Defence Science Journal, Vol. 56, No. 1, January 2006, pp. 5-12

Requirements Analysis Spiral

Rajendra Prasad

Research Centre Imarat, Hyderabad–500 069

ABSTRACT

Requirements symbolise the need or the set of needs for triggering the development process of the system. The system developed must follow the law of the requirements. Capturing the requirements of a system is a challenge. It is both subjective and objective process. The realistic and comprehensive requirements should be evolved as early as possible during the development cycle of the system. Many a times, it may not be possible to freeze the requirements in a single cycle. This may require a number of iterations. A template has been evolved for speeding up the capturing process of requirements. Requirements analysis spiral (RAS) developed helps in evolving the requirements.

The development of the system or the product cannot wait till the requirements have matured, and further, it is also an evolving process. Therefore, continual models of the system have to be developed for achieving the maturity of the system. RAS can be used to freeze the requirements for the initial model and the subsequent models till the maturity of the system is achieved, both in terms of requirements and quality. The paper illustrates the application of RAS for evolving the frozen and matured requirements through a case study.

Keywords: Requirements, requirements analysis spiral, CRANE cycle, law of requirements, RAS

1. INTRODUCTION

A system is developed to fulfil a need or a set of needs. The system developed must follow the law of the requirements. For the fulfillment of the human needs, the needs and the requirements must be congruent. Requirements symbolise the need or the set of needs for triggering the development process of the system. Capturing the requirements of a system is a challenge. It is both subjective and objective process. The quality of a system developed corresponds to the fact that how realistic and comprehensive are the requirements. The realistic and comprehensive requirements should be evolved as early as possible during the development cycle of the system. Many a times, it may not be possible to freeze the requirements in a single cycle. This may require a number of iterations. A template has been designed for speeding up the capturing process of requirements. Requirements analysis spiral (RAS) developed helps in evolving the requirements. The development of the system or the product cannot wait, till the requirements have matured, and further, it is also an evolving process. Therefore, continual models of the system may have to be developed for achieving the maturity of the system. RAS can be used to freeze the requirements for the initial model and the subsequent models till the maturity of the system is achieved, both in terms of requirements and quality.

Received 04 October 2005

2. REQUIREMENTS ANALYSIS SPIRAL

Requirements analysis spiral or CRANE cycle has been described in Fig. 1. RAS consists of the following steps:

I CAPTURE

- I A Identify the requirements
- I B Analyse the requirements
- I C Formulate the requirements

II REVIEW

- II A Brainstorm the requirements
- II B Review the requirements

III ANALYSE

- III A Analyse the reviewed requirements.
- III B Re-formulate the requirements.

IV FREEZE

- IV A Deploy the requirements in the prototype.
- IV B Field analyse the prototype.
- IV C Identify the new requirements, else freeze..

RAS is a spiral because one enters the spiral with identified requirements (new) and iterate the sequence as per the sequence of RAS till the requirements are frozen. A template, as per *Appendix* 1

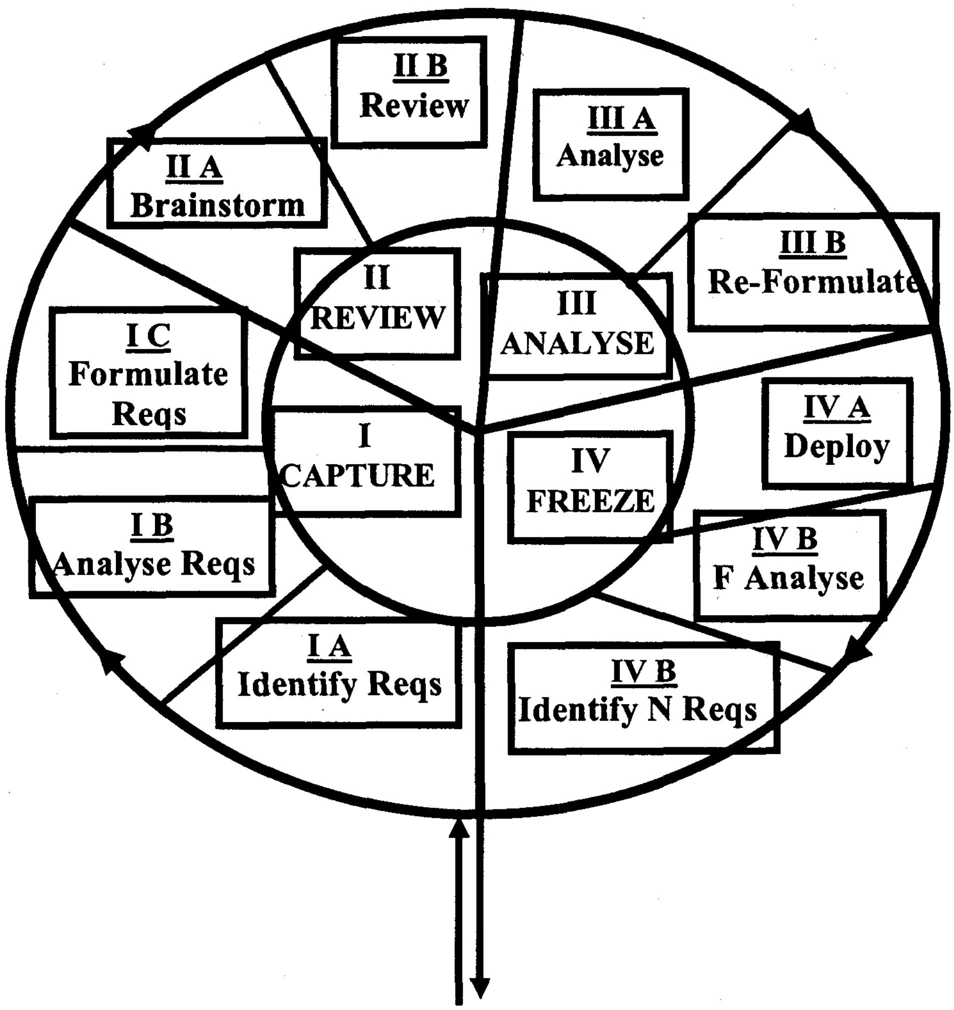

Figure 1. Requirements analysis spiral

has been evolved for speeding up the capturing process of requirements. The main purpose of the RAS is to establish and ensure realistic and comprehensive requirements as early as possible during the development cycle of the system or the product. Thus, RAS precipitates in freezing the requirements.

3. APPLICATION OF RAS

There was a requirement for a dc-dc converter. The input was the battery supply varying from 18 V to 36 V and the expected output was 28 V. It was required to draw the requirements for the dc-dc converter for outsourcing for aerospace applications.

The following explains the way RAS may progress:

I A **Identify** : Input: 18–36 V
Output: 28V

I B **Analysis** : Output accuracy to be spelt

I C **Formulate** : Input: 18–36 V
Output: 28 ± 1V

II A **Brainstorm** : (a) Regulation for input voltage variation
(b) Effect of internal disturbances

II B **Review** : (a) Regulation value for input voltage variation to be spelt
(b) Effect of internal disturbances because of intraelectromagnetic interference, such as, transients, surges, etc, to be spelt out.

III A **Analysis** : (a) Regulation: 0.5 %
(b) Transient: 300 mV
(c) Surge: 150 mV
(d) Ripple: 20 mV_{rms}

III B **Re-formulate**: Input: 18–36 V
Output: 28 ± 1 V
Regulation: 0.5 %
Transient: 300 mV
Surge: 150 mV
Ripple: 20 mV_{rms}

IV A **Deploy** : Deployed

IV B **Field Analysis**: (a) Load regulation required
(b) Short-circuit protection

IV C **Identify New Requirements**:
(a) Load regulation
(b) Short-circuit protection

Based on the new identified requirements, RAS cycle may be iterated as follows :

I A **Identify** : Input: 18-36 V
Output: 28 ± 1 V
Load/line regulation : 0.5 %
Transient: 300 mV
Surge: 150 mV
Ripple : 20 mV_{rms}
Short-circuit protection to be provided

I B **Analysis** : (a) Effect of internal disturbances may be given as noise
(b) Over and under voltage and reverse polarity protection

I C **Formulate** : Input: 18-36 V;
Output: 28 ± 1 V
Load/line regulation : 0.5 %
Noise: 250 mV
Short-circuit, over and under voltage, and reverse-polarity protection to be provided

II A **Brainstorm** : (a) Input-output-base isolation

		(b)Various environment:– electromagnetic, climatic, dynamic, etc
		(c)Efficiency
II B **Review** (To be spelt)	:	(a)Input-output isolation
		(b)Various environment:– electromagnetic, climatic, dynamic, etc
		(c)Efficiency
III A **Analysis**	:	(a)Input-output isolation: 3000 V_{rms}
		(b)Various environment:– electromagnetic, climatic, dynamic, etc.
		(c) Efficiency: Min 90%
III B **Re-Formulate**	:	Input: 18-36 V
		Output: 28 ± 1 V
		Load/line regulation: 0.5 %
		Noise: 250 mV
		Efficiency: Min 90%
		Input-output
		isolation: 3000 V_{rms}
		Short-circuit, over and under voltage, and reverse-polarity protection to be provided. Various environments:– electromagnetic, climatic, dynamic, etc.
IV A **Deploy**	:	Deployed
IV B **Field Analysis**	:	(a)Input-output-base isolation
		(b)Thermal behaviour
		(c)Reliability
		(d)Current limit
IV C **Identify New Reqirements**	:	Input-output-base isolation
		Thermal behaviour, such as between base-to-sink, case temperature
		Reliability in MTBF
		Current limit during operation

Once the requirements are frozen/sealed, one may come out of the RAS. However, new requirements may be added depending upon the application, eg, requirement of radiation hardening for space application, requirement of EMP for application in nuclear environment, etc.

4. BENEFITS OF RAS

Requirements analysis spiral provides many benefits. These benefits have an impact on development and productivity, testing and quality, and the organisation. One gets these benefits during the development of new systems as well as during maintenance of the existing systems.

4.1 Impact on Development & Productivity

The most visible benefit of RAS is faster and higher quality requirements analysis. A full set of requirements allows an analyst to identify all the conflicts between user requirements upfront. Identifying all unanswered questions and getting answers to those questions early, saves the time and effort spent in producing the wrong product and the time and effort spent reworking the product which was based on the poor requirements. A good set of requirements also represents a single source of a system's requirements. It means that all the functions a system performs to meet a set of user needs can be found at one place.

A good set of requirements provides a foundation to begin design. The analyst's two primary customers speak two different languages. The user is interested in seeing the business from the system use point of view. The developer wants to understand the structure and dynamic behaviour of the system to ensure that the design accomplishes what the user, wants. A good set of requirements provides a direct mapping, from the requirements as expressed in the language of the user, to the requirements as expressed in the language of the developer.

4.2 Impact on Testing & Quality

Requirements analysis spiral helps decrease a new team member's learning curve. Ideally, a good set of requirements provides three views: an abstract view from the user's eyes, a structural (static) view from a system architect's eyes, and a dynamic view from the developer's eyes. A new team member can then quickly learn to use the system, while at the same time, understanding the structure of the system. With the big picture firmly in place, a new team member can use a good set of requirements to develop into specifics without losing perspective.

Requirements analysis spiral also facilitates faster and more systematic testing. The tester can learn the system quickly, much as a new team member would. The tester can then build test cases from the user's point of view to organise his approach operationally. However, a good set of requirement helps the tester understand what the system must do, under what conditions, to fulfil the user's requirements. A good set of requirements must allow the tester to understand and test all the conditions under which the user may operate the system.

4.3 Impact on the Organisation

Finally, RAS provides a safe store of a company's intellectual property. Many system functions are easy to duplicate. However, it is almost impossible to understand the intricacies of the most complex systems. This situation can be further exacerbated with the changes introduced over time. Building and maintaining the system becomes incredibly expensive and error-prone if one cannot understand the full set of requirements.

5. CONCLUSIONS

A system is developed to fulfil a need or a set of needs. The system developed must follow the law of the requirements. For the fulfillment of the human needs, the needs and the requirements must be congruent. requirements symbolise the need or the set of needs for triggering the development process of the system. Capturing the requirements of a system is a challenge. It is both subjective and objective process. The quality of a system developed corresponds to the fact that how realistic and comprehensive are the requirements. Requirements analysis spiral developed helps in evolving the requirements. The development of the system or the product cannot be postponed, till the requirements have matured, and further, it is also an evolving process. Therefore, continual models of the system may have to be developed for achieving the maturity of the system. RAS can be used to freeze the requirements for the initial model and the subsequent models till the maturity of the system is achieved, both in terms of requirements and quality.

Contributor

Rajendra Prasad joined DRDO in 1972. He is BTech from the Indian Institute of Technology Delhi, New Delhi, and ME from BIT, Ranchi. He Joined DRDL and presently he is the Director, R&QA at the Research Centre Imarat (RCI), Hyderabad. He has been involved in the development of inertial sensors and dc-dc sensor packages for IGMDP as Head, Inertial Sensors Division. He has worked in the development of inertial guidance and control systems. He was Project Manager for the development of strapped down inertial navigation system for *Prithvi* at the Hindustan Aeronautics Limited (HAL) and the Tata Electric. He was System Manager (QA) for the maiden flights of *Prithvi* and *Agni*. He has been responsible for the qualification testing and evaluation of *Prithvi* and its subsystems for design certification. He piloted ISO 9001: 2000 Accreditation for the RCI. He managed development and quality of fire control systems of *Brhamos*/PJ 10 and K 15, and Instrumentation System of k15. He also piloted IS 16000 : 2004 Standard–Aerospace quality system requirements. His areas of interest are: System engineering, control and guidance, quality system in R&D, and Quality management for life cycle of aerospace systems. He has 40 papers and four books to his credit. He is the Chairman, Organising Committee, CONQUEST-2006.

APPENDIX I

TEMPLATE FOR IDENTIFYING THE REQUIREMENTS

1.0 *Defining scope*: To give description of system, specifications (electrical,mechanical, environmental) test procedures, test instruments and test jigs required, acceptance test reports.

2.0 *List of abbreviations, symbols, etc*

3.0 *List of tables (if, any)*

4.0 *List of drawings (if, any)*

5.0 *List of standards (if, any)*

6.0 *Applicable documents (if, any)*

7.0 *Introduction:* To give brief description of system highlighting its features.

8.0 *System description*: To be given in the form of a block diagram, describe top-level functionality, individual subsystem level functionality, and interactions among subsystems to realise top-level system functionality (including detailed description of individual subsystems with the help of schematics).

9.0 *Requirements*: Requirements can be arbitrarily, classified as functional, interfaces, norms, and endurance.

9.1 *Functional*: Functional requirements can be arbitrarily, classified as input, transfer parameters and output. Input initiate the design; design based on input generate transfer parameters to ensure the required output.

9.1.1 *Input*

(a) Operational

(b) Physical

(c) Constraints

(d) Restraints

9.1.2 *Transfer Parameters*

(a) Mechanical

(b) Electrical

(c) Testability, etc

9.1.3 *Output*

9.2 *Interfaces*

(a) Mechanical

(b) Electrical

(c) Ergonomic

(d) Testability

9.3 *Norms*

(a) Good design practices

(b) Safety

(c) Statutory, etc

(d) Maintenance, etc

9.4 *Endurance*

9.4.1 *Environmental*

(a) Dynamic

(b) Climatic

(c) Electromagnetic

(d) Chemical

(e) Biological, etc

9.4.2 *Life*

(a) Time, number of cycles, number of pulses, distance run, number of counts, etc.

9.4.3 *Reliability*

(a) Reliability, MTBF / failure rate, etc