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## **Anatomy of an Engineering Project**

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# Anatomy of an Engineering Project

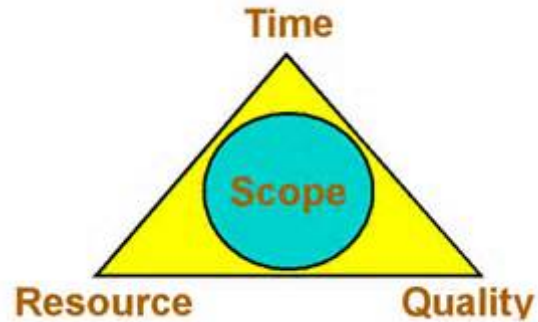
Engineering projects as typically applied for heavy commercial, industrial and utility applications follow a very typical pattern even though the technical applications may be significantly different. The goal is to provide a working system that:

- Meets all necessary technical requirements
- Meets all legal, ethical, and liability requirements
- Is completely documented
- Is safe
- Is reliable
- Is maintainable
- Is profitable

This document will examine each goal above for each part of the project. Parts of a typical project are:

- Project Scope
- Project Plan
- Research
- Calculations
- Design
- Checking
- Submittal
- Field Assistance
- Project Close

## Project Scope



The project scope is the basis for the work that is to be done for the project. Project scopes depending on the circumstances of their creation, can vary in how helpful they will be to determine what actions must be performed to complete a project. It is the engineer's responsibility to interpret the scope and determine the required actions. Actions below include:

### Technical requirements

Review the scope to determine if there are any technical issues that should be addressed. Items to be considered:

Technical Requirements	Completed?
Does the project scope provide conflicts with accepted practices?	X
Is the project scope actually constructable?	X
Is the project scope vague such that multiple ways of completing project scope are indicated with no clear recommendation?	
Are there items that could add to scope?	
Are there ways to add value to ensure client goodwill, satisfaction and future work?	

### Legal, Ethical and Liability Requirements

Review the scope to determine if there are any issues that put you and your company at risk. Items to be considered:

Legal, Ethical, and Liability Requirements	Completed?
Does the project scope include adverse issues?	
Determine how these will be handled.	

### **Documentation Requirements**

Review the scope to determine what is required for documentation at all stages of the project. Items to be considered:

- Document sizes
- Document control
- Document ink colors
- Number of documents to be provided
- Number of document submittals
- Drafting requirements

### **Safety requirements**

Review the scope to determine what is required for safety at all stages of the project. Items to be considered:

Safety Requirements	Completed?
What additional safety training, equipment, or practices beyond current standard is required for this customer?	
Document any issues that are considered safety issues.	
Determine scope requirements and verify.	

### **Reliability requirements**

Review the scope to determine what is required for system reliability for this project. Items to be considered:

**Project scope should be reviewed for reliability issues.** These should be considered for adding value to project, for adding scope, for adding budget, and at minimum, for good will. Examples are:

- Revising design for simplicity but greater protection
- Revising design for better application of equipment

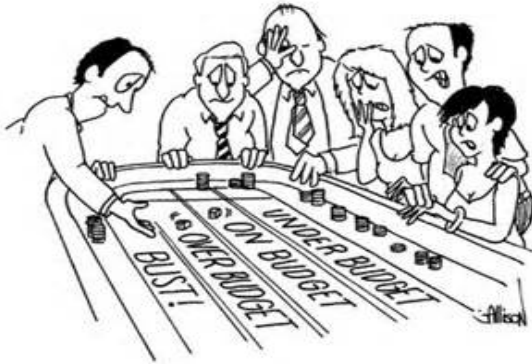
### **Maintainability requirements**

Review the scope to determine what is required for system maintainability for this project. Items to be considered:

**Project scope should be reviewed for maintenance issues.** These should be considered for adding value to project, for adding scope, for adding budget, and at minimum, for good will. Examples are:

- Revising design for ability to keep system in service but allow maintenance of critical equipment
- Revising design for eliminating unnecessary complexity allowing simpler shutdown

### **Project profitability**



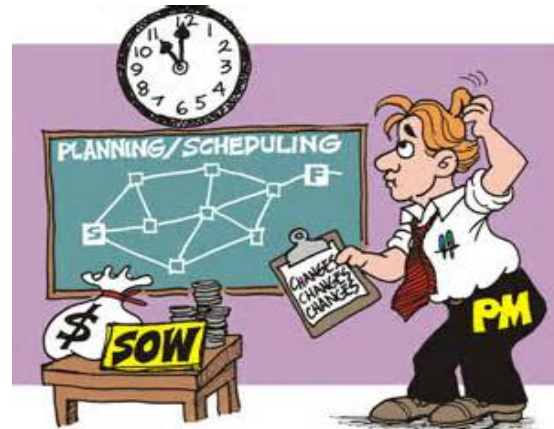
Review the scope to determine what is required to ensure project profitability. Items to be considered:

- Consider the differences between lump sum projects and time and materials projects.
- If there are risks in a project and project is lump sum quotation, be sure to clarify where scope stops in your proposal and/or to add sufficient money to scope to ensure cost for risk is included upfront.
- Be sure to inform client when risk money is included if cost of project is an issue. It is possible that client will retain risk for lower project cost.
- Develop and maintain payment schedule. Make it ironclad and meet your deliverable dates.
- Carefully consider liquidated damages projects. Be sure there is complete understanding and acceptance before taking these on.
- Has every item been considered and included in project scope?
  - Field trips
  - Possible conflict areas
  - Client responsibilities
  - Limits on work being provided
  - Is scope understandable within and outside of organization?

- Schedule
- Safety requirements
- Deliverables
- Pricing and payment schedule

Consider that due to various reasons (unclear scope, changing circumstances, etc.) the project budget will face revision throughout the project. Engineers and project managers need to be sure to keep scoped work within budget and to address out of scope items best suited for the client.

## Project Plan



The project plan is the breakdown of tasks required for the project. A project plan is a detailed plan of project tasks. This breaks down these project tasks into minute steps. (The idea is being successful with small tasks leads to success overall.)

The procedure for the project plan should be minimal so that the engineer is forced to create the plan through thorough consideration of the project. Too much preformatted data will prevent this thorough consideration from being performed. This plan should reflect the creative process.

Finally a new plan should be created for each project. As project plans are created and compared, similarities and efficiencies will be taken into account and the plan will evolve hopefully for the better. Project plans help with the following:

- Provide clear objectives
- Increase efficiency
- Bring issues to forefront
- Allow project work to be transferrable

It is the engineer's responsibility to interpret the scope and determine the project plan. Actions include:

### **Technical requirements**

Items to be considered:

- **Client**
  - Consider who your product is for and how it will help them when putting together a project plan.

- Consider field technicians.
- Consider oversight engineers.
- Consider non technical personnel with project responsibility.
  
- **Calculations**
  - Electrical engineering calculations
  - Mechanical engineering calculations
  - Civil engineering calculations
  - Chemical engineering calculations
  - Etc.
  
- **Scope clarifications**
  - Review possible decisions affecting the scope required for the project and develop questions up front.
  
- **Diagrams**
  - Basic system (one line diagrams, P&ID, schematics, wiring, etc.) layout with required data. Meet client requirements.
  
- **Plans and details**
  - Equipment, routings, equipment types, locations, circuits, associated equipment, and details. Meet client requirements.
  
- **Elevations and sections**
  - Specific equipment information. Meet client requirements.
  
- **Schedules**
  - Schedules of required equipment. Meet client requirements.
  
- **Specifications**
  - Must be in client required format.
  - Recommended to be developed in way that the vendor will answer technical questions up front.
  - Must be technically correct.
  - Required for all equipment:
  
- **Construction scope of work**
  - Must be in client required format.
  - Specifies all contractor work.
  - Specifies all contractor purchases.



- Recommended to be developed in a way that the contractor will answer technical questions up front.
- Must be technically correct.

**Legal, ethical, and liability requirements**

Items to be considered:

- Provide rules and controls to ensure required legal entity requirements.
  - Ensure that all documents and drawings are accompanied with documentation that limits liability to project scope.
  - Ensure that records are kept of all calculations and relevant conversations that liability is known and protected.
  - Perform all work to ensure protection of liability.

**Documentation requirements**

Items to be considered:

- Engineering should stress importance of this area.
- Determine drawing, document and submittal requirements.

Documentation for Drawings	Completed?
Document and record all drawings checked out.	
Keep record of original issue.	
Meet client requirements for drawing handling.	
Verify drawing sizes, colors, drafting requirements to meet client requirements.	
Obtain client required paperwork for handling drawings.	
Perform necessary record keeping.	
Utilize time date stamp.	
Create job books.	
Etc.	

For documents	Completed?
Record all relevant documents when corresponding about project.	
Use client required formats where required.	
Utilize time date stamp.	
Transmittals should be an engineering task.	
Create job books.	
Etc.	

## **Safety requirements**

Items to be considered:

- List safety requirements and perform.
- Take into account this requirement in all work. Field trips can affect time planning, design, and people's lives.

## **Reliability requirements**

Items to be considered:

- Analyze design based on reliability requirements and incorporate into design tasks. Analysis should be considered for adding value to project, adding scope, adding budget, and at minimum, good will. Examples are:
  - Revising design for simplicity but greater protection.
  - Revising design for better application of equipment.

## **Maintainability requirements**

Items to be considered:

- Analyze design based on maintenance requirements and incorporate into the design tasks. Analysis should be considered for adding value to project, for adding scope, adding budget, at minimum, good will. Examples are:
  - Revising design for the ability to keep the system in service but allow maintenance of critical equipment.
  - Revising design for eliminating unnecessary complexity allowing simpler shutdown.

## **Project profitability**

Items to be considered:

- Review project plan in terms of:
  - Does this plan utilize best practices?
  - Is the project plan efficient?
  - Are there ways of doing things differently to help reduce project costs?
  - Etc.
- Review project plan in terms of:
  - Are there issues that can cause scope creep?

- Are there issues that will cause project to be unprofitable?  
(Address these first.)
- Review project plan in terms of:
  - What is the best way to perform this project that will produce future benefit in terms of experience, tools, knowledge, customers for the engineering company?  
(This item allows breaking down project tasks and comparing to cost. Furthermore, it can be used as a tool to improve proposals, engineering and the bottom line.)

# Research



The research portion of a project is to gather information to specifically determine the minute details of the project. Research is intended to produce the following:

- Review of actual conditions.
- Review of actual equipment.
- Review of existing documents and drawings.
- Understanding how actual conditions will affect design.

It is the engineer’s responsibility to develop research plan to efficiently use time and gather the right information. Actions below include:

## **Technical requirements**

Items to be considered:

Develop field trip plan	Completed?
List of safety requirements for trip.	
List of equipment for trip.	
List required clothing	
Detailed list of items to view in field.	
List of people and phone numbers/email addresses for relevant people. <i>(People you are meeting at the site including office people that may be able to provide assistance in case of need.)</i>	
Detailed list of drawings to obtain from site.	
Data on how to get to site	
Entrance/exits data for where you will be working.	
Schedule/itinerary for trip.	

Equipment	Completed?
Bring camera with extensive data storage and high resolution. <i>(It is not unrealistic to take 500 or more pictures daily of a site.)</i>	
Be sure camera is charged and charging equipment is available in case of discharge. Bring extra batteries.	
Bring notebook suitable for worksite environment.	
Bring 2 pens, pencil, and eraser.	

Actions on site	Completed?
Take extensive and detailed pictures of all equipment that is involved in project.	
Take extensive and detailed pictures of all equipment and conditions around equipment involved in project.	
If equipment is to be physically moved obtain measurements of existing equipment, and area that will be considered to bring in or out equipment.	
Take extensive and detailed notes of all equipment that is involved in project.	
Take extensive and detailed notes of all equipment and conditions around equipment involved in project.	
Take pictures and notes of relevant nameplate data.	
Talk to technical personnel concerned with project about their expectations and preferences. Take notes of responses.	

### **Legal, ethical, and liability requirements**

Items to be considered:

- N/A

### **Documentation requirements**

Items to be considered:

- When making copies of drawings at site, 11x17 are the best option.
- Bring USB port storage for getting research data.
- For checking out drawings:
  - Talk to personnel in charge of checking out drawings and fully understand personnel involved and how to contact them and process.
- Obtain all necessary forms and understand how to use them.

## **Safety requirements**

Items to be considered:

- Site entry will require specific safety tasks and equipment.
  - List should include all tasks.
  - List should include provisions for obtaining equipment.
    - Equipment can include specific clothing required to be worn while on site.
- Safety credentials – Items to be considered:
  - TWIC card
  - OSHA card
  - Security Passport
  - Etc.

## **Reliability requirements**

Items to be considered:

- Talk to technical personnel concerned with project regarding reliability issues for project. Take notes of responses.

## **Maintainability requirements**

Items to be considered:

- Talk to technical personnel concerned with project regarding maintenance issues for the project. Take notes of responses.

## **Project profitability**

Items to be considered:

- Planning the research correctly and inclusively eliminates the need for additional trips to site.
- Planning the research correctly ensures efficient communication and efficiently receiving drawings and documentation.
- Including site personnel communication in field trip provides site personnel confidence that work is being done in their best interests.

# Calculations



The calculations portion of the project is to produce data that determines the following:

- Safe operating parameters.
- Capacities and requirements for equipment for the project.

It is the engineer's responsibility to determine the calculations, perform the calculations, and determine the presentation and content. Actions below include:

## **Technical requirements**

Types of calculations to be considered:

- Electrical engineering calculations
- Mechanical engineering calculations
- Civil engineering calculations
- Chemical engineering calculations
- Etc.

## **Legal, ethical, and liability requirements**

Items to be considered:

- In the case of legal action calculations are extremely critical. Correctness, stating calculation parameters, stating assumptions, stating client parameters, and using conservative approach are all very important.

## **Documentation requirements**

Items to be considered:

- Presentation of calculations is governed by consultant and client requirements. Using a presentation that clearly reports results is best to provide clear view of the intent and allow full understanding and communication.
- Submittal of calculations (with complete and understandable explanations of risks) to client so that they are informed and that they understand the basis of the calculations.

### **Safety requirements**

Items to be considered:

- Conservative approach should be used to ensure maximum required safe practices.

### **Reliability requirements**

Items to be considered:

- Reliability requirements should be considered in all calculations.

### **Maintainability requirements**

Items to be considered:

- Maintenance requirements should be considered in all calculations.

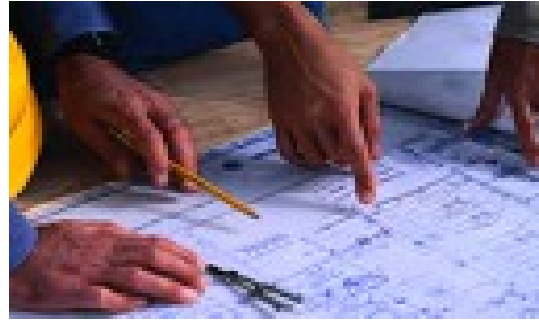
### **Project profitability**

Items to be considered:

- Calculations are the basis for specifying equipment and are very important criteria that can affect the project bottom line.
- Publishing calculations to client for approval ensures one (1) time purchase activity.



# Design



The design portion of the project is where the engineering is performed and the project is built on paper. Design provides the following:

- Actual drawings depicting design.
- Actual documents depicting design.
- Continued review of design for problems to ensure the project is a success.

It is the engineer's responsibility to perform the minute details of the design. Actions below include:

## **Technical requirements**

Items to be considered:

- Diagrams
- Plans and details
- Elevations and sections
- Schedules
- Specifications
- Construction scope of work

## **Legal, ethical, and liability requirements**

Items to be considered:

- In the case of legal action, design practices are extremely critical. Correctness, stating parameters, assumptions, client parameters, and using conservative approach are very important.

### **Documentation requirements**

Items to be considered:

- Ensure meeting client requirements for detailing the design:
  - Drawing and document sizes
  - Drawing and document ink colors
  - Font size
  - Specific details
  - Presentation

### **Safety requirements**

Items to be considered:

- Conservative approach should be used to ensure the maximum required safe practices.

### **Reliability requirements**

Items to be considered:

- Reliability requirements should be considered in all design.

### **Maintainability requirements**

Items to be considered:

- Maintenance requirements should be considered in all design phases.

### **Project profitability**

Items to be considered:

- Perform the work as efficiently as possible; 1 markup and 1 check are ideal for a project. While this rarely happens, attaining this with a successful working project will keep cost low.

## Checking



The checking portion of the project ensures project success. Checking provides the following:

- Quality assurance.
- Quality control.
- Ensures good design.
- Protects the company and engineering staff.

It is the engineering management's responsibility to ensure project checking is done to a very high level.

It is the engineer's responsibility to provide a complete package prepared for issue to checker. Actions below include:

### **Technical requirements**

Items to be considered:

- Calculations.
- All drawings to be issued on project.
- Research data.
- Transmittals.
- Scope data.
- Scope clarification data.
- Specifications.
- Vendor data.
- Equipment cut sheets used for design.

### **Legal, ethical, and liability requirements**

Items to be considered:

- Checking is a very important aspect which prevents legal and ethical situations and ensures adherence to correct liability and safety requirements.

### **Documentation requirements**

Items to be considered:

- Checking should ensure complete delivery on every aspect of a deliverable. The documentation requirements are especially relevant since only technical personnel will understand technical aspects. The package will be judged first on documentation requirements and appearance.

### **Safety requirements**

Items to be considered:

- Any requirements should have already been incorporated.

### **Reliability requirements**

Items to be considered:

- Any requirements should have already been incorporated.

### **Maintainability requirements**

Items to be considered:

- Any requirements should have already been incorporated.

### **Project profitability**

Items to be considered:

- The checking aspect has a direct impact on the quality of production and making sure that company liability is protected. Inevitably this has a direct impact on the company and project profits.

## Submittal



The submittal portion is the delivery of the actual product. The submittal for the project includes the following:

- Correspondence.
- Documents (Specifications, documented calculations, manuals).
- Drawings.
- Transmittals.

It is the engineer's responsibility to ensure deliverables are correct in all manners, in presentation and per client requirements. Actions below include:

### **Technical requirements**

Items to be included:

- Calculations
- Scope clarifications
- Diagrams
- Plans and details
- Elevations and sections
- Schedules
- Specifications
- Vendor data
- Construction scope of work

### **Legal, ethical, and liability requirements**

Items to be considered:

- Transmittals are the documentation of product delivery (very important).

### **Documentation requirements**

Items to be considered:

- Document sizes
- Document ink colors
- Font size
- Document format (hard copy, software format, etc.)
- Number of documents to be provided
- Number of document submittals

### **Safety requirements**

Items to be considered:

- N/A

### **Reliability requirements**

Items to be considered:

- N/A

### **Maintainability requirements**

Items to be considered:

- N/A

### **Project profitability**

Items to be considered:

- The documentation requirements are especially relevant because only technical personnel will understand technical aspects. The package will be judged first on meeting documentation requirements and appearance.

## Field Assistance



The field assistance portion of the project is for providing verbal and personal help for the actual construction of the project. Field assistance provides the following:

- Factory acceptance testing.
- Phone calls regarding technical help.
- Correspondence regarding technical help.

It is the engineer's responsibility to determine the scope and determine requirements for field assistance. Actions below include:

### **Technical requirements**

Items to be considered:

- Ensure provided assistance is within project scope.
- Ensure answers to a question do not impact design unless client specifically requires this.
- Ensure that this is not the time to perform design. If it is a scope addition, then treat as such. Liability is at risk.

### **Legal, ethical, and liability requirements**

Items to be considered:

- Ensure that this is not the time to perform design. If it is a scope addition, then treat as such. Liability is at risk.

### **Documentation requirements**

Items to be considered:

- This should not be an issue for this phase of the project unless there is incorrect design or scope change. Keep copies of all correspondence; document with date, time and contact person for all conversations regarding the project.

### **Safety requirements**

Items to be considered:

- As necessary for field trips.

### **Reliability requirements**

Items to be considered:

- N/A

### **Maintainability requirements**

Items to be considered:

- N/A

### **Project profitability**

Items to be considered:

- Tight controls need to be maintained to ensure work is billable and within project scope.



## Project Close



The project close portion of the project is the final work to complete and close out a project. Project close includes the following:

- Recording final data.
- Providing final drawings and data to client for their use.
- Storing project drawings and data for internal record.
- Ensuring project is complete and working through open items to close project.

It is the engineer's responsibility to close the project. Actions below include:

### **Technical requirements**

Items to be considered:

- Review all the following items for final issue:
  - Calculations
  - Scope clarifications
  - Diagrams
  - Plans and details
  - Elevations and sections
  - Schedules
  - Specifications
  - Vendor data and manuals
  - Construction scope of work

### **Legal, ethical, and liability requirements**

Items to be considered:

- Keeping a complete copy of client deliverables is required as a record of work.

### **Documentation requirements**

Items to be considered:

- Deliver the following per client requirements:
  - Document size
  - Document ink colors
  - Font size
  - Document format
  - Number of documents to be provided
  - Number of document submittals

### **Safety requirements**

Items to be considered:

- N/A

### **Reliability requirements**

Items to be considered:

- N/A

### **Maintainability requirements**

Items to be considered:

- N/A

### **Project profitability**

Items to be considered:

- Final closeout is usually required for release of final money. Don't let this hang around.

## **Conclusion**

Project planning should be performed to ensure efficient success and customer goodwill.

Note the final points:

- The intention is to aid in the project process. Don't develop bureaucracy that will kill creativity and efficiency.
- Some or even all of the described criteria may not fit some projects. Eliminate fear and allow change.
- Allow the required people to plan, engineer, and create efficiently.
- Sometimes this type of planning shows personnel and organization weaknesses. Not all situations, personnel and organizations fit together all the time. Capitalize on successful areas and strengths.

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