Establishing a Requirements Management Process

Integrated Chipware Technical Paper

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Abstract

This paper describes a general requirements management process that you can tailor to fit your organizational and project needs. It probably overlaps in significant ways with what you already do; it may provide additional ideas or structure them differently.

As a discipline, Requirements Engineering is about developing requirements and managing them. The figure below shows a decomposition of Requirements Engineering into development, management, and their component activities. Requirements Development is focused on elicitation, identifying end user and product needs, refining concepts and ideas extracted from elicitation activities, and ensuring that those have been formulated correctly. These activities are aimed at arriving at establishing detailed objectives for an engineering effort.
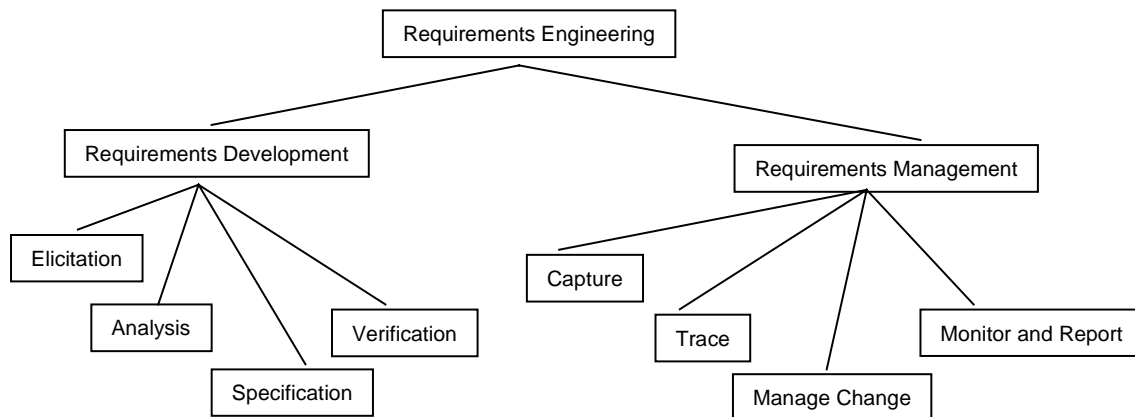
Requirements Engineering decomposed

Assuming that requirements development efforts result in a representation of the technical objectives, the goals of requirements management are simple. The foremost goal is to ensure that requirements are a central focus of the engineering activity, driving what is done as well as what is not done. An effective requirements management process preserves and promotes a shared vision of engineering objectives by facilitating communications among stakeholders. The consequences of inadequate requirements management are blown project budgets and schedules, inadequate products, dissatisfied customers.

Viewed as a black box, the inputs to requirements management are:

- Statements of requirements as identified by requirements development activities
- Issues with existing requirements that need to be recorded and resolved
- Proposed changes to existing requirements

- Information about design, code, and test artifacts that need to be related to requirements
- Requests for analysis and information about requirements and their interrelationships such as the connections between different kinds of requirements or the linkages between requirements and other engineering work products

The outputs or results of requirements management are:

- A populated repository of requirements and related data
- Reports that provide information to managers and engineers about the evolving body of requirements data

The key activities of requirements management are capture, managing change, tracing requirements to other data, communicating about the managed requirements, and monitoring the process to track progress and assess effectiveness. The description also starts with a planning activity that will help you to prepare for the other activities. In the activity descriptions below, a brief description of the activity is followed by a set of questions designed to help you identify specific issues to be addressed or information to be produced by the activity.

The items below present these key activities and their component tasks in a hierarchical way to give you a thumbnail sketch of the process:

Plan the requirements management activity

- Identify requirements inputs
- Determine stakeholder roles
- Determine the work products
- Determine the monitoring needs
- Determine the kinds of information to be managed
- Establish the infrastructure to support the plans
- Adjust plans based on progress and external events

Gather, capture, and record requirements and related data

- Obtain official requirements inputs
- Establish and populate repository
- Refine, evolve, add and remove data as needed

Manage change

- Protect the repository
- Establish baselines
- Analyze, comment, negotiate
- Propose changes

- Analyze impact of proposed change
- Review and disposition proposed changes

Establish and maintain traceability among the data

- Define permissible and required linkages among requirements
- Define linkages to non-requirements artifacts
- Connect artifacts as appropriate
- Update linkages as needed

Monitor the activity

- Measure progress
- Measure completeness and consistency
- Measure effectiveness
- Report on content, quality, and progress

To apply or adapt this process to your situation, you will need to consider how your organization functions, and whether or how the activities described here can be performed in your environment. When you use automated support, such as is provided by RTM, you need to determine how much formality and enforcement is necessary and scale accordingly. If your organization is just getting started with automated requirements management, don't fall into the trap of trying to adopt and automate everything all at once. Start simply and evolve instead. If, on the other hand, your organization has a lot of experience with requirements management, it might be useful to consider the mapping between this process description and yours.

Plan the Requirements Management Activity

Planning occurs both before and during the actual requirements management activity. In engineering as in most of life, plans are just that, plans. Rarely does everything go exactly according to an initial plan. It is vital, however, to scope out your requirements management activity so that you know what you are getting into. With a plan, you can manage the activity within resource budgets, and are able to ensure that you have the necessary tools, facilities, and resources at hand when they are needed.

Initial requirements management planning activities include determining the basic parameters that will help you organize the effort. Determine how much and what kinds of information will be managed; who will be responsible for its quality, integrity, and accuracy; what kinds of

information will be needed or produced as a result of requirements management; and what mechanisms you will use to accomplish the job.

Later planning activities include adjusting or expanding existing plans and accommodating unforeseen events. As your project evolves, initial assumptions about the size and scope of the requirements management activity may be invalidated and you will have to adjust the effort accordingly.

The following list of planning activities includes questions that may help you to scope the requirements management job. Each activity in the list represents information gathering and structuring tasks that will affect the overall quality of the actual requirements management job.

Activity: Identify requirements inputs

Requirements inputs come in many forms. Your project may use any of a large number different methods for eliciting requirements, such as prototyping, Joint Application Design (JAD), brainstorming, customer councils or user groups, and market surveys. Your own project team will provide additional requirements as they perform review and analysis as part of their assigned tasks. These are activities designed to identify the actual requirements themselves. From the requirements management perspective, the results of using these methods must be recorded and preserved. Documents of varying types and degrees of formality will likely be inputs to requirements management.

Find answers to the following questions:

Who are the stakeholders in your engineering activity? A stakeholder is someone who has an interest in the outcome of the activity, and therefore is likely to affect it in some way. Examples include users, sponsors, systems engineers, designers, developers, QA engineers, test engineers, and so on. These individuals may provide actual requirements content in documents or may contribute content and issues through review. What are their concerns? How will the requirements management activity absorb their input and address their needs? How will those stakeholders communicate their needs or other input? How will that input be fed into the requirements management activity?

How is requirements information represented? In many environments, users or sponsors provide operational requirements. Sales and Marketing departments may contribute business requirements. Existing systems or products may also be a source of requirements. Government or

corporate regulations or standards may also provide requirements or constraints. How will your engineering activity receive this information? In what format will it be delivered?

How will stakeholders participate in the project? How will they communicate with the project? How much access to requirements data will they need? Will they generate it? If so, how often will you receive updates? Will they review requirements? Are they trusted users inside your corporate firewalls or are they external? How much will you reveal to external stakeholders?

Activity: Determine stakeholder roles

Defining stakeholder roles allows you to group individuals into categories according to the kinds of tasks they perform. The primary purpose of role definition is to codify the rules governing who can do which tasks and when they can do them. A secondary benefit from role definition is input on tool and data access needs.

Which stakeholders define requirements? Will this change over time? Especially in the early stages of a project, informal approaches work well to encourage the flow of ideas and to support requirements gathering activities. As the project team grows and the requirements take shape, most projects reach a point at which it becomes important to establish a baseline and a change authority: what's in, what's out, and who makes the decisions about it.

Which stakeholders make requirements decisions? Who decides what is in or out, and what is the priority of each requirement? What are the criteria for making these decisions? How are the needs for decisions communicated to those decision-makers?

Which stakeholders are authorized to change baselined requirements? Once the project has reached a certain threshold, it's time to establish a baseline and carefully control any changes. The individuals responsible for the actual data management are likely to be different from those making the decisions. You need to identify those persons with actual physical responsibility for the integrity of baselined requirements so that appropriate access controls can be established.

Activity: Determine the work products

The work products of a requirements management process are its outputs at a conceptual level. These include specifications, compliance matrices, action items, change packages, and so on. Requirements management work products are not just requirements statements, but requirements-related information as well. Examples include the relationships between requirements statements and the work products of downstream activities like designing, coding, and testing; review

comments and results; issues; and progress or status reports concerning the requirements management activity.

What are the outputs of the requirements management process? Are they formal requirements specification documents? Are the work products lists of requirements? What deliverables must be produced by your engineering activity, in what format, and what must they contain? Do you need to show relationships between requirements and customer/sponsor desires, design artifacts, code, or test artifacts?

What non-requirements data are you generating? How are these things related to the requirements that you are managing? Can you define or specify these other work products?

Determine the monitoring needs

Monitoring the performance of your requirements management process is closely related to its work products. In order to produce progress and status reports for the activity you must identify ways of obtaining meaningful data from the activity. Common concerns include the effectiveness of the process, progress over time, quality, size, and volatility of the requirements data, and, of course, actual performance against schedules and plans.

How will you know how well your requirements management process is working? If it isn't working well, what can you do to fix it? How will you know if stakeholders are playing by the rules? How will you help them do so?

How will you show progress? How will you measure growth and volatility? How will you measure the extent to which requirements are being used in engineering activities?

How will you show that you have addressed everything? Is it complete? Is it consistent?

Activity: Determine the kinds of information to managed

Based on the roles, work products, and monitoring needs, you must define and categorize the kinds of information that your requirements management process will handle. Once you know this, you can structure and organize a repository for the information that will support the process in an effective way.

What data will be collected and managed? Collect specifications, concepts of operations, proposals, Requests For Proposals, Statements of Work, business rules, specifications or other information on existing systems, project plans, product plans, etc.

What information will be generated by your project? System or software specifications, design models, code, test plans, test procedures, test steps, test results? Review results?

What related, non-requirement information is needed? Do you have project plans, product plans, risk management data, action items, etc.?

How often will the information to be managed change? Will the marketing department issue periodic updates to their requirements? Will your customer update the concept of operations?

Activity: Establish the infrastructure to support the plans

Having determined the kind of information to be managed, you will need to establish both procedures and environmental or physical infrastructure to support the process.

What policies or business rules must you implement with your requirements management tools? How are the rules communicated to affected stakeholders? How will they be supported or enforced? Do soft, or people-intensive, organizational mechanisms need some tool support? For example, a change control board might be required to provide a decision-making forum. How can you prevent unauthorized changes to your requirements data and ensure that only approved changes are made? How will you present issues and other requirements information to the change control board? What support will you need to enable reviews to be conducted?

What tools will you use? How will you use your tools? How will you implement your plans with the tools? How will your tools accommodate the requirements inputs and the various, possibly distributed, stakeholders that you have identified? How will your tools be used to generate the work products that you have identified? How will your tools support your requirements management procedures?

Activity: Adjust plans based on progress and external events

As your requirements management activity unfolds, reality will inevitably diverge from your plan. New requirements inputs appear, the stakeholders come and go, your infrastructure arrangements may need to be changed, and your monitoring efforts (described later) may reveal problems, either in your plan or its execution. Review the results of monitoring regularly and be prepared to adapt your plans when the need arises.

Gather, Capture, and Record Requirements and Related Data

The gather/capture/record activity is about collecting requirements into some sort of repository where they can be managed, evolved, and used to guide engineering activities. Many projects accomplish the initial capture and recording tasks only to find themselves with no mechanism to move forward with their recorded requirements. Perhaps the project team views simple recording as the objective, or the tools used for activities like design, coding, and testing do not interoperate with the tools used for recording. The main purpose of recording requirements is so that the recorded requirements can be used to guide downstream activities like designing, coding, and testing.

Activity: Obtain official requirements inputs

From where will you obtain official copies of artifacts that constitute requirements inputs? In what formats will these artifacts be available? Do you have the tools and resources with which to extract actual requirements statements from the artifacts?

Activity: Establish and populate repository

A requirements repository provides a logically centralized depot for your project's requirements data. Your repository doesn't have to be terribly sophisticated, but it does need to provide:

- A single source for requirements data;
- Adequate access controls to prevent accidental loss of data;
- Access for all who need it;
- A clear and well-documented organization; and
- Support for versioning and other data management functions.

The objectives for a repository are to ensure that the entire project team is working from the same set of requirements and that the information obtained from the repository can be trusted to be the correct, official version.

How will you organize your repository? What structure is needed in your repository to enable you to represent the requirements inputs and their derivatives, which you may create?

What will you need to do to the artifacts in order to store their content in the repository?

Activity: Refine, evolve, add, and remove data as needed

Good quality requirements are precise, concise, and verifiable. Your source requirements may lack some of these qualities. Requirements statements found in product plans, concepts of

operations, and other such documents are often formulated to be read in context. Written in natural languages, such as English, these statements are often ambiguous or vague. To arrive at more precise requirements, you may find it necessary to decompose complex statements into simpler ones, propagate contextual information to sentence fragments, or derive new statements from originals by inferring missing or additional information.

By what criteria does your project judge a quality requirements statement? Is it implementable? Is it testable? Is it verifiable in some other way?

How will you determine whether requirements are adequately formulated? How will you know if you have identified all of the requirements? How will you record the evolution of the requirements? How much history can you gather and manage? How will you use that historical information?

Manage change

Effective change management is a critical success factor for most engineering endeavors. Without it, projects can fail because they are shooting at a moving target. Change can be particularly destructive in the requirements arena simply because it's the requirements that drive everything else. Two particularly damaging sorts of change are "requirements creep" and "feature creep." Requirements creep occurs most often when requirements development efforts have not managed to uncover real system needs so that "new" requirements pop up at inconvenient times. Probably less frequent, but equally difficult, are those occasions when requirements drivers like business conditions change in mid-project. Feature creep, or gold-plating, occurs most often when project team members add requirements or design elements that are not user- or customer-driven. However well-intentioned they may be, these kinds of requirements changes can derail a project. That is not to say that all change is bad and to be avoided. Requirements change is often absolutely necessary; it just needs to be recognized as such and controlled so that its effects on the project and its target are desirable ones.

Activity: Protect the repository

Protect your requirements repository from accidental or malicious change. Standard security or access control mechanisms such as password-protected user accounts and file system access control can be used to lock out unauthorized access. Depending on the nature of the repository and the size and composition of the stakeholder group with access, these controls may be enough.

<u>Who has what kinds of access to the repository</u>? Can access be divided so that only some users can write to the repository, while others can only retrieve from it? Are non-project staff able to access the repository?

Activity: Establish baselines

A baselines represents a snapshot of your project state at some point in time. In general, baselines provide reference points that can be used to help show progress and to provide status input to project management activities. You can establish a baseline at any point in time. It is often useful to do so before and after important reviews and project milestones so that you can show the impact of, and progress between, these events.

<u>When will you establish baselines and how will they be used</u>? What are your requirements management milestones? How do they relate to your overall project milestones? How does your organization determine whether a milestone has been achieved? Do you conduct reviews to determine milestone achievement?

Review, analyze, comment, and negotiate

Requirements review is an intellectual activity that results in issues, comments, and suggestions for improvements, clarification, or changes.

What formal and informal review activities will your organization perform?

How will stakeholders communicate their input? How will they interact to resolve issues and make recommendations? How will they use the requirements information in the repository to perform review and comment tasks? What infrastructure or other capabilities are needed to support review?

Activity: Propose changes

Requirements development is about arriving at a precise understanding of a system or software mission. Everyone in the organization or project must arrive at some version of the same understanding if the project is to accomplish its goals. The requirements repository is a major part of the physical mechanism for achieving, formalizing, and retaining that shared understanding. Allowing all your stakeholders to change requirements in the repository can work well during the exploration stages of a project. After a certain point, however, you may find it useful to formalize things and prevent unrestricted change. Gating the changes slows them down and can help ensure that they are made in a way that is consistent with the established, unchanged requirements.

Do you need to establish a change proposal mechanism? What mechanisms will you use to gather proposed changes? What information will you require from a change proposal (Text of suggested change to existing requirements, rationale for the change, prioritization, business case, etc.)?

Activity: Review and disposition change proposals

When you limit change to the requirements and require stakeholders to develop change proposals, you will need to institute review and approval processes to enable and control actual change. Most organizations have some sort of decision-making process involving a product review committee or change control board. Depending on the nature of your business, this committee may include customers or sponsors as well as internal product team members.

How often will you review change proposals? How often are change proposals submitted? How many will you expect to receive in a given time period?

What criteria will be used to make decisions regarding change proposal disposition? How will you identify the impact of proposed changes on the rest of the project?

How will decisions on requirements changes be recorded and disseminated to stakeholders?

Establish and Maintain Traceability

Traceability refers to relationships among requirements and between requirements and non-requirements data. There are several different kinds of traceability that you might consider maintaining. The historical record of requirements evolution provides one form of traceability that enables you to reconstruct a sequence of events. Traceability from one kind of requirement to another, say from business requirements to system requirements, or from system requirements to software and hardware requirements, gives you visibility into the decomposition and allocation of operational needs into system components. Traceability from requirements to design, code, and test artifacts enables you to use requirements to drive these downstream activities and to monitor how these artifacts address the requirements. Being able to demonstrate traceability among requirements and from requirements to other engineering artifacts instills confidence in customers, sponsors, and project managers. When you establish and maintain traceability, you can demonstrate completeness and consistency among your work products.

Activity: Define permissible and required linkages among requirements

Defining permitted and necessary linkages among the requirements is essentially a planning activity in which analysis of your requirements inputs reveals their inherent interrelationships.

For example, a business or marketing need represented as requirements should be reflected in system, hardware, or software requirements. You might want to tailor your requirements management tools or infrastructure to enable it to record these relationships. You might enforce rules about these kinds of relationships, such as requiring that each business or marketing requirement is reflected somewhere in the hardware or software requirements.

What different kinds of requirements do you deal with? What are the inherent relationships among them? How will you represent and record those relationships?

Activity: Define linkages to non-requirements artifacts

Enabling requirements to drive engineering activities is the most important goal of a requirements management process. Traceabiltiy from requirements to design, code, and test information is critical to demonstrating that the project team is satisfying stakeholder needs.

To what non-requirements artifacts can you connect your requirements? How can you record and manage those connections? How can you ensure that such links are created and maintained by the project team?

Activity: Connect artifacts as appropriate

Creating the physical linkages between related artifacts will enable you to answer traceability related questions. Such questions include:

How many business or operational requirements are addressed by software requirements? Which ones have not yet been addressed? Which software requirements are not yet addressed by design or test artifacts?

What mechanisms do you have for representing connections among artifacts?

Activity: Update linkages as needed

How fast do requirements and their interrelationships change? How will you know that they are changing?

Activity: Impact analysis

Impact analysis is frequently needed when determining whether to allow a requirements change. Using traceability that you have established in your repository, an impact analysis tells you what the knock-on effects of a requirements change are likely to be. For example, if you have established traceability among several different levels of requirements (business requirements,

system requirements, hardware, software, etc.) you can determine the impact of a business requirement change on the related system, hardware, and software requirements. If you have linked these lower-level requirements to design, implementation, and test artifacts, you can also identify which parts of these other data are likely to be affected. With this information, you will be prepared to produce cost and effort estimates that can be used to help make decisions about whether and when to allow these requirements changes to be made.

Based on the traceability that you have (or will establish) among the project work products, how can you use it to determine the cost and schedule impact of the proposed change? If there are gaps in the traceability among work products, how will you estimate the impact of change?

Monitor the Activity

Having established plans, a repository, and mechanisms to support requirements management for your organization, you need a way to evaluate whether and how well these things are working. Measuring certain aspects of the repository content can provide information on progress and effectiveness. Planning how the process will be monitored is an important aspect of overall planning for requirements management. If you know what measures you are looking for, you have a better chance of implementing support for them.

The better structured and represented your process is in your infrastructure, the greater the number of things you can effectively monitor and the greater the opportunity for automated support. For example, if you define a life cycle for your requirements, it can be useful to know how many requirements are in each life cycle phase and how long the average requirement takes to transition through the required phases. These kinds of information cannot feasibly be generated from manual record keeping; they require automated recording and calculation. Giving the requirements and the requirements management process electronic representation can make it possible to quantify aspects of the requirements management process.

An overly structured or overly mechanized process, however, runs the risk of problems during performance. Complex or labor-intensive housekeeping activities can impede process performance to the point that the process will not be performed properly or that users will circumvent it.

You also need to monitor the right things. Simply counting the number of requirements does not provide much information. Knowing how many requirements are associated with each component

of the product architecture, or how many tests are associated with each requirement, can provide useful insight during project planning and sizing.

Activity: Measure progress

Measuring progress is a key, fundamental aspect of any management process. Customers and managers need to know whether the effort is on track, and where problem areas may exist. For requirements management, progress indicators are the actual vs. expected repository content, and the size and extent of change activity. These measures are particularly important during periods of analysis either early in a project or during times when new features or products are being planned.

How will you measure the rate of population and rate of change in the repository? Are there informal and formal change processes to be measured? At what time granularity do you need to measure change? Weekly? Monthly? Quarterly?

Activity: Measure completeness and consistency

Measuring the completeness and consistency of your requirements data can be extremely difficult, as these qualities are not easily represented in physical ways. How do you know whether your requirements are complete? Part of the answer may lie in traceability among requirements and between requirements and other data. For example, if you have 50 business requirements and 300 software requirements, it could be useful to know the relationship between these different sets of requirements. If all of the business requirements are somehow related to at least one of the software requirements, for example, you might have some assurance that they are at least influencing the engineering process. If, on the other hand, there are 150 software requirements that do not relate to the business requirements or to other software requirements, are they really needed? Conversely, if the software requirements do not address some subset of the business requirements, are these business requirements being ignored?

How will you measure the completeness of different kinds or groups of data? How will you know whether the interrelationships among your data are accurate?

Activity: Measure effectiveness

Measuring the effectiveness of a requirements management process can take a variety of forms. The essential issue is whether performing the process is better than not performing it. If you have information on the effectiveness of past ways of managing requirements, there is a basis for

comparison. If not, you have to rely on how practitioners perceive the process and whether they feel it improves their tasks.

You can measure the effectiveness of your infrastructure by examining how it is used in comparison with how it was intended to be used. If some parts of the repository or tooling are not used at all, the reasons for this should be examined. If parts of your infrastructure are misused, how and in what ways is this happening? Are operational problems being reported? How many and how serious are the problems?

Activity: Report on content, quality, progress

Communication among project stakeholders is the glue that holds projects together. Reporting on the progress and results of any process is critical to ensuring further progress.

How will you generate information that tells stakeholders about the progress and effectiveness of the requirements management process? What transformations on and abstractions of the requirements data are needed to produce the information needed?

Summary

Managing requirements is a critical success factor for engineering projects. When it's done effectively, requirements management helps projects meet cost, schedule, and quality goals. When requirements and their connections to other engineering work products are explicitly managed, organizations are able to use them to help drive and focus the engineering effort. The information managed provides insight needed for estimating the size and scope of engineering activities and provides a basis for effective quality management.

Establishing an effective requirements management process takes planning as well as support for the process in the form of infrastructure and mechanisms.

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