Data Management and Communications Plan for Research and Operational Integrated Ocean Observing Systems

Part III. Appendices

Appendix 5. System Engineering Approach

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The other sections of this document describe a wide variety of requirements that represent a diverse group of stakeholders. The resultant complexity would likely render ineffective any uncoordinated approach to satisfying these requirements. Accordingly, there is strong evidence that the Data Management and Communication Subsystem of the Integrated Ocean Observing System can only be accomplished using a formalized System Engineering process. The following provides a brief description of three System Engineering process models and recommends the approach that should be used for the DMAC development and integration. The three process models discussed are the Waterfall Model, the Rapid Prototype Model, and the Spiral Model.

The Waterfall Model is the most commonly used approach for major acquisition systems over the past several decades. Under this approach there are a series of steps that will have to be achieved from system concept to system operations and all will be preformed in series, not in parallel. The transition from each step to the next is only accomplished after successful completion of a very structured review process. Table 1 shows the typical process steps and corresponding reviews for each phase in the Waterfall Model.

Table 1. Typical process steps and reviews for Waterfall Model

	Task/Step	Review
1.	Requirement Definition	System Requirement Review
2.	Analysis	Risk Assessment Review
3.	Design	Preliminary/Critical Design Reviews
4.	Coding	Walk Through Review
5.	Testing	Technical Evaluation Review/Operational Evaluation Review
6.	Operations	Initial Operational Capability

For each task and review there are many structured documents that are prepared, reviewed, and maintained for the life of the system. The highly structured nature of the waterfall method makes it quite applicable for large well-defined projects. This linear approach has been adopted by the Department of Defense for major acquisition programs (DoD Instruction 5000.2-R).

The third process model to be considered is the Spiral Model. This model accommodates the waterfall "task-oriented" highly structured approach while allowing rapid prototyping and risk-analysis to be performed at juncture points of the project. Another difference between the waterfall approach and the Spiral Model is that in the former, all requirements are known up front and are all developed throughout each step; in the spiral model selected requirements are chosen for devel-

opment through requirements to operations. Then more requirements are added and the process from requirements to operations is repeated through this "spiral" until all requirements are accomplished.

A variant of the spiral model is the phased approach. In this method, the system requirements are allocated to phases where a preceding phase may have influence on the subsequent phase requirements. The phases can be executed using a waterfall-like process, i.e. with requirements specification (or update), analysis and design, system development, and verification performed for each phase. Each phase (sometimes referred to as effectivity), then, would represent a complete end-to-end execution of a subset of the requirements.

Figure 1 illustrates the tasks and sequence associated with each phased cycle in the spiral model. After steps one through seven additional requirements are specified and the cycle is repeated.

Figure 2 represents a full-blown project implementation following the Spiral Model; this implementation includes the formalism of the Waterfall Model.

Table 2 compares all three types of process models. Based on a review of the Data Management and Communication Subsystem requirements and a view of the Comparison Table it is recommended that the Spiral Model for Systems Engineering be selected.

A phased approach that would fit this purpose is shown in Figure 3.

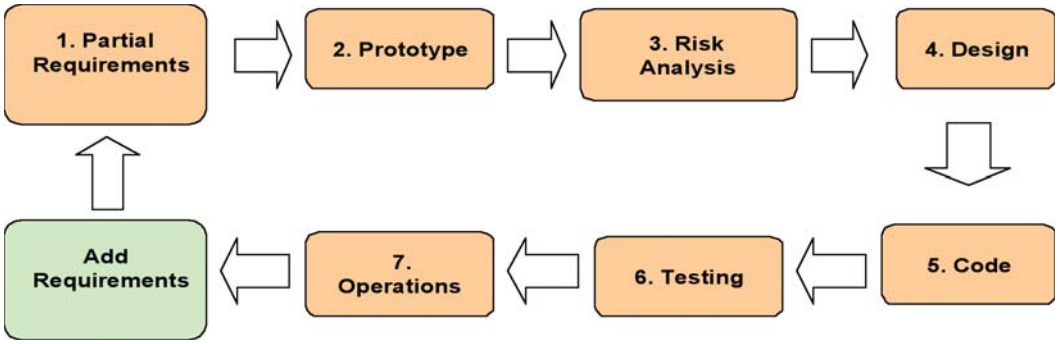

Figure 1. Tasks and sequence cycle for Spiral Model

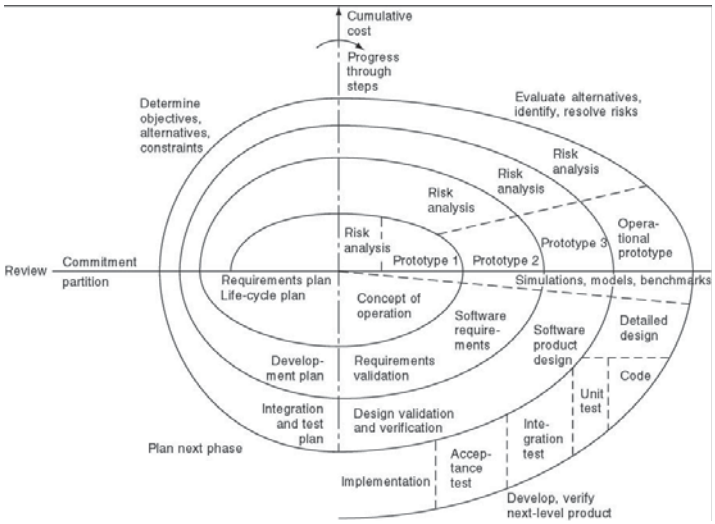

Figure 2. Full Spiral Model

Table 2. System Engineering comparison of Waterfall, Rapid Prototype, and Spiral Models

Waterfall Model	Rapid Prototype Model	Spiral Model
Pro	**Pro**	**Pro**
Documentation	Allows frequent changes	Risk analysis preceding each phase
Maintenance easier	Helps define user requirements	Allows for changing requirements
Quality product at finish	Rapid return on investment	Allows prototyping
Con	**Con**	**Con**
Specification document	Increased maintenance costs	Once risk cannot be mitigated the project is terminated
Have to get it right first time	How do you know you are finished?	Not effective for large-scale projects
Does not allow for prototype	Build-and-fix	
Time consuming		
Costly		
Hard to accommodate		
Doesn't accommodate new requirements		

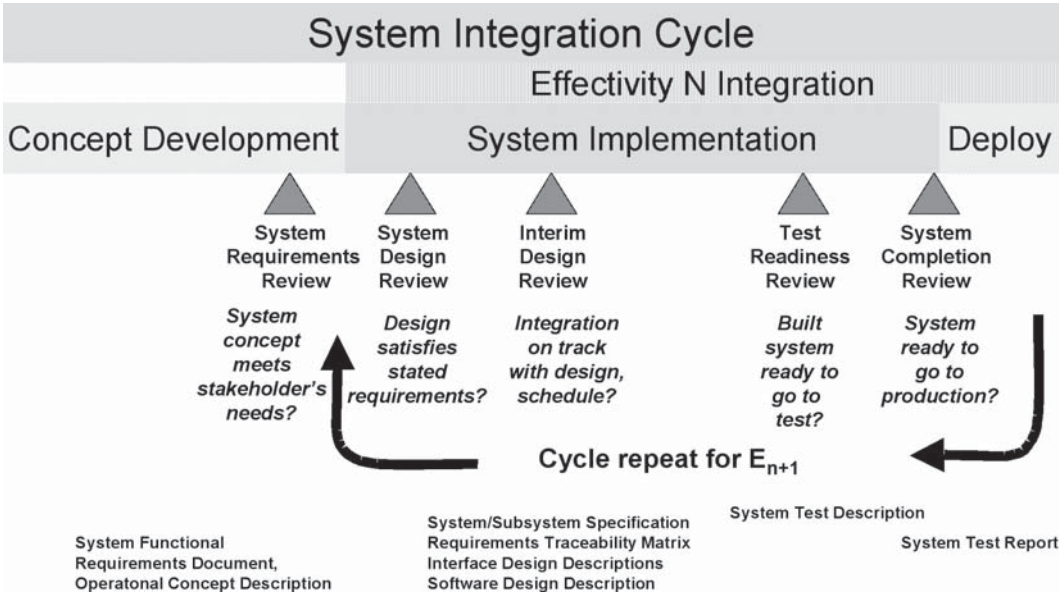

Figure 3. System Integration Cycle for the Spiral Model