In this context, Taha (2002) proposed a model for most valuable cargo loading in terms of weight restrictions which is a simpler version of the problem that can be addressed by using dynamic programming (see Bellman, 1962 and Denardo, 1982) method. CLP in terms of volume restrictions is a more interesting, conceptually different and more critical problem. This needs specific attention because sometimes volume is an important consideration than weight. To handle such problem we have developed a methodology which is discussed in the section 3.4 of the third chapter. The methodology of designing the related information system have discussed in the section 2.3 of this chapter.

The second functional area is traffic management. Here we have got a very interesting and port specific problem called as Cargo Unloading Problem (CUP). The problem is like that: a vessel of fairly large size and carrying load, coming from other ports is willing to enter the dock of the port under study to off-load the materials completely or partially. If the navigational depth does not permit the entry of vessels into the dock smoothly due to the lesser water depth of the navigational track then what will be remedial measure. Generalizing the problem we can say that how a load can be brought to the dock with a minimum cost and without consuming much of time. This is also a decision taking area where as such no methodology is there in the literature. This is a pioneering work in the Indian context. To propose the solution we have partly used some standard methods and extensively developed port specific methodology. These we have discussed in the section 4.2.4 and section 4.3 of chapter four. Here to measure the efficiency from experience of a pilot we have discussed two methods which are analytical approach and survey method. For the former one we have proposed a mathematical measure in the section 4.3.1.1 of chapter four. In the third functional management area i.e. financial management we
have developed the information system using existing tools of the literature which we have discussed in the section 2.3 of this chapter.

Besides that we have used regression analysis to get the rise of water depth of the navigational track with the passage of time. Regression analysis models the relationship between one or more response variables (also called dependent variables, explained variables, predicted variables, or regressands usually named $Y$), and the predictors (also called independent variables, explanatory variables, control variables, or regressors usually named $X_1, \ldots, X_p$). If there is more than one response variable, we speak of multivariate regression. The goal of regression analysis is to determine the values of parameters for a function that cause the function to best fit a set of data observations that you provide. In linear regression, the function is a linear (straight-line) equation.

In the linear regression model, the dependent variable is assumed to be a linear function of one or more independent variables plus an error introduced to account for all other factors. Applications of regression analysis exist in almost every field.

The least squares fitting procedure described below can be used for data analysis as a purely descriptive technique. However, the procedure has strong theoretical justification if a few assumptions are made about how the data are generated. The starting point is the regression equation which describes some causal or behavioral process. The independent variables play the role of experimental or treatment variables,

Simple linear regression refers to a regression on two variables while multiple regression refers to a regression on more than two variables. Linear regression assumes the best estimate of the response is a linear function of some parameters.
The linear model usually assumes that the data are continuous. If least squares estimation is used, then if it is assumed that the data are normally distributed, the model is fully parametric. If it is not assumed that the data are normally distributed, the model is semi-parametric. If the data are not normally distributed, there are often better approaches to fitting than least squares. In particular, if the data contain outliers, robust regression might be preferred.

To make the choice of weights of the different parameters that we have from the survey method we have used the standard preference theory.

2.2 About the Survey Work

To estimate the efficiency curve for the pilots we have undertaken a survey work on the pilots, by interviewing the concerned head of the department of port. In this study we have used personal interview method based on a structured questionnaire. The main logic behind this is surveying is an exchange of ideas between interviewer and respondents. A face-to-face interaction is very much helpful to clarify the main intention of the question. This reduces the error part of the responses. We present a copy of the questionnaire for ready reference.
Questionnaire for the Head of the Department (about the Pilots):

1. Temperament:
   a) He is calm and he retains poise at times of pressure of work
   b) He gets provoked easily
   c) He is able to tolerate differences of opinion

2. Intelligence and Understanding:
   a) Exceptional and has clear grasp of any matter, however complicated.
   b) Is intelligent and grasps a point correctly with reasonable speed
   c) Shows a barely adequate grasp
   d) Very slow and/or often misses the point

3. Knowledge of Rules, Codes, Manuals, Instructions and Procedure:
   a) Has an exceptionally good grasp of the work of the office as a whole and rules, codes, manuals generally and a through and intensive knowledge of work of the branch
   b) Has a sound knowledge both of the work of the branch and that of the office as a whole
   c) Knows just enough
   d) Not good enough

4. Quality of Work:
   i. Attention to details:
      a) Most reliable and comprehensive
      b) Considers all relevant details
      c) Apt to the over-concerned with pretty details and losses perspective
d) Inclined to be superficial

ii. Judgment:
   a) His proposals or decisions are consistently sound and well thought of
   b) Reliable
   c) Takes a reasonable view
   d) Unreliable, undecided, rigid, superficial or erratic

iii. Presentation of cases:
   a) Extremely clear, cogent and logical
   b) Very good and expresses himself clearly and concisely
   c) Just good enough
   d) Does not have ability to present cases properly

iv. Ability in noting and drafting:
   a) Excellent
   b) Very good
   c) Good
   d) Average
   e) Poor

v. Promptness in disposal of work:
   a) Very prompt
   b) Reasonably prompt
   c) Is slow and tends to delay

2.9
2.3 Methodology for Information System Design

In this section we will describe the methodology of our research to develop a computer based information system for a port. The goal of us is to present timely, accurate, and complete information to decision-makers and decision-takers and knowledge workers while minimizing cognitive and economic costs. As such, Information System (IS) is a broad, eclectic field that must address issues touching on hardware and software, politics, economics, marketing, psychology, engineering, and aesthetics. Designers and design methodologies for Information System must embrace and address all of these dimensions.

The available methodology to develop an information system in the literature is linear or waterfall cycle of system development. It is a development process that centres around planned work and is best suited for development projects where the requirements are clearly defined (Harwryszkiewycz, 2000). The linear cycle divide the development activities into a number of consecutive phases. The major phases are concept formation, system requirements definition, system design, system development and installation and post installation activities which are the completion of the development.

2.3.1 Introduction to SSADM

Structured Systems Analysis and Design Methodology (SSADM) is also a systems approach available in the literature to the analysis and design of information systems. SSADM was produced for the CCTA, a UK Government office concerned with the use of technology in government, from 1980 onwards. System design methods are a discipline within the software development industry, which seek to provide a framework for activity and the capture, storage, transformation and dissemination of information so as to enable the economic development of computer
systems that are fit for purpose. SSADM is also a waterfall method by which an information system design can be arrived at; SSADM can be thought to represent a pinnacle of the rigorous document-led approach to system design, and contrasts with more contemporary Rapid Application Development methods such as Dynamic System Development Method (DSDM).

2.3.2 Objective of SSADM

SSADM was developed with the following objectives:

- Ensure that projects can successfully continue should a loss of staff occur without a damaging effect on the project
- Develop overall better quality systems
- Improve the way in which projects are controlled and managed
- Allow more effective use of experienced and inexperienced staff and their development
- Make it possible for projects to be supported by computer based tools e.g. computer-aided software engineering systems
- Improve communication between participants in a project so an effective framework is in place

2.3.3 Steps Used in SSADM

The SSADM method involves the application of a sequence of analysis, documentation and design tasks concerned with:

1. Analysis of the current system
2. Outline business specification

3. Detailed business specification

4. Logical data design

5. Logical process design

6. Physical design

1. Analysis of the current system

It is also known as feasibility stage. Analyze the current situation at a high level. A Data Flow Diagram (DFD) is used to describe how the current system works and to visualize known problems. The following steps are part of this stage:

- Develop a Business Activity Model. A model of the business activity is built. Business events and business rules would also be investigated as an input to the specification of the new automated system.

- Investigate and define requirements. The objective of this step is to identify the problems associated with the current environment that are to be resolved by the new system. It also aims to identify the additional services to be provided by the new system and users of the new system.

- Investigate current processing. It investigates the information flow associated with the services currently provided, and describes them in the form of Data Flow Model. At this point, the Data Flow Model represents the current services with all their deficiencies. No attempt is made to incorporate required improvement, or new facilities.
• Investigate current data. This step is to identify and describe the structure of the system data, independently of the way the data are currently held and organized. It produces a model of data that supports the current services.

• Derive logical view of current services. The objective of this step is to develop a logical view of the current system that can be used to understand problems with the current system.

2. Outline business specification

This stage is also known as requirements analysis stage. This stage consists of two parts. The first part is researching the existing environment. In this part, system requirements are identified and the current business environment is modeled. Modeling consists of creating a DFD and Logical Data Structure (LDS) for processes and data structures that are part of the system. In the second part, Business Systems Options (BSO), are presented. One of the options is selected and built. The following steps are part of this stage:

• Define BSOs. This step is concerned with identifying a number of possible system solutions that meet the defined requirements from which the users can select.

• Select BSO. This step is concerned with the presentation of the BSOs to users and the selection of the preferred option. The selected option defines the boundary of the system to be developed in the subsequent stages.

3. Detailed business specification

Sometimes this stage is also called as requirements specification stage. To assist the management to make a sound choice, a number of business system
options, each describing the scope and functionalities provided by a particular development/implementation approach, are prepared and presented to them. These options may be supported by technical documentation such as Work Practice Model, Logical Data Model (LDM) and DFD. They also require financial and risk assessments to be prepared, and need to be supported by outline implementation descriptions. This stage includes the following steps:

- Define required system processing. This step is to amend the requirements to reflect the selected Business System Option, to describe the required system in terms of system data flows and to define the user roles within the new system.

- Develop required data model. This step is undertaken in parallel with the above step. The LDM of the current environment is extended to support all the processing in the selected business system option.

- Derive system functions. During the parallel definition of data and processing, additional events are identified, which cause existing functions to be updated and new functions to be defined. Service level requirements for each function are also identified in this step.

- Develop user job specifications. A Work Practice Model is developed to document the understanding of the user jobs in concern.

- Enhance required data model. Its objective is to improve the quality of the required system LDM by the application of relational data analysis (also known as normalization).

- Develop specification prototypes. It is used to describe selected parts of the required system in an animated form, for demonstration to the users. The
purpose is to demonstrate that the requirements have been properly understood and to establish additional requirements concerning the style of the user interface.

- Develop processing specification. This step is principally concerned with defining the detailed update and enquiry processing for the required system.

- Confirm system objectives. During stage 1 and 3, the requirements will have been recorded, as they are identified, in the user requirements. This step represents the final review of the requirements before the completion of the Definition of Requirements Stage.

4. **Logical data design**

It is also known as logical system specification stage. In this stage, technically feasible options are chosen. The development/implementation environments are specified based on this choice. The following steps are part of this stage:

- Define Technical Systems Options (TSOs): Its purpose is to identify and define the possible approaches to the physical implementation to meet the function definitions. It also validates the service level requirements for the proposed system in the light of the technical environment.

- Select TSO: This step is concerned with the presentation of the TSOs to users and the selection of the preferred option.

5. **Logical process design**

In this stage, logical designs and processes are updated. Additionally, the dialogs are specified as well. The following steps are part of this stage:
• Define user dialogue. This step defines the structure of each dialogue required to support the on-line functions and identifies the navigation requirements, both within the dialogue and between dialogues.

• Define update processes. This is to complete the specification of the database updating required for each event and to define the error handling for each event.

• Define enquiry processes. This is to complete the specification of the database enquiry processing and to define the error handling for each enquiry.

6. Physical design

The objective of this stage is to specify the physical data and process design, using the language and features of the chosen physical environment and incorporating installation standards. This stage includes the following activities:

• Prepare for physical design.

• learn the rules of the implementation environment;

• review the precise requirements for logical to physical mapping; and

• plan the approach.

• Complete the specification of functions.

• Incrementally and repeatedly develop the data and process designs.

SSADM techniques
**Logical Data Modeling** – This is the process of identifying, modeling and documenting the data requirements of the system being designed. So here the data requirements of the system being designed are identified, modeled and documented. The data are separated into entities (things about which a business needs to record information) and relationships (the associations between the entities). Once the database model is identified, the conceptual design can be mapped to the logical design that is tailored to the selected database model. In the logical design stage, the conceptual design is translated into internal model for the selected database management system. This includes mapping all objects in the model to the specific construct used by the selected database software. The logical design transforms the software-independent conceptual model into a software dependent model.

**Data Flow Modeling** – It is the process of identifying, modeling and documenting how data moves around an information system. Data Flow Modeling examines processes (activities that transform data from one form to another), data stores (the holding areas for data), external entities (what sends data into a system or receives data from a system), and data flows (routes by which data can flow). It also concerned with how the data moves around the information system.

**Entity Behavior Modeling** – The identifying, modeling and document events with respect to the entities in the system and the order in which these events take place.

**The Steps**

SSADM is a waterfall view approach whereby there are sequences of events that run in series and each step leads on from the last. There are five steps in total and each step can be broken down further. The steps are:

1. **Feasibility study** – To determine whether it is cost effective to go ahead with the system and whether it is actually possible.
2. **Requirements Analysis** – Identifying of the requirements and needs of the system and modeling these needs in terms of the processes carried out.

3. **Requirements Specification** – The functional and non-functional requirements are identified in detail.

4. **Logical System Specification** – Technical systems options are created and the logical design of the system created. This includes the design of update and enquiry processing.

5. **Physical Design** – The logical system specification and technical system specification is used to design a physical database and set of program specifications. For each of the above stages SSADM defines techniques and procedures for recording and communicating the information. This includes both textual and diagrammatic representations.

2.3.4 **Benefits of SSADM**

**Timelines:** Theoretically, SSADM allows one to plan, manage and control a project well. These points are essential to deliver the product on time.

**Usability:** Within SSADM special emphasis is put on the analysis of user needs.

Simultaneously, the systems model is developed and a comprehensive demand analysis is carried out. Both are tried to see if they are well suited to each other.

**Respond to changes in the business environment:** As in SSADM documentation of the project’s progress is taken very seriously, issues like business objectives and business needs are considered while the project is being developed. This offers the possibility to tailor the planning of the project to the actual requirements of the business.
Effective use of skills: SSADM does not require very special skills and can easily be taught to the staff. Normally, common modeling and diagramming tools are used. Commercial CASE tools are also offered in order to be able to set up SSADM easily.

Better quality: SSADM reduces the error rate of IS by defining a certain quality level in the beginning and constantly checking the system.

Improvement of productivity: By encouraging on-time delivery, meeting business requirements, ensuring better quality, using human resources effectively as well as trying to avoid bureaucracy, SSADM improves the overall productivity of the specific project and the organization.

Cuts costs: SSADM separates the logical and the physical systems design. So the system does not have to be implemented again with new hard -or software.

2.3.5 SSADM in Context with the Business Situation

After discussing various aspects of SSADM, advantages as well as disadvantages have been identified. And these are closely related to the stability of the business situation of the organization. It can only profit from the advantages that SSADM provides, such as better quality (due to the review of each stage) or meeting the requirements more exactly (due to emphasis on the requirements analysis stage), when the following criteria are met: First of all the volume and the time that is at disposal must be large enough to undergo the whole development process. Secondly, the short-term business situation is not supposed to change drastically, because SSADM does not intend to change the specifications that were made in advance after the review of the stage had been completed. This fact can lead to the problem that the end result deliver does not meet the business requirements at the point of time when it is delivered. Considering the long-term situation, SSADM has shown
that it increases the overall quality of Information Systems within an organization. The fact that SSADM has become the imperative development methodology for government departments and their suppliers of IS proves this fact. However, it must be considered that SSADM was developed especially for these kinds of companies and that government projects, in general, have enough time, money and human resources to cope with the bureaucratic nature of SSADM. This SSADM we have applied when we have designed and developed the information system.

2.3.6 Disadvantages of SSADM

SSADM puts special emphasis on the analysis of the system and its documentation. This causes the danger of over-analyzing, which can be very time and cost consuming. Due to various types of description methods, checks of consistence cannot be carried out. Especially with large systems, the outline diagram can become very unclear, because all relevant data flows have to be included. However, large companies carrying out various projects can profit from the fact that SSADM gives the possibility to reuse certain techniques and tools for other projects. This reduces cost and time spent enormously in the long run. Hence, the danger of spending too much money on analysis can be compensated by the reuse of the developed systems and experience gained. Again it has some important properties like it has definite sign-off points where some activities need to be terminated. All of its activities are performed in a strict sequence. One phase must be completed before the next phase starts and no phase can be repeated. It assumes that one can develop and specify a system in a top-down manner. Successive phases elaborate the system in increasing detail where each phase defining a partial solution and then calling for a more detail evaluation in the next phase. In real life situation it is seen that the assumptions made in the early phases no longer hold due to some work at the earlier stage was incomplete or something was overlooked or not completely understood.
Consequently it may be necessary to return at the earlier phase and redefine an objective or redo some of the earlier work. One more problem with this technique is arising of loopiness. It arises by default because something was overlooked in the original plan. It requires wasteful rework of earlier phases which consumes extra cost and needs to be avoided.

2.3.7 The Other Methods of System Design

The other methods for system development available in the literature are structured analysis, staged development, prototyping, evolutionary development using the spiral model (Boehm, 1988) etc.

Structured Analysis Development

Many information systems specialist acknowledge the difficulty of understanding large and complex systems completely. The structured analysis development method is aimed at overcoming that difficulty through partitioning the system into components and constructing a model of the system (see DeMarco, 1978; Keller, 1983). It consists of elements of both analysis and design. Structured analysis focuses on specifying what the system or application is required to do. It does not state how the requirements should be accomplished or how the application should be implemented. Rather it allows individuals to see logical elements apart from the physical components it uses (see Gane et. al, 1979). Afterwards a physical design is developed that will be effective for the situation in which it is to be used. The major elements of structured analysis are graphic descriptions, data flow diagrams and a centralized data dictionary.

Staged Development

This method of development can be applied where breaking up the problem into a number of subsystems is possible. Here the first step may be a global concept phase
that decides the size of the development project. Such a study may suggest that the project is extremely big and it should be developed in stages. The next step of this method is to break up the whole project into a number of phases. Each phase is developed using linear cycle and each subsystem is developed separately with its own problem definition phase. It is also necessary to get a detailed assessment and plan for each stage and also to evaluate the feasibility of integrating the module produced in each stage with the module developed in the next stages.

**Use of Prototyping in System Development**

Frequently designers are faced with the difficulty of specifying operations that cannot be specified accurately using models. Imprecise systems occur when it is impossible to develop a exact system specification. This often happens in organizations that are just starting to use computers without having any prior experience. Alternatively it is more appropriate to develop the system gradually, knowing the system capabilities. Prototyping is often used in system development to clarify user requirements in imprecise systems (see Alavi, 1984 and Anriole, 1992). A decision to use prototyping is usually made in the feasibility phase. It is used to gain a better understanding of possible solutions and the prototype then becomes the requirement model in the system specification phase (see Naumann, 1982).

**Evolutionary Development**

It is another way to design systems that cannot be accurately specified. It combines the elements of staged design and prototyping. It develops the whole project as a number of stages and the outcomes of one stage serving to identify the conceptual solutions for the next phase. It is therefore often experimental in nature where development starts with some petite part of the system. It does not assume the subdivision the problem into separate and slackly coupled stages and design the
system in one pass through these phases, as in the case of staged development. Alternatively, the system is developed gradually. Here, we develop a system component and learn more about the problem from the operation of that component. Subsequently we use knowledge gained from this process to define the next part to be developed. In evolutionary design each step adds a new competence to the system. The experience gained with a system is used to characterize the requirements for the next step. The latter extends system capability a little bit further and the process continues until no further improvement appears possible or sensible. The problem that is particularly vulnerable to the evolutionary approach is decision support systems where the connections used to support the decision-making cannot be precisely predicted and an experimental approach is needed.

The Spiral Model

One prescribed method to evolutionary development is spiral model. The design of the spiral model shows the system development procedures by the improvement of successive prototypes each new prototype adding extra functionality and being integrated with the earlier prototype. The assessment at this stage can consider the risks and concentrate on eliminating risk in parts at each prototype rather than a whole. The system developed progressively by successive developments of prototypes considering risk analysis to establish the most expected path to successful development (see Boehm, 1988).

Different kinds of problems usually call for different problem solving cycles and it is important to choose the most suitable cycle for a given problem. The choice is influenced by the nature of the problems which are as follows:

- The degree of system structure
- Familiarity with the technology and
**Project size**

Linear cycles are usually best suited to problems which are well understood and highly structured in these cases it is possible to make accurate predictions about system behaviour in the early design stages and to proceed towards a problem solution in a sequence of well defined steps. Problems that are unstructured and harder to understand require more experimentation in the early stages. The evolutionary or prototype approaches become attractive for these problems. Familiarity with technology also influences the choice of problem solving cycles. If one is familiar with the technology, better predictions can be made earlier and the linear cycle becomes more attractive. New and unfamiliar technology calls for more early experimentation. Problem size also affects the choice. The most pressing needs for some problems is to produce early results and mention user commitment to the project. A staged development approach is often attractive for large problems.

### 2.3.8 Our Choice of Information System Design

From the methodology available in the literature we have adopted the method of linear cycle, structured analysis, prototyping and staged development for the development of our system because port is a large organization. We have used extensive prototyping and opt for continuous improvement in systems development because it shows respect for the users which make them happy. It is more responsive to user ideas and suggestions than the conventional formal system development. The other reasons behind selection of abovementioned methods are feasibility as well as technological aspects of the development. To develop a system that we are going do, first of all we need to see feasibility of the project and then the technology to develop the system. The methods we mentioned consider both the aspects of development. Above all, considering the cost aspect of the development of the information system we have selected the said methods. Because these
methods are the most cost effective methods in our context. Besides that, the elements of the methodology we have adopted for our study are as follows:

- Formalization of the subject domain and functionality
- Formalization of the systems design problem
- Criteria of efficiency and constraints
- Spatio-temporal characteristics of information flows
- Heuristic model for designing solutions and efficiency assessment

Features of the chosen methodology include subject domain, formalization principles, and heuristic software environment. In order to cater the research work in a systematic manner, first of all we should specify the subject domain, which includes the following:

- Determination of the information environment.
- Input variables
- Principal variables

It is necessary to formalize a physical object because it determines a certain environment in which the created computer system will work. In this regard, a distinctive feature of the methodology is the identity of the approach to formalize a physical object and the approach to formalize a computer system. It allows us, to a certain extent, to simplify the formalization tasks. Formalization suggests a certain hierarchy in representation of an object and a computer system. Transition from lower levels of the hierarchy to higher levels is called abstraction. Accordingly, transition from higher levels of the hierarchy to lower levels is called interpretation.
When the objectives of the computer system, its functionality and constraints on the implementation are formulated, there is an emerging problem of initial formalization of an object or process, on which or with which the system will work.

At this initial stage, a certain initial model is formed. As a rule, this model includes three main parts.

1. Initial descriptions, which usually represent the entire range of information available to the researcher about an object or system. Naturally, a part of this information is simply unnecessary and some important part of the information, from the researcher point of view, may be missing.

2. Selection of principal variables is the first stage of abstraction, when the researcher, according to the objectives of the systems design, determines a list of variables, with which the system will work.

3. Data specification - data, which describes the dynamics of principal variables designated for the system.

Initial model actually sets some "language" for the description of initial data. In this sense, this model is the information interface between the actual physical world and the formal description of the object. It is the foundation for further abstraction and an information "window" into the concepts of actual physical object for the tasks of interpretation.

Initial model is called "initial", because it is only the first level of a hierarchy of formal descriptions. The ultimate goal (the topmost level of hierarchy) is the design of a complex heuristic model to study the interaction of the physical object and the created computer system. The amount of hierarchical levels of formalization and their specific content depends on the complexity of the created system and the complexity of physical object.
However, as a rule, it is necessary to have a hierarchical level specifying the data models. It is also necessary to have a hierarchical level specifying the approximation of stochastic information flows according to appropriate distributions.

Computing experiments with Heuristic models are controlled within the frameworks of custom developed scenarios. These scenarios take into account the entered criteria of efficiency and existing constraints. Outcome of the computing experiments are some valuations of system parameters of the designed system. Interpretation of these valuations allows us to prepare the necessary recommendations on rational architectural solutions for the specific system. Using the obtained recommendations, we can design an information system satisfying existing constraints and the most capable of solving the formulated problems.