Engaging Stakeholders in the Definition of Requirements for New Technology Systems

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Many transit agencies face the challenge of deploying new technology systems into in-service networks. These new technology systems cannot afford the schedule slippages and cost overruns associated with poorly specified requirements. Additionally, many properties are faced with aging infrastructure and are attempting to upgrade various pieces of the system via separate procurement contracts. Integration challenges are experienced as newly procured systems are expected to interface seamlessly with each other and older systems at the same time. These older systems may not have been developed using open and non-proprietary protocols.

In the transportation industry, successful projects are defined as ones that are completed on time, within budget, and most importantly, meet the expectations and needs of “stakeholders.” The key to project success starts at the beginning by capturing, vetting and documenting “Business” and “Stakeholder” requirements in order to accurately define Project Requirements.

Projects are scoped and funded in support of transportation agency/corporate goals and objectives that are typically found in high-level, officially sanctioned documentation, i.e., Annual Reports, Needs Assessments, and Capital Programs. The requirements found in these documents are referred to herein as Business Requirements. Business Requirements may include necessities such as:

- Improve the passenger carrying capacity;
- Improve throughput on the system;
- Improve the safety of the system;
- Improve passenger communications;
- Bring the system into a state of good repair.

This technical paper describes a set of best practices that can be used to engage stakeholders and users in developing a set of requirements based on stakeholder requirements and business drivers. It will address how to translate those drivers into a set of technical requirements that can ultimately be incorporated into a Technical Specification. This paper will focus on how to:

- define the correct set of stakeholders;
- engage stakeholders in defining requirements;
- document stakeholder requirements;
- ensure the requirements meet business needs;
- define a set of Project Requirements from the stakeholder requirements;
- track modifications to the requirements;
- establish ownership of requirements.

This process can be used by a design team, which may be a combination of consultant and agency personnel. The design team should have a good knowledge of the Requirements Analysis Process. Also good interpersonal skills and domain knowledge is a must as the designers will be required to meet with stakeholders to discuss their needs as it relates to the new system. The designers must have the ability to take a top-down approach to requirements development, starting with broad general requirements and working towards producing specific and unambiguous requirements.

Developing Business Requirements

Business Requirements represent the goals and objectives that the project is expected to achieve. The Business Requirements are the drivers for the project. Business Requirements may be documented in Needs Assessments, Capital Programs and Scope of Work documents. So why are Business Requirements important to the Requirements Analysis process? At the end of the day, when a new system is fully commissioned, how do you know that it actually achieved the goals and objectives that it was supposed to achieve? A defined set of Business Requirements provide the traceability that demonstrate requirements have been met.
One of the first Requirements Analysis activities for a design team is to review the Program and Project documents and develop a list of the Business Requirements. Business Requirements may also come from discussions with senior agency personnel.

Business Requirements may relate to an entire agency’s Capital Program; however it is the designer’s responsibility to determine how the project at hand will support these over-arching Business Requirements. The Business Requirements must be refined to the project level. For example, the agency may be undertaking the procurement of a new Passenger Communication System that will achieve the goal of improving passenger communications. Specific Business Requirements for the Passenger Communication System must be defined. The Business Requirements for the Passenger Communication System will define the high-level requirements of the system, such as “Provide next train arrival messages; in compliance with ADA requirements”. It is important to note that Business Requirements, for the most part, are not testable requirements. Additional requirements analysis activities will help to refine these Business Requirements into testable requirements.

Once the designers have developed the draft set of Business Requirements for the project, then these should be presented to senior and project management for concurrence. Once agreement is reached, it is then necessary to document these requirements in a requirements repository.

**Stakeholder Analysis and Management**

Stakeholders can be anyone who has a vested interest in the system being procured. Stakeholders may include users, operations & maintenance staff, financial partners, sister agencies and government agencies. Defining the right set of stakeholders is imperative as these people will be the ones affected by the system. It is important to note, that not all stakeholders are equal. Stakeholders should be prioritized in terms of who is most impacted by the project and who has the most influence on the project. The most influential stakeholders are usually the ones most impacted by the project.

**Step One: Identify the Stakeholder Groups**

The first step in the Stakeholder Analysis and Management process is for the design team to review all available Contract Documents, such as the Scope of Work documents, Concept of Operations (ConOps), and Needs Assessment documents and develop a draft list of stakeholders. At this point, the draft list of stakeholders could include agency departments, such as Division of Car Equipment, Signaling and Maintenance, Rail Operations and Information Technology Systems. The draft list of stakeholders should then be discussed with senior and project management to ensure that all stakeholders have been identified.

During discussions with senior and project management, the names of the stakeholder representatives should be assigned. For example, if the Signaling and Maintenance Department is a stakeholder, then the name and title of the stakeholder representative for this department should be defined. The stakeholder representative should be a senior manager within the group as they will have the following responsibilities:

- Make decisions on behalf of the stakeholder group;
- Identify personnel in their group who will be interviewed to elicit User Needs;
- Provide sign-off on Requirements Analysis artifacts (Interview Report, User Needs, Project Requirements, etc);
- Be assigned ownership of requirements for his/her stakeholder group;
- Participate in requirements change management.

It is important to understand the chain of command when identifying stakeholder representatives. Requirements sign-off needs to be at the right level within the organization.

**Step Two: Analyze Stakeholder Position and Manage Based on Position**

Once the list of stakeholders and stakeholder representatives is agreed upon, the next step is to prioritize the stakeholders based on the impact the project will have on them and based on how much influence they have on the project. The highest priority stakeholders, therefore are the person(s) who are most affected by the project and have the most influence on project decisions. The amount of involvement that each stakeholder should have with the project can be based on the comparison of project impact and project influence as follows:
As this graphic demonstrates, stakeholders with the most influence and that will be impacted most by the project should be highly involved in project requirements and decisions. Conversely, those with little influence and not impacted by the project do not need active involvement in the project, but should be kept informed of key decisions. It should be decided with project management whether the low priority stakeholders should be actively involved in the Requirements Analysis process.

**Step Three: Involve the Stakeholders**

Once the stakeholder representatives are defined, a kick-off meeting should be held to brief the stakeholder representatives on the Requirements Analysis process and to explain to them the importance of their role in the process. It is also a good idea to brief them on the project goals and objectives. In many instances, the stakeholder representatives may not yet be involved in the new project as it is just in the initial stages of design.

Stakeholder interviews are a good way to gather information on the needs of the stakeholders. The stakeholder representative should provide a list of personnel that he/she would like to be interviewed. In the example of the Signaling and Maintenance Department, a signal maintainer may be identified as an interviewee as he/she will be the end user of the signaling system. A difficult challenge is to keep the list of interviewees manageable; once the interview process starts, many more potential interviewees may appear as people like to ensure their voices are heard. It is critical to work with the stakeholder representative to ensure the interviewees are representative and that the list remains manageable.

In preparation for the stakeholder interviews, it is recommended that an interview questionnaire be developed. Questionnaires should be standardized as much as possible in order to compare notes from the various interviewees. In the event that the stakeholder is in an operations or maintenance role, it is very helpful to observe them during normal and abnormal operations. This provides the opportunity to see how the interviewee interacts with the various departments in the agency, observe interaction with agency systems and observe the reporting tasks that they perform, etc.

During the interview, it is very important to understand why the stakeholder needs a certain requirement. Justification for requirements should be recorded along with the User Need. Documenting the justification is imperative as the stakeholder group may be required to defend why the agency should spend money to implement a specific set of requirements.

**Step Four: Analyze the Stakeholders Needs**

User Needs are those capabilities expressed by the interviewee that are required in order for them to perform their job function. User Needs should not be confused with “wish lists”. The User Needs should be compared to the Business Requirements to ensure that they support the Business Requirements. It is important to note that not all User Needs will have a clear relationship to a Business Requirement. For example, the requirement to have an incident reporting system as part of an automatic train supervision system may not directly tie to a Business Requirement; however it does support the goal of improving safety of the system. If it is questionable whether the User Need supports the Business Requirement then further analysis and discussion may be required as the User Need may represent an out-of-scope item. Potential out-of-scope items should be flagged for discussion with the stakeholder representative and project management.

The priority of the stakeholder should also be assessed when analyzing the User Needs. The User Needs of high priority stakeholders should carry more weight than those of lower priority stakeholders. This may come into play when reviewing potential out-of-scope items and attempting to juggle which items the agency can afford to implement within the project budget.

If multiple interviews with the same stakeholder group were performed, the User Needs should be compared to identify any discrepancies between interviewees.

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1 Provided by Duncan Kemp, UK Department for Transport, in cooperation with the INCOSE Transportation Working Group
After the interview has been completed, an Interview Report should be produced. The Interview Report is a compilation of all observations and interview notes, and User Needs. The Interview Report should include the interviewee’s name, the stakeholder group they represent, the date and the location of the interview and/or observation. The Interview Report, along with the list of discrepancies and out of scope items should be forwarded to the stakeholder representative. Meetings with the stakeholder representative should be scheduled to resolve out-of-scope issues, discrepancies and to ultimately sign off on the Interview Report and the User Needs.
The following is a flowchart of the interview process.

Defining the Requirements

The Project Requirements are developed not only from the User Needs, but also from existing standards and documentation. Designers take the User Needs and develop “shall” statements that represent the User Need. “Shall” statements represent requirements of the contract that must be fulfilled by a Contractor. A single User Need may result in multiple Project Requirements. For example a User Need may be “Provide synchronized audio and visual messages for public announcements”. One of the many Project Requirements could be as follows: “The Passenger Communication System shall provide text-to-speech capabilities”.

The Project Requirements should be written to a level that is understandable by the procuring agency and to a level where they can be easily incorporated into a Technical Specification. The designer may be required to have additional meetings with the stakeholder group to further define the requirements.

Requirement Re-Use – Does it Help or Hinder?

In the transit industry, Technical Specifications rarely get written using a clean sheet of paper. Requirements get incorporated from a number of potential sources including:

- Industry standards;
- Agency standards;
- Prior project Contract Documents;
- Agency standard Technical Specifications.

The use of these sources of requirements can be risky, as there is a tendency to “lift” sections of requirements from these sources, without ensuring that the requirements fulfill a User Need and/or Business Requirement. Controlling the influx of potential Project Requirements can be a daunting task.

For example, an agency may elect to use the requirements from a prior signaling contract for Line A on the signaling contract for Line B. Initially, that may sound like a very good idea, however when you approach the problem from a Systems Engineering standpoint, you may find that there are inherent issues with Line A’s set of requirements. Due diligence must be performed on Line A’s set of requirements before being used on Line B. For example:

- Has the set of requirements for Line A been updated throughout the life of the project to reflect change orders?
- Have the Business Requirements changed between the time Line A was procured and Line B was conceptualized?
- Have the stakeholders changed or the stakeholder needs changed?
- Were unnecessary requirements implemented; i.e. not being used by operations and/or maintenance personnel?
- Have the lessons learned on Line A, been documented and analyzed?

In many cases, design teams are anxious to use an existing set of requirements on a follow-on contract as it appears that the systems are very similar. However, if a thorough analysis of the aforementioned issues is not performed, then an incorrect set of requirements may work their way into the Technical Specification for the new system, which may result in excess and/or unnecessary costs to the procuring agency. However, if a thorough systems engineering process is being followed and requirements analysis performed, then a cost savings
from the re-use of requirements may be recognized. In summary, one cannot and should not blindly re-use requirements from prior projects.

Inclusion of agency and industry standards are another area of requirements re-use. Agencies may have standards for various technical areas, such as network communications standards or cable wiring standards. Citing and/or including these standards into Contract Documents may have value and may save time in developing requirements, however the engineering process of determining whether the entire standard should apply or only portions must be performed.

The Systems Engineering phase is called “Requirements Analysis” for a reason. The effort must be put into analyzing the potential set of re-useable requirements against the User Needs and Business Requirements. Only the requirements that fulfill a User Need and/or a Business requirement should be included in the set of Project Requirements. This activity should be performed in conjunction with the stakeholder group; carefully ensuring that there is justification for the re-use of requirements.

Establishing Ownership of Requirements

A key area that is often overlooked when developing Project Requirements is ensuring the requirements have ownership. This can become a large problem when requirements are re-used from prior projects or when designers are left to their own devices in developing Project Requirements. Each newly written requirement and/or re-useable requirement should be assigned to the stakeholder associated with the User Need. Signoff by the stakeholder representative is required on all Project Requirements. Sign-off by the stakeholder representative implies ownership of the requirement. This is a key point, as ownership means that the representative will be involved in any change management activities relating to his/her set of requirements.

Management of Requirements

Transit projects typically result in a large number of Project Requirements that must be carefully managed. It is highly recommended that a Requirements Repository be implemented by using either an Excel file or a relational database management system. The decision is dependent on the number of Project Requirements and how the designers and agency want to interact with the repository.

There are a number of commercial-off-the-shelf (COTS) Requirements Management tools, such as IBM Rational® RequisitePro® or IBM® Rational® DOORS®. These COTS tools include a graphical user interface front end and a relational database backend. The relational database provides an easy means to manage and report on requirements and their relationships. It is recommended that a Requirements Management Tool be used for large, complex projects.

Establishing a Requirements Database

Microsoft Word documents can be automatically imported into the requirements database by the COTS tool, by parsing sentences and looking for “shall” statements. Every “shall” statement in the document represents a requirement, which will be individually numbered as a requirement and stored within the database. The COTS tool also has the ability to create Microsoft Word documents from the requirements stored in the relational database. The Microsoft Word document can include the individually numbered requirements for traceability.

The requirements database should store all data that has been collected, starting with the establishment of Business Requirements through to the definition of Project Requirements. The following is a list of the data that should be stored:

1. **User Needs** – Each User Need should be uniquely numbered and represent a single need, such as UR1.
2. **Business Requirements** – Each Business Requirement should be uniquely numbered and represent a single requirement, such as BR1.
3. **Project Requirement** – Each Project Requirement should be uniquely numbered and represent a single requirement, such as PR1.
4. **Technical Specification Requirement** – Each Technical Specification Requirement should be uniquely numbered and represent a single requirement, such as TSR1.
5. **Justification** – Justification for each requirement should be provided.
6. **Source of Requirements** – The source of each requirement (i.e. Scope of Work document, Capital Program requirement, Agency Standard, stakeholder interview) should be included.
7. **Owner** – Each stakeholder (owner) should be defined for the requirement.
8. **Change History** – Change orders affecting each requirement should be logged.
Project Requirements will ultimately be incorporated into the Technical Specification. Therefore, additional information should be captured for the Project Requirements as follows:

1. If it is a technical requirement, define the subsystem that each requirement belongs to, (i.e. signals, traction power, ATS).
2. If it is a process requirement, define the process area (i.e. training, quality assurance, safety).
3. Establish parent and child relationships between requirements.

**Establishing Traceability**

Traceability of requirements from Business Requirements to User Needs to Project Requirements, and then finally into the Technical Specification is imperative. This level of traceability will provide the means to show how the requirements within the Technical Specification support the goals and objectives of the organization and meet the needs of the stakeholders. The following flowchart illustrates how the requirements are defined from the Business Requirement level through to the Technical Specification.

![Flowchart](image)

Traceability of requirements should be provided through the requirements database. Designers will be able to generate reports such as “all requirements for a given stakeholder group” or “all requirements that belong to the signaling system and belong to the Signaling and Maintenance Department”.

**Managing Changes to Requirements**

Changes to requirements are inevitable. As noted earlier, ensuring ownership of requirements is important when a decision must be made as to how to handle a change to a requirement. The stakeholder representative will be responsible for reviewing the requested change and ensuring that the change will help to fulfill the needs of his/her group and support the Business Requirements. When a change to a requirement is approved, the requirements database must be updated and all associated linkages to other requirements verified and/or modified.

The requirements database will provide the means to generate reports on the history of a requirement from its inception through to its incorporation into the Technical Specification; including a history of any changes made to the requirement throughout the design phase.

**Technical Specification Requirements**

When writing a section of the Technical Specification, the designer can easily gather all requirements for their assigned area of the Specification by performing a query to the requirements database. The query can be based on all Project Requirements for a given technical area or process area.

Technical Specification Requirements will be written at a more detailed level than the Project Requirements as they represent specific functional capabilities that must be provided to meet the project goals, objectives and User Needs. Once again, it is very important that the stakeholder representative sign off on the Technical Specification requirements indicating that they accept and own the requirements.

**Summary**

Having a loosely defined set of requirements, with no ownership or basis for inclusion, is likely to negatively impact the project’s budget, schedule and overall value-for-money/return-on-investment. Without control over the requirements development process, and establishing ownership, the Technical Specification may be a compilation of wish lists and outdated requirements that do not meet the goals and objectives of the project. Transit agencies can minimize this risk by performing a detailed analysis and definition of Project Requirements prior to development of Technical Specifications. Implementing good Systems Engineering processes at the front of a project life cycle will help the agency to successfully meet the project’s objectives and goals while controlling impact to schedule and budget.