Recognize need

Conceptualize candidate solutions (incl. brainstorming)

Assess feasibility: Synthesize candidate solutions and analyze

Decide to proceed, acquire funding

Issue RFP for external work

Assign organizational responsibilities & develop work breakdown structure

Evaluate proposals and select

PRELIMINARY DESIGN

DETAILED DESIGN and development testing

Analyze perf. and cost

Qualification testing of prototype

Plan production and tooling

PRODUCTION

Acceptance tests
Recognition of need:

- Formal request from internal or external source (e.g., RFP)
- Informal request from colleague, peer, or potential customer
- Unsolicited proposal (solution conceptualization precedes formal expression of need)
- Assignment from supervisor
- Need that arises as a result of another project
- New government legislation or regulation
- Spawned by capability of new technology

During the conceptualization phase, it is human nature that people tend to identify with ideas and approaches that they have helped to develop. Therefore, they become resistant to other ideas or changes. It is crucial to have a thorough understanding of the need so that changes and new approaches can be justified based upon the need.

Conceptualization: See Creative Problem Solving.

Feasibility assessment: Determine whether candidate solutions involve any portion that is technically, physically, or financially impossible, and where new technology is necessary.

Synthesize: Build up candidate solutions without attention paid to details of individual parts. Key: All aspects of the need must be addressed.

Analyze: Break down candidate solution by examining each portion to determine whether it is feasible and whether it contributes to satisfying the need.

Work breakdown structure (WBS): Divides project into manageable tasks and relates tasks to one another and to overall project goals. Assigns responsibility and scheduling of tasks.

Preliminary design: Defines details of the design (or designs, if two or more candidate solutions are still under consideration), sometimes called embodiment design. Conducted in conjunction with development of the design requirements, a “living” document (may be partly or mostly graphical, like drawings) that describes in some detail (increasing level of detail as the project continues, usually) the requirements of each subsystem or subassembly. Key elements in developing good design requirements:

1. Recognize that it is impossible at the outset of the project to correctly specify all the requirements. Thus, anticipate that the requirements will be changed many times and establish a procedure for making those changes.

2. Understand that because of the iterative nature of the requirements specification,
frequent and prompt feedback are needed.

3. Use automation and computer models wherever possible to help the process (CAD/CAM software, electronic documentation, etc.).

4. Make sure that everyone contributing to or using the design specifications understands the terminology and usage so that their interpretations of the specifications are the same.

5. Use component or system tests if the cost and the information to be gained warrant them. (Hardware testing is usually expensive, while software testing is usually cheap.)

Detailed design: Finalize the details of the design (including detailed drawings of mechanical parts and of any assembly sequences) and the final product specifications. This is an iterative process with the preliminary design phase. Analysis of the detailed design vs. the cost and performance requirements or goals will determine whether further alterations to the preliminary design are necessary. Development testing is used to verify performance characteristics.

Qualification testing of prototype: At some point, a prototype of the end product must be produced and tested. Any required alterations are made in the final design and the product is then ready for production (or construction, or release, or whatever the appropriate term is).

Production planning: Identify the raw materials, processes, and machines needed to produce the final article and plan for the sequencing and scheduling of all operations required for production and for testing of partially of fully completed production articles for quality control. Computer-aided manufacturing techniques have made much of this process easier, but still by no means trivial, especially if resources are limited.

Acceptance testing: Tests on production articles (fully or partially complete) to insure that specifications are met and continue to be met as production continues.