CHAPTER 3: WRITING THE PROJECT DEFINITION

Chapter outline

- Mission statement
- Constraints
- Users and stakeholders
- Requirements
- Specifications
- Format for the project definition
- Development of the project definition

As you conduct the research outlined in Chapter 2, you will get a clearer idea of the problem your design must solve. In EDC, you keep track of the formulation of the problem through a document called a "project definition," which is composed of four parts:

- Mission statement: a concise, solution-independent statement of the problem to be solved
- Constraints: limitations imposed on the design by the client, regulators, or other stakeholders
- User and stakeholders: those who will use, produce, market, install, maintain, or in other ways interact with the product; also, those in the larger community who will be affected by the product.
- Requirements and specifications: the needs that the users and stakeholders want the design to fulfill, and the measurable values associated with those needs. Engineers translate requirements into specifications as part of the design process.

A project definition goes by a variety of names in the engineering workplace. "User requirements," "functional requirements and constraints," "engineering specification," and "the spec" are just a few of these terms. To add to the confusion, the terms are used in subtly different ways.

Whatever it is called, the project definition is a living document that parallels the creation of the design itself. Although common sense may suggest otherwise, you don't write the document first and then create the design. Instead,

the document evolves along with your research and testing. The initial version typically has a first-draft mission statement, perhaps a few client constraints, and some broad user requirements, such as “easy to install.” As you learn more about users, your project definition will become more detailed, specific, and focused. For example, an early version of a project definition documenting the design of an innovative desk organization system might include the specification, “must reduce desk clutter.” Later versions might specify that the system “must keep at least 50% of total desk space free of documents not currently in use.” As you add detail, your project definition will grow, even as you eliminate requirements and specifications that prove irrelevant or unnecessary or too costly. The bottom line is that your final project definition will contain all the requirements of your design and the metrics for measuring its success.

A project definition’s main function is to describe the purpose of the design, how it will work, and how a user will interact with it so that the team, the client, and the supervisors can **evaluate** the design.

You may be wondering if it wouldn’t be easier and more efficient to just observe how well the design works. The reality is that members of the design team need a project definition to help them evaluate **as they are designing**. If they are unable to express what the design must do to meet the requirements of users, clients, and other stakeholders, they won’t be able to tell if their design will succeed. The project definition also typically outlives the design team, allowing others to make the customary revisions and improvements.

When you first create your project definition, it will be **solution-independent**. That is, it will describe what the solution must do, but it will not actually describe the solution. This stage is necessary because it allows your team to keep itself open to various solutions and explains to those who get involved later in the project the reasoning behind your selection of features. In later versions, as you zero in on a solution, the project definition will include the specifics of that solution, as discussed at the end of this chapter.

The following sections describe each part of the project definition in more detail.

3.1 MISSION STATEMENT

Admittedly tricky to write, a good mission statement not only succinctly summarizes the problem to be solved, but also provides direction and tells others what you are trying to accomplish. Following are guidelines for writing a good mission statement.

3.1.1 Guidelines for writing a mission statement

1. Phrase your mission statement in a solution-independent way to help you ascertain the problem. For example, a client who needed something to organize her work asked an EDC team to design an under-the-desk, rotating filing system. After they observed her at her desk, team members realized the client needed a system that would allow her to keep work in view, not under her desk. They came up with this mission statement:

   > To design a physical structure (or structures) that significantly improves our client's organization of her supplies, loose papers, and folders/projects and that she can easily use while seated at her desk.

   Although this statement contains **focusing assumptions** about the design (it will be a physical structure rather than a set of instructions or techniques for changing her work habits), it doesn't go into detail about the features of the solution. Had the team designed an under-the-desk system, it would have proven unsatisfactory to the client.

2. Emphasize measurable objectives that allow you to determine whether you have accomplished your goal. The versions below illustrate how a mission statement was revised to emphasize measurable results:

   > Original mission statement: Design a soda vending machine with a "user-friendly," off-the-ground dispensing bin.

   Apart from the fact that it includes a solution ("off-the-ground"), the statement makes it difficult to measure the success of the design because the term "user-friendly" is subjective and difficult to quantify. A better mission statement would be:

   > Improved mission statement: Design a soda vending machine with a dispensing bin that can be reached with minimal bending.

   Now the team can observe and measure the amount of bending users need to do and whether it is a comfortable solution.

In this chapter, we will track the development of a project definition involving wheelchair accessibility. The team's client was the Northshore Opera Company, which performed in a YMCA building that also housed a childcare center. To transport people in wheelchairs from the back parking lot to the first floor auditorium, the company used an electronic lift that people found uncomfortable, inconvenient, and possibly unsafe. The team in charge of designing a better system formulated a mission statement that is solution-independent and makes it possible to measure the safety and comfort of the design.

Example 3.1: Mission statement for wheelchair access project

Design a method that safely and comfortably transports wheelchair-bound patrons of Northshore Opera Company from the street level to the first floor of the McGaw YMCA Child Care.

3.2 CONSTRAINTS

Almost all projects are subject to constraints, usually imposed by the client and related to scope, cost, and regulatory approval. Constraints **cannot be changed** and therefore limit the design space you explore. For example the client may specify that the design must be manufactured using existing equipment in the factory, or that each unit must cost less than 30 cents to make. Constraints may also be imposed by industry standards and regulatory agencies (for instance, Americans with Disabilities Act guidelines).

If a client imposes constraints, review them carefully to understand why the client thinks they are essential. If no clear rationale is stated, talk to your client about eliminating the constraint. For instance, a client initially said he wanted a beach umbrella that would hold its ground in windy conditions. The design team asked him if the final design had to be an umbrella (as opposed to a canopy or tent). In other words, they wanted to know if "umbrella" was a constraint on the design. The client said that it wasn't, so the team had free rein to consider other possibilities. Things could have gone the other way, however, with the client saying it had to be an umbrella, perhaps because he manufactured beach umbrellas and wanted to use existing factory equipment.

The client for the wheelchair access project specified two constraints, which the team added to the project definition:

Example 3.2: Constraints for wheelchair access project

Constraints

- Must cost no more than $1,000.
- Must comply with all relevant requirements of the Americans with Disabilities Act

Some students confuse constraints with user requirements. If a product must be safe, that is a requirement because there are many ways to ensure safety. If it must conform to specific standards of the American National Standards Institute (ANSI), that is a constraint.

3.3 USERS AND STAKEHOLDERS

Composed of all those who are affected by a product's success or failure, users and stakeholders fall into the following categories:

Primary users: end users, the client, and anyone else who makes important decisions about buying, using, or maintaining the product. Primary users can be subdivided into demographic groups. For example, a team charged with designing a highchair footrest to help children with Down Syndrome and cerebral palsy sit up straight while eating divided their primary users into three groups:

- children with Down Syndrome and cerebral palsy who have trouble sitting up straight while eating (end users of the product)
- the parents of these children, who will purchase, install, and adjust the footrest for their child
- childcare workers at daycare centers, who will need to adjust the footrest for different-size children with different physical conditions

The wheelchair access team identified one primary user group besides the client: patrons of the Northshore Opera Company who use wheelchairs.

Secondary users: those employed in the client's various departments (manufacturing operation, service, marketing, etc.). Secondary users also include those will interact with the product at some point: installers, repair people, salespeople, and others. In the case of the wheelchair access project, the secondary users were:

- other patrons of the Northshore Opera Company (who will be affected by access at the rear entrance by the parking lot)
- the maintenance crew

Other stakeholders: Regulatory agencies, community organizations, and others who are somehow affected by the design and have an interest in its functioning. The wheelchair access team identified these stakeholders:

- YMCA Childcare Center administrators, teachers, parents, and children, who all have an interest in how the access method affects use of the rear entrance during the Center's operating hours
- Evanston Fire Department, which enforces the local fire code
- Evanston Building Commission, which dictates that the access method comply with local building standards

The example below provides the complete list as it appeared in the project definition:

Example 3.3: Users and stakeholders in wheelchair access project

Users and stakeholders

- Patrons of the Northshore Opera company who use wheelchairs
- Northshore Opera Company
- Other Northshore Opera Company patrons

- Crew responsible for maintenance of access method
- YMCA Childcare Center administrators, teachers, parents, and children
- Evanston Fire Department
- Evanston Building Commission

3.4 REQUIREMENTS

As a designer, one of your major tasks is to uncover the requirements of your users and stakeholders, who are not always aware of or able to articulate them. For example, users testing cell phones may not have known they "needed" a built-in address book until they were in a situation where they needed a phone number quickly.

To see how teams uncover user and stakeholder requirements, review the process used by the wheelchair access team. Members conducted research, following the methods outlined in Chapter 2 and illustrated in Understanding user requirements below.

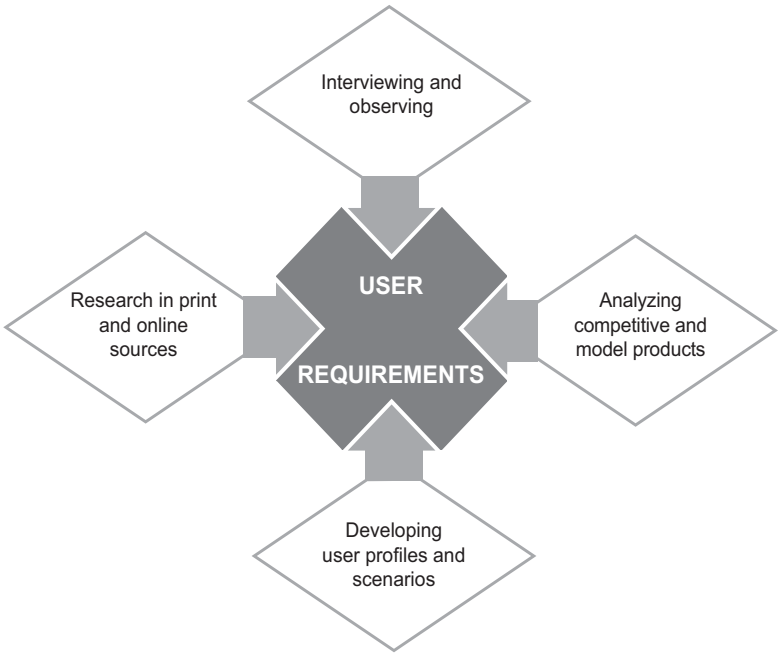

Figure 3.1: Understanding user requirements

3.4.1 Identifying client requirements

Face-to-face meetings provide a good opportunity to identify client requirements (although some clients may give you written specifications). Asking

clients the reason for each requirement will help you understand their thinking.

By asking the opera company director why she wanted a collapsible ramp, the wheelchair access team discovered that the company's real requirement was for an access method that can be stored between performances. This spurred the team to brainstorm other temporary means of access, such as a stair lift with a retractable seat and footrest, which would be less cumbersome than a ramp. The wheelchair access team uncovered the following requirements in their initial client interview:

- must be safe
- requires no more than three crew members to assemble, disassemble, and operate
- can easily be assembled and disassembled by crew
- can be stored in the rear of the auditorium or in the available storage room
- accommodates motorized and non-motorized wheelchairs

3.4.2 Identifying the requirements of primary users

You can identify the requirements of primary users through observation; interviews; analysis of competitive products; online and print sources; and user profiles and scenarios.

1. Observation. User observation, discussed in Chapter 2, involves studying users as they interact with a competitive product.

   The wheelchair access team did not have the opportunity to watch wheelchair users using the current method for getting into the YMCA building, the motorized wheelchair lift. But they were able to observe a few of their members sitting in the lift as the crew operated it. Those in the lift reported a feeling of hanging precariously in mid-air as they were being hoisted from the bottom to the top of the stairs, which took five minutes. As a result of these observations, the team uncovered two user requirements:

   - must provide a stable base for the user
   - must get user up or down the stairs in less time than it takes the current lift (five minutes)

2. Interviews. The wheelchair access team conducted two interviews with Northshore Opera Company patrons who use wheelchairs. These interviews confirmed their earlier observations of the lift as well as revealing another important requirement:

- users must be able to get up to and down from the first floor unassisted

3. Analysis of competitive products. (See Chapter 2 for more details.) Searching online, the wheelchair access team found that some stair lifts had adjustable seating positions, which made members realize their solution would have to accommodate people of different heights and weights. They also found that some stair lifts were battery-operated and others used power cables connected to a 110-volt outlet. The battery-operated model had the advantage of being able to operate in the event of a power failure. As a result of their online search, the team added two more user requirements:
   - must accommodate users of different weights and heights
   - must be usable in case of emergency, such as fire or power failure
4. Online and print research. As seen above, online research is useful in learning about competitive and model products and how they solve problems.
5. User profiles and scenarios. (Discussed in Chapter 2.) The wheelchair access team could imagine the user's mental state and surroundings from the moment she arrives at the outside entrance to the moment she reaches the first floor. She might be nervous about not being able to see well enough in the dark to operate the access method, or being late due to bad weather, and therefore not being admitted after the curtain goes up. Based on their scenario, the team added a few more requirements:
   - user must be able to easily see components of the access method
   - wheelchair must not slip in rain or snow
   - access method must be easy to operate

3.4.3 Identifying the requirements of secondary users

Assessing the requirements of secondary users—those who manufacture, install, maintain, service, sell the product—involves using the same techniques you would employ to assess end users' requirements.

The wheelchair access team interviewed those who would have to install and maintain their design solution, as well as administrators, teachers, and children and their parents at the YMCA Child Care Center. These interviews led the team to identify additional requirements:

- can be quickly put into use on the day of a performance
- can be quickly moved out of the way after a performance
- will not impede daily foot traffic by blocking stairs
- will not slow down drop-off of children by blocking rear entrance
- will not interfere with automobile access to parking lot

3.4.4 Identifying community requirements

Most engineering designs affect the broader community in some way. For instance, automobiles produce pollutants and require massive regular road maintenance. There are literally hundreds of public and private organizations that set **standards** and **regulations**. Some of the better-known ones are the Food and Drug Administration (FDA), the Federal Communications Commission (FCC), the Federal Aviation Administration (FAA), the American National Standards Institute (ANSI), the Consumer Product Safety Commission (CPSC) and various professional societies such as IEEE, ASME, and ASCE. Virtually every engineering design has to meet a set of standards or regulations.

The wheelchair access team knew their design had to meet ADA requirements, so they found the detailed specifications on the Web. The team also realized that the design would have to conform to local fire and building codes, so members interviewed the local fire marshal, which led them to add this requirement:

- must provide an alternative method of exiting the building in case of fire

Example 3.4 provides the wheelchair access team's complete list of requirements. To make the long list easier to work with, the team placed requirements into categories.

Example 3.4: Requirements for wheelchair access project

Safety

- users must be able to see easily while using the access method
- must be usable in case of emergency, such as fire or power failure
- wheelchair won't slip as a result of rain or snow
- must provide an alternative method of exiting the building in case of fire

Comfort

- must provide a stable base for the user

Ease of operation

- requires no special training to operate

Convenience of use

- users must be able to get up to and down from the first floor unassisted
- must be faster than current method

Wheelchair user accommodation

- must accommodate motorized and non-motorized wheelchairs
- must accommodate users of different weights and heights

Accommodation of other (non-wheelchair) users

- must not impede daily foot traffic by blocking stairs
- must not interfere with automobile access to parking lot
- must not slow down drop-off of children by blocking rear entrance

Maintenance

- can be quickly put into use the day of a performance
- can be quickly moved out of the way after a performance
- requires no more than three crew members to assemble, disassemble, and operate

Storage

- can be stored in the rear of the auditorium or in the storage room

3.5 SPECIFICATIONS

Once engineers identify user and stakeholder requirements, they must turn them into precise, measurable terms to evaluate whether their design satisfies those requirements.

For instance, a team designed a traffic flow plan for parents dropping off and picking up their children in a grade school parking lot. The team couldn't merely specify that "parents need to be able to drop their children off quickly and efficiently." They needed to apply "quickly and efficiently" to a specific number of cars, a time period, and specific circumstances. After observing the parking lot for several mornings, the team settled on the following specifications for the morning drop-off period:

- 75 cars need to park to drop off children between 7:55 and 8:15 a.m.
- 50 non-parking cars need a fast way (less than two minutes each) to drop off children between 7:55 and 8:15 a.m.
- it must be safe for 50 cars to move through the parking lot between 8:10 and 8:15 a.m.
- 294 children need to be delivered to the main building between 7:55 and 8:15 a.m.
- 35 preschoolers need to be dropped off between 8:25 and 8:35 a.m.

These specifications made it possible for the team to measure the viability of alternative design solutions, revise their proposed designs to meet user requirements, and test the success of their final design. In presenting their final design to the client, the team could demonstrate how their traffic flow pattern could accommodate 75 parked cars and 50 non-parking cars in the 20-minute drop-off period.

Metrics are used even for requirements that are difficult to quantify. For the highchair footrest project, the team determined from user interviews that the footrest must be easy to clean because of the food that children would drop on it and grind in with their feet. “Easy to clean” sounds self-evident and sufficient, but it does need to be specified with metrics: How much time will parents and daycare providers be willing to spend cleaning the footrest? How deep must a groove be before it becomes difficult to clean? How narrow a space at a joint will make it difficult to clean out debris? No matter the design, engineers need metrics to precisely evaluate the viability and success of their concepts.

In their original project definition, the wheelchair access team lacked the information to develop specifications with metrics. As they did more research, they were able to add these metrics or put placeholders (in the form of XX) for metrics:

Example 3.5: Specifications, with metrics, for wheelchair access project

Safety

- structure must bear these weights under the following conditions:
  - a ramp must hold 1,500 lbs
  - lift must hold up to 1,000 lbs
- wheelchair won’t slip as a result of rain or snow
  - surface on which wheelchair moves has 0.XX minimum coefficient of friction
- users are able to see at least 10 feet ahead while using the access method
- structure provides escape method in emergencies, such as fire or power failure
  - access method is not dependent on building’s electric power source
  - alternative escape if access method fails

Comfort

- if the access method is a motorized lift, user’s back is at a 90-degree angle to the ground

Ease of operation

- requires no special training to operate

Convenience

- gets user up or down the stairs in less time than current lift (less than 5 minutes)
- users should be able to get up to and down from the first floor unassisted
  - ramps will have a 1:12 slope and handrails
  - lifts will permit users to transfer to and from wheelchair without assistance

Wheelchair user accommodation

- accommodates motorized and non-motorized wheelchairs weighing up to 700 lbs
- accommodates weight up to 300 lbs
- accommodates users of heights up to XX inches

Accommodation of other (non-wheelchair) users

- entire width and length of current stairway is usable when access method is not in operation
  - each step is 6 ft. wide
  - stairway is 9 ft., 8 in. long
- access method does not slow down drop-off of children by blocking rear entrance
- does not interfere with automobile access to parking lot
  - driveway outside entrance is 14 ft., 4 in. wide

Maintenance

- requires no more than three crew members to assemble, disassemble, and operate
- access method can be put into use in less than one hour the day of a performance
- access method can be moved out of the way in less than one hour after a performance
- requires no special training to be put into use or moved out of the way
  - instructions are provided
  - all parts are labeled

Storage

- if storage is required, the device can fit in the rear of the auditorium or in the available storage room
  - rear of auditorium is 36 ft. x 4 ft.
  - storage room is 20 ft. x 20 ft.

The metrics in these specifications are derived from research, not guesswork. The team measured the storage area, the steps, and the rear of the auditorium. They interviewed users about the most comfortable angle in which to sit when using a lift.

One final note about specifications: most requirements must be linked to metrics to evaluate the success of a design. Some requirements, however, are simply binary—the design either meets them or doesn't. The parking lot traffic flow team stipulated that the existing entrance and exit of the parking lot be used in their design. This needs no further specification. The high chair design team determined that the footrest should be adjustable with one hand, because a childcare worker might be holding a child in the other arm. There may be no specific metrics to evaluate whether the design meets this requirement. Evaluation may simply require observation.

3.6 FORMAT FOR THE PROJECT DEFINITION

As you enter upper level design classes and various workplace settings, you will find a variety of formats used to document a design. The format we use in EDC has two beneficial characteristics: (1) The project definition is easy to update as the design evolves. (2) The table format helps designers see the relationship between requirements and specifications. Example 3.6 shows Version 2 of the project definition for the wheelchair access project.

Example 3.6: Project definition for wheelchair access project

Project name: Opera Wheelchair Access

Client: Sonia Winslow, Director of Northshore Opera Company

Team members: Hossein Farazi, Kate Liebner, Milton Tom, Frank Underwood

Date: April 10, 2007

Version: Two

Mission Statement: Design a method that safely and comfortably transports wheelchair-bound patrons of the opera company from the street level to the first floor of the YMCA Childcare Center.

Constraints

- Must cost no more than $1,000.
- Must comply with all relevant requirements of the Americans with Disabilities Act (ADA)

Users and stakeholders

- Patrons who use wheelchairs
- Other patrons
- Northshore Opera Company
- Crew responsible for maintenance of access method
- YMCA Childcare Center administrators, teachers, parents, and children
- Evanston Fire Department
- Evanston Building Commission

Requirements	Specifications

• Safety
  • User/wheelchair won't cause access method to collapse
  • Wheelchair won't slip in snow and rain
  • User can see where he or she is going
  • User can get out in an emergency
	• Bears weight under these conditions:
	  • Ramp: 1,500 lbs.
	  • Lift: 1,000 lbs.
	• Surface has O.XX minimum coefficient of friction
	• Provides at least 10 ft. visibility
	• Functions or provides alternative route during fire or power failure

• Comfort • User feels stable	• If access method is a lift, user's back is at a 90-degree angle in relation to ground • If a ramp, it has handrails and 1:12 slope

• Convenient
  • User can get in and out of theater quickly
  • User can get in the theater independently
	• Moves user up or down stairs in less than 5 minutes
	• If a lift, user can transfer to and from lift without assistance

• Ease of operation	• Provides intuitive or simple and explicit understanding of use
• Wheelchair user accommodation • Users and wheelchairs of all sizes can use the access method	• Accommodates wheelchairs weighing up to 700 lbs. • Accommodates users weighing up to 300 lbs. Accommodates users between XX and YY heights

Requirements	Specifications

• Accommodation of other (non-wheelchair) users
  • Non-wheelchair users can use the driveway and stairway any time of day or week
	• Does not interfere with drop-off of children at rear entrance
	• Does not interfere with auto access to parking lot
	  – Driveway is 14 ft. 4 in. wide
	  – Allows entire width and length of stairway to be used when access method is not in operation
	  – Each step is 6 ft. wide
	  – Stairway is 9 ft. 8 in. long

• Maintenance • Crew can assemble and disassemble access method quickly and easily	• Requires no more than three crew members to assemble, disassemble, and operate • Set up in less than one hour • Disassembled and stored in less than one hour • Requires no special training instructions • All parts are labeled
• Storage • If storage is required, access method must fit in rear of auditorium or storage room	• Rear of auditorium: 36 ft. x 4 ft. • Storage room: 20 ft. x 20 ft.

Notice that the “requirements” column groups several requirements under a heading. The corresponding “specifications” column states the engineering criteria that these requirements must meet. The brackets in the “requirements” column indicate that there is not necessarily a one-to-one correspondence between requirements and specifications. For example, one requirement might have four specifications. Conversely, one specification might involve two different requirements.

3.7 DEVELOPMENT OF THE PROJECT DEFINITION

You will produce several versions of the project definition, each more complete and detailed than the previous one. The first version, written early in the

project, may have a sketchy mission statement, constraints learned from the client, and a few potential requirements picked up from initial reading. As your research and testing evolve, the mission statement will become sharper, the constraints may change, the list of requirements will expand and become more refined, and you will put specifications (with metrics) next to requirements. As your team settles on a particular design alternative, your specifications will become more solution-dependent. For instance, at a certain point the wheelchair access team decided that the solution would be a platform lift that could accommodate a user in a wheelchair. They then eliminated references to a ramp in their specifications. In addition, the team added specifications and made others more precise and solution-dependent. For instance, a specification for platform size was added: 31.5 inches wide by 48 inches long. They also specified that the emergency battery be 24 volts.

The organization of your project definition also will change as it grows. In early drafts, you will find it convenient to organize your requirements by users and other stakeholders, because that's how you discover the requirements. As your project definition evolves, however, you will want to eliminate repetition of requirements by grouping them according to their related functions. For example, early drafts of the wheelchair accessibility team's project definition listed requirements by client, user, and community. Later drafts organized requirements by safety, convenience, comfort, and storage.It is imperative that you keep a copy of each version of your project definition in your project notebook. These sequential drafts, which provide a paper trail of your thinking, are obligatory if your design turns out to be patentable or if you hand off your design to a new design team or product developers. If they want to understand the rationale for a requirement, for example, they will be able to trace its evolution through your project definition.