Product Development System
Top Down Planning and Design
Business Process Guide

PDS 5.0

November 2004

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Contents

Change Record

Chapter	Description
Book-level change	Updated guide for PDS 5.0.

About This Guide

Preface

Business Process Guides are process-oriented descriptions of how PTC's Product Development System (PDS) supports common Product Development processes.

The goal of a Business Process Guide is to:

- Define recommended business process steps and activities that could be performed by a Product Development organization using PTC's PDS.
- Provide a common understanding of concepts and terminology relevant to the business process.

A Business Process Guide is designed for use in conjunction with a *Validated Process* document. Validated Process documents describe the paths through PTC PDS software that are used to test a given business process. The goal of a Validated Process document is to:

- Describe the scope of process-oriented testing in the PTC PDS Quality Systems Test Group
- Provide implementation guidance by illustrating detailed use cases.

Standard product documentation, which is functionality-oriented rather than process- oriented, should be referenced for more detailed descriptions of exactly how specific capabilities work and are used.

What is the Top Down Planning and Design Business Process Guide?

This is a guide to using PTC's Product Development System (PDS) to design a product. In this document, you will learn about:

- Recommended methods and techniques for designing products
- Functionality and tools within the PDS that support and manage the Top Down Planning and Design process

This guide has a different focus than typical product documentation. The process guide is process-focused, while standard documentation is functionality-focused. This guide provides general descriptions of the activities you will perform at various steps in the Top Down Planning and Design process, and descriptions of the appropriate PDS tools to help you accomplish these activities. This guide should be used in conjunction with the standard Windchill PDMLink, Windchill ProjectLink, and Pro/ENGINEER Wildfire documentation, which should be referenced for more detailed descriptions of exactly how specific functionalities work.

The overall methodology and procedures described here are the result of countless consultant and customer experiences. They collectively provide the best approach to the Top Down Planning and Design challenge. However, it is understood that every company will manage their design process differently. Accordingly, the tools in the PDS have been designed as flexible solutions that are scalable and modular enough to be adopted, in whole or in part, to your established Top Down Planning and Design methodology. Because of this, we encourage you to explore the ideas presented here, even if you have an established methodology in place. Some minor modification inspired by an idea described here could make your Top Down Planning and Design process more efficient, making your investment in reading this guide worthwhile.

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1

Overview of the Top Down Planning and Design Process

This chapter introduces several topics necessary to fully understand the overview of the Top Down Planning and Design process. It also provides a brief overview of that process.

Objectives of the Top Down Planning and Design Process

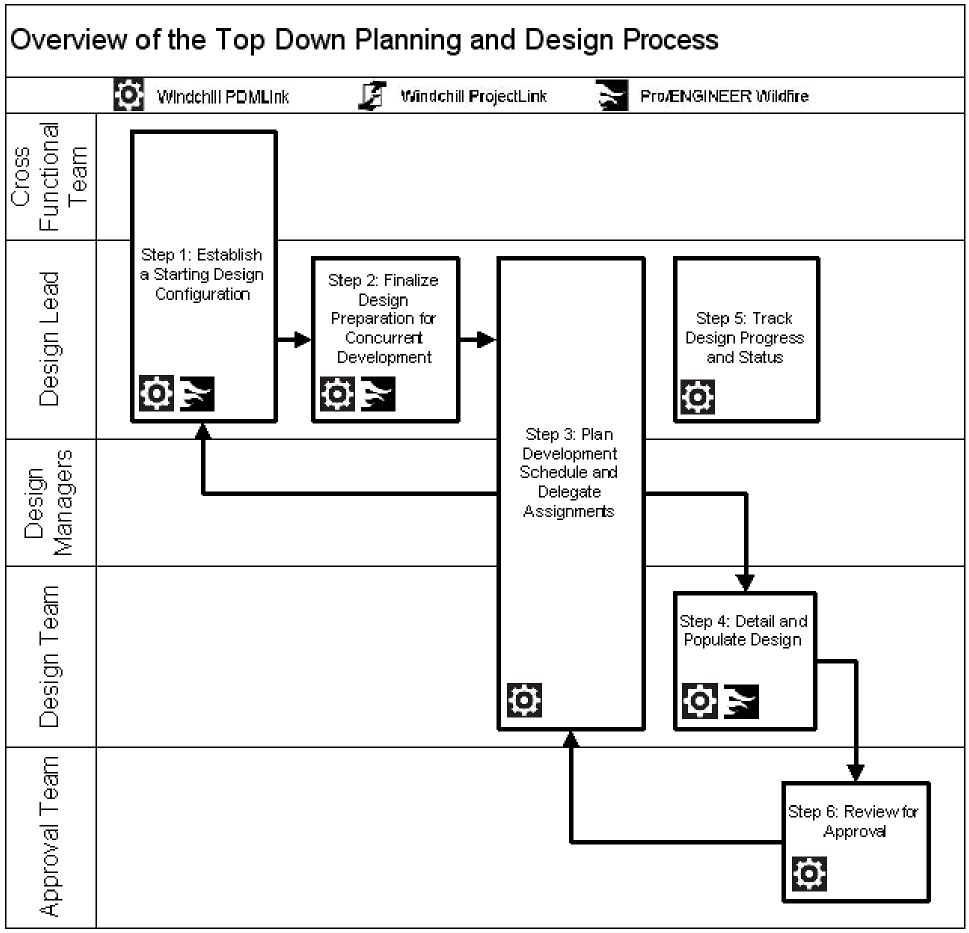
The Top Down Planning and Design process accomplishes four main objectives:

- It enables the selection of a starting design configuration that minimizes production costs and development efforts by promoting reuse while satisfying the fundamental requirements for the new product.
- It supports the creation of a framework to clearly communicate design criteria and boundaries of responsibility, which enables large-scale and cascading changes.
- It facilitates and controls the development of the design by distributed teams in a concurrent manner.
- It ensures technical and business due diligence prior to final approval and release of the design data.

The Six Steps of the Top Down Planning and Design Process

This section provides a brief overview of the six steps of the Top Down and Planning Design process. Before continuing to understand the process, it is important to note two complications within this process.

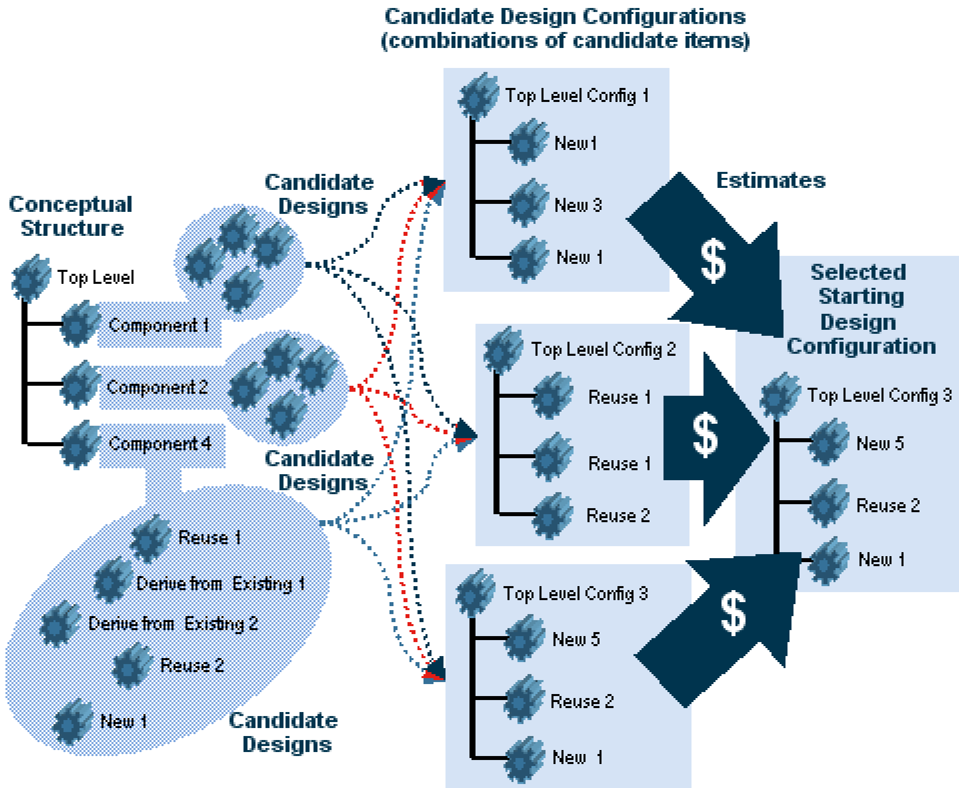
- The first four process steps can be nested, meaning that they will be repeated any number of times, particularly if the product has a deep product structure. This also means that the roles executing these first four steps will vary because of the delegation and hand offs after every cycle through the loop.
- Different sections of a design will be developed on different time schedules. As a result, these different sections of the designs will be at different steps in this process concurrently. This is further complicated by the fact that some designs are predecessors or are required for the completion of other designs.



The following sections describe each step and its associated activities in greater detail. These steps and activities are described in much greater detail throughout the rest of this process guide.

Step 1: Establish Starting Design Configuration

This first step in the Top Down Planning and Design process involves the identification or development of candidate designs, the creation of candidate design configurations and the selection of one of these as a start point for the design based on criteria such as cost, time to market or risk.



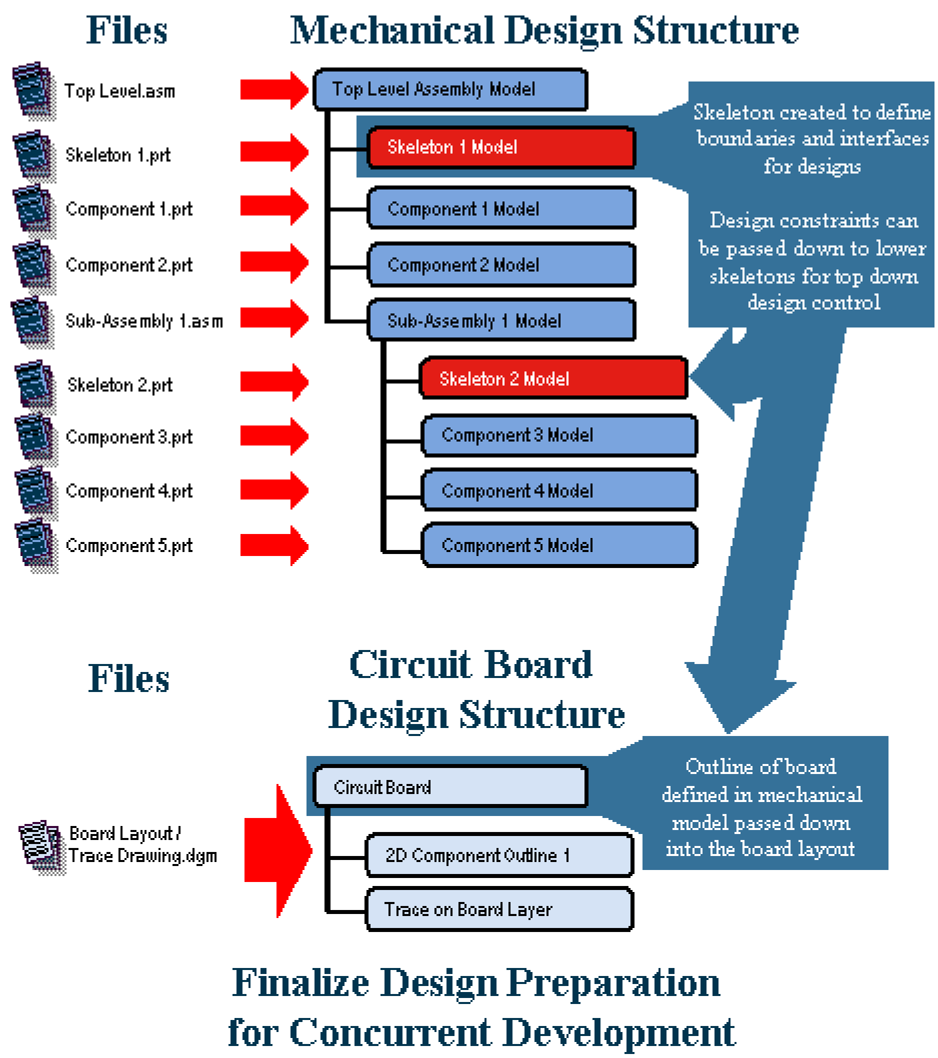
Establishing a Starting Design Configuration

Activity #	Description
1: Plan development options for designs.	Establish a plan that outlines the development possibilities for each design. • If reconfiguring an existing design into a new design, determine whether the planned subordinate design will be reused as currently defined or replaced with another existing design or a new design. • If creating a new design from scratch, determine which existing designs will be reused and which will be created new.

Activity #	Description
2: Create or find candidates for designs.	Candidates for each design must be identified and should fall into one of the following categories. • Reuse the existing subordinate design. • Replace the existing subordinate design with a different existing design. • Save the existing subordinate design as new. • Save a different existing design as new. • Create a new subordinate design. This also includes developing discipline-specific representations of the new designs, including mechanical space claims and electrical concepts, for use in mockups.
3: Down-select candidate designs.	Analyze and compare the performance and compatibility of each subordinate design candidate against design requirements. Eliminate those that do not comply.
4: Build candidate design configurations.	Develop candidate design configurations for each combination of designs that should be considered, including enterprise and design structures. This is commonly done in a top down or bottom up structure approach. This includes building mockups for each candidate design configuration.
5: Estimate each candidate design configuration.	Review candidate design configurations and document estimated efforts to develop each into the final design data.
6: Select starting design configuration.	Select the one design configuration to use as the starting point for development.

Step 2: Finalize Design Preparation for Concurrent Development

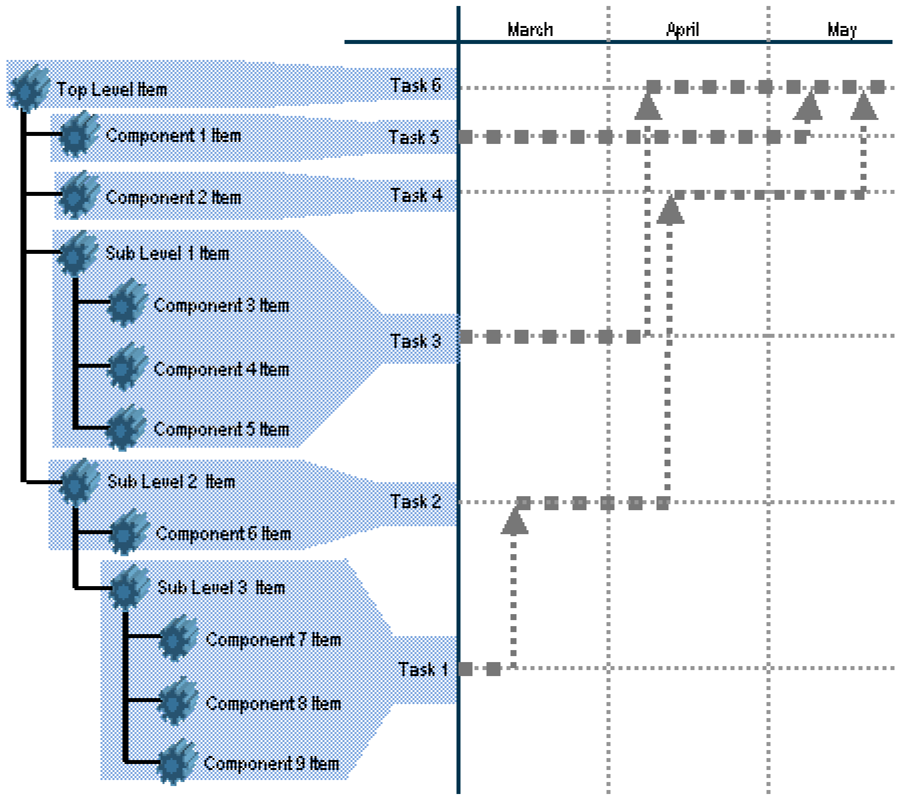
The second step in this process covers all the activities necessary to prepare the design for delegation to a larger team. This includes the creation of critical design information such as design placements, structures, and criteria.



Activity #	Description
7: Finalize structure and design placement.	Finish any additional structure work required after selecting the starting design configuration in a top down or bottom up approach. The design configuration mockup will evolve into a detailed design regarding placement of its subordinate designs.
8: Develop and disseminate design criteria.	Modify existing design criteria and/or create new design criteria as needed. Disseminate or re-disseminate the appropriate design criteria into each design as appropriate.

Step 3: Plan Development Schedule and Delegate Assignments

The third step in the process involves setting up the schedule, defining all standards and communication mechanisms, and developing schedules and procedures necessary for delegation.



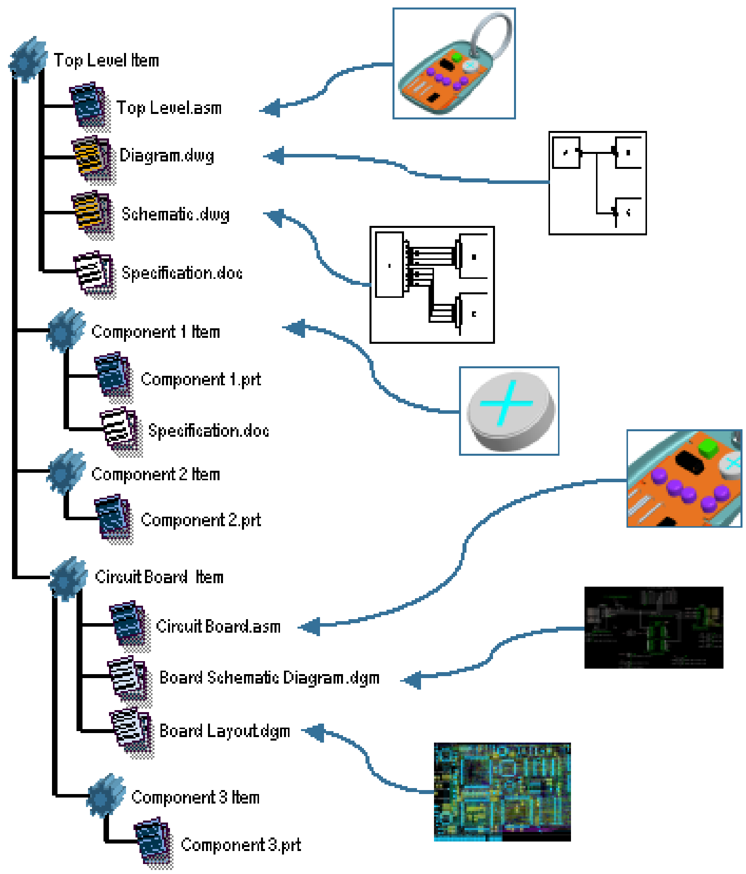
Plan Development Schedule and Delegate Assignments

Activity #	Description
9: Create development schedule.	Create a detailed schedule, with milestones and gates, tracking the development of the design.
10: Define communication and status procedures.	Document the communication practices during the development of the design once it is delegated.
11: Break out and delegate individual assignments.	Create assignments that are based on completing a specific deliverable within the design. Concisely record the instructions for work on the design in the form of documents or markups. Delegate the assignments to the appropriate individuals.

Activity #	Description
12: Delegate design control.	Modify the access control for each component of the design so that the owner to whom it is delegated can assume responsibility for it.
13: Host design kick-off meeting.	Communicate key information to the design team in support of their assignments.

Step 4: Detail and Populate Design

In this fourth step of the process, the designs are detailed and populated to their final states.



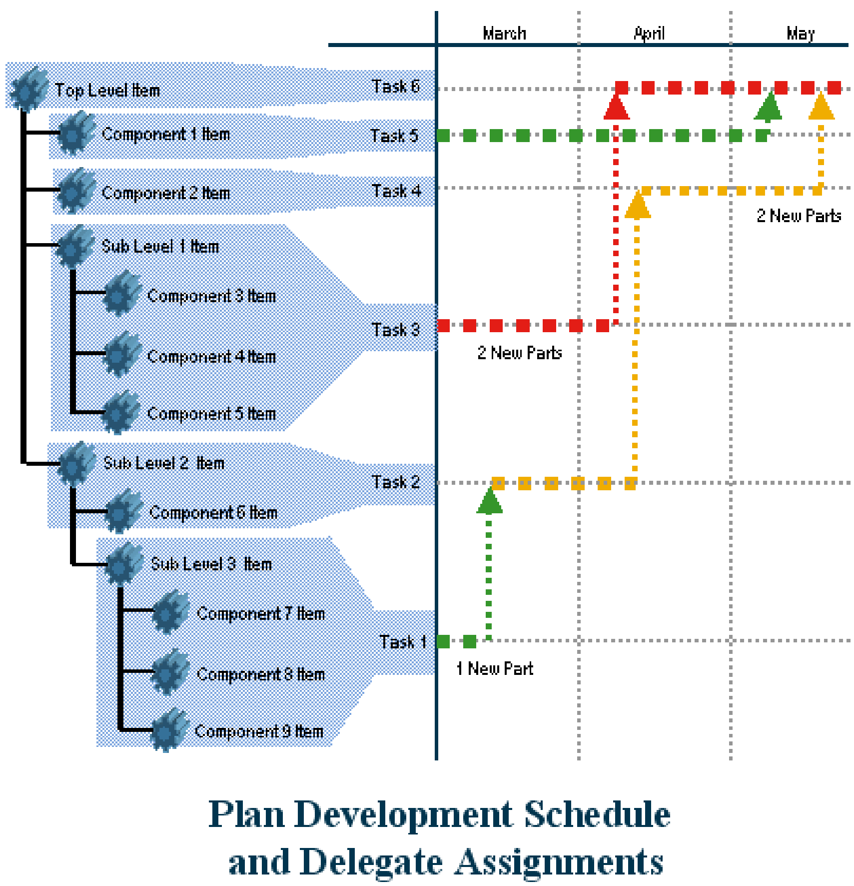
Detail and Populate Designs

Activity #	Description
14: Review assignments.	Review and, if necessary, revise the deliverable-based assignments.

Activity #	Description
15: Author and populate detailed designs.	Author and populate designs as specified in the deliverable-based assignments. This will include developing structures in a top down or bottom up manner.
16: Author design deliverables.	Author additional deliverables, such as drawings associated with designs, as specified in the deliverable-based assignments.
17: Update progress on assignments.	Update the status of the deliverable-based assignments.
18: Complete assignments.	Once all the deliverables are complete, then complete the assignments.

Step 5: Track Design Progress and Status

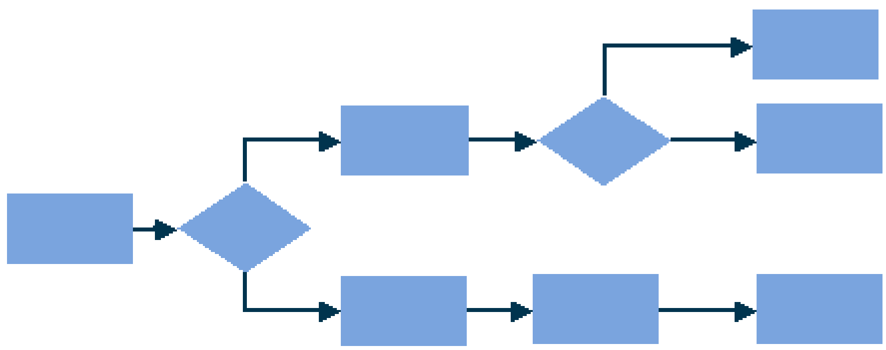
The fifth step in the process allows the progress and status of the design to be tracked closely by various levels of management.



Activity #	Description
19: Review status of design.	Review the progress and status of designs and subordinate designs.
20: Track new part introductions.	Track and review the number of new parts that are introduced as the design progresses. Where possible, redirect to reuse existing parts instead of introducing new parts.
21: Track assignment progress.	Track the progress of assignments to gain a broad overview of the progress toward design completion and visibility into any schedule changes initiated by the progression.

Step 6: Review for Approval

The seventh step in the process provides a means to approve the final design work so that it can pass into the next process.



Review for Approval

Activity #	Description
22: Review development plan.	Review the original plan for the design to understand the original boundaries on the assignment.
23: Review design.	Review the design in order to compare the planned design effort to the resulting design effort.
24: Review new parts introduced.	Review the new parts that are introduced with the completion of the design. This may result in more work to replace these new parts with existing ones in an effort to promote reuse and reduce costs.

Activity #	Description
25: Review against standards.	Review the design against industry, product, or modeling standards to ensure conformance.
26: Final approval.	This is the final step prior to releasing the design data.

Paths Through the Top Down Planning and Design Process

The Top Down Design and Planning process can be executed in a variety of ways, depending upon the types of activities required. The path chosen is based on factors such as the need to have someone external to the company or an organization participate as one of the roles, or the need to project manage the execution of the design plan.

In most cases, someone external to the company or organization would participate in steps 1, 3, 4, or 5, in the roles of a member of the cross-functional team, a design manager, or a member of the design team or approval team. These roles are described in detail in the *Product Development System Global Product Collaboration Process Guide*.

Project management is particularly applicable to steps 3, 4, and 5. These steps are described in detail in the *Product Development System Project Manage an Engineering Team Process Guide*.

Participants in the Process

Individuals and groups in processes fall into one of two categories. They are either *intermittent*, meaning they join in the process for a specific product development or *continuous*, meaning they join every product development effort in the same role.

Individual participants in the Top Down Planning and Design process may have an intermittent role; they join in the process to develop a specific product.

Title	Type	Description
Design Lead	Intermittent	The Design Lead is primarily responsible for developing configurations and preparing the design for delegation.

The four distinct groups in this process can be either intermittent or continuous participants, depending on the industry, the company and even the product.

Title	**Type**	**Description**
Design managers	Intermittent or Continuous	Design managers participate in preparing the overall product development schedule and are responsible for assigning design responsibility and tasks.
Designer team	Intermittent or Continuous	This design team is responsible for detailing and populating the design to completion.
Approval team	Intermittent or Continuous	The approval team is responsible for executing the final review of the product data prior to release.
Cross-functional team	Intermittent or Continuous	The cross-functional team is responsible for developing estimates of time and effort required to make the physical product and to develop all the product design deliverables. These estimates are used to choose which design configuration to use as a starting point.

2

Deliverables and Tools of the Top Down Planning and Design Process

This chapter introduces several topics necessary to fully understand the overview of the Top Down Planning and Design process. It also provides a brief overview of that process.

Deliverables of the Process

Ultimately, the deliverables from this process are split between design content and the structure around that content. These items are used downstream to plan and fabricate the end product.

Design Content

The term *design content* describes the variety of files that define the design at a detailed level. This content feeds by the next progressive process to fabricate the product.

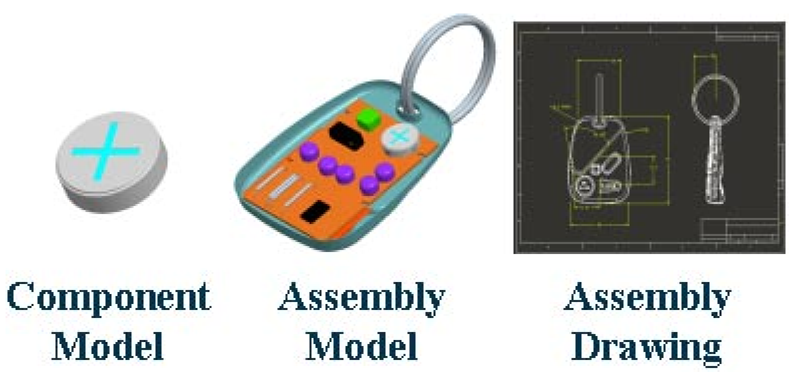
Sets of design content are commonly generated for one or more discipline-specific forms that may include mechanical, wiring, and circuit board definitions. Commonly, these forms of the design content are simply different representations of the same design. When this is the case, the representations must be synchronized periodically.

While there are other types of product content that are finally shipped with the product such as installation manuals and packing materials, these are deliverables not directly generated from the design process. As a result, the development of those items is not covered in this guide.

The following sections describe the discipline-specific types of design content and the ways in which these representations relate to one another.

Mechanical Design Content

Mechanical design content consists of deliverables that describe an item in terms of three-dimensional representations or their mechanical physical properties. The following is a list of mechanical design content.



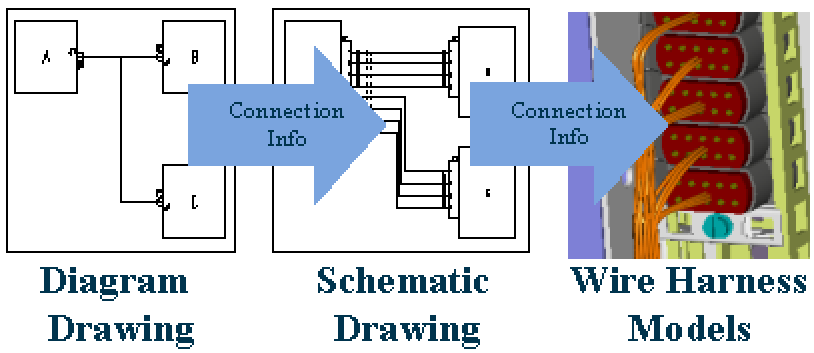
Type	Description
Component model	A three-dimensional representation of physical items made of a single continuous solid.

Assembly model	A three-dimensional representation of physical items that describes how component models and/or other assembly models fit together.
Component drawing / Assembly drawing	A two-dimensional representation of models. This deliverable commonly contains many views of the same model along with other details of its shape, which may include dimensions and notes.

There is a wide variety of other mechanical content such as process drawings, manufacturing models and cutter paths. However the creation of these deliverables are not covered in this guide as it focuses on the deliverables of the design process, which are the design models and drawings.

Wiring Design Content

Wiring design content describes an item in terms of a combination of two-dimensional abstractions and three-dimensional representations (or their electrical and mechanical properties).

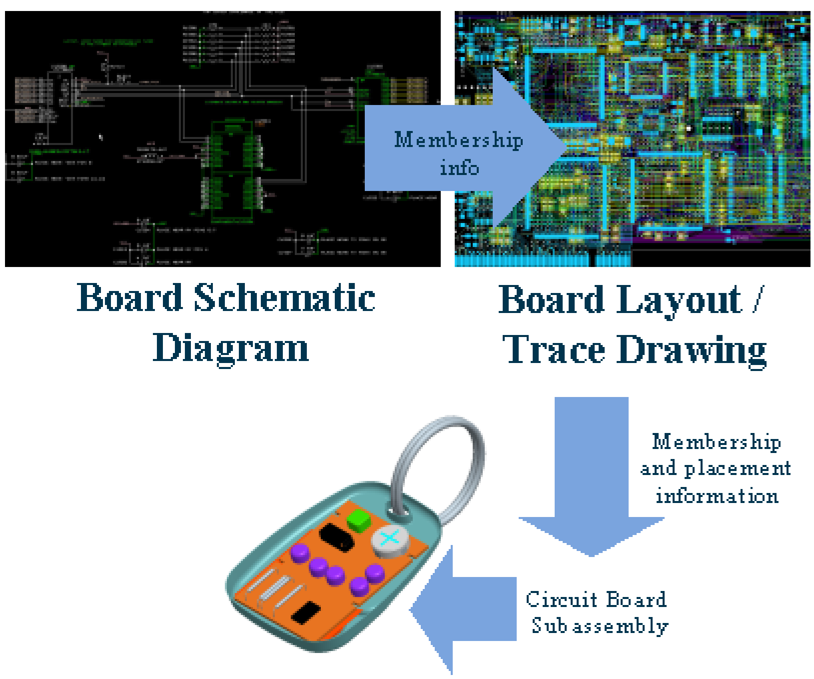


Type	Description
Diagram drawing	This two-dimensional drawing is an abstraction of the electrical wires going from one generic electrical symbol to another (from-to connection information). It is used as a logical conceptual check for the wiring system.

Schematic drawing	This two-dimensional drawing is a detailed representation of the electrical wires routed from one specific pin connector on an item to another. A schematic drawing builds on a diagram drawing, providing more detail. Again, from-to connection information is tightly tracked tightly for downstream routing purposes.
Wiring harness models and connector models routed through assembly model	The wiring harness model represents the routing of the wires and harness through the mechanical assembly model. The connector models represent the termination points of the wires and harnesses in the mechanical assembly model. This is a mechanical representation of the schematic drawing.

Circuit Board Design Content

Circuit Board Design Content describes an item in terms of a combination of two-dimensional representations, three-dimensional representations, and/or their electrical and mechanical physical properties.



Board Schematic Diagram

Type	Description

Board Outline/Trace Drawing	These two-dimensional drawings contain outlines of the circuit board. The metal traces within each layer of the board are included and represent a routing. Each sheet of the drawing commonly represents a different layer of the board, and thus a different set of traces.
Board Schematic Diagram	In this two-dimensional drawing, board component symbols are placed on the outline of the board. The board component symbols are always taken out of a standard approved library.
Circuit board assembly model and component models placed in assembly model	The circuit board assembly model is a three dimensional representation that is placed in the mechanical assembly model. The component models represent the items placed onto the circuit board. This is a mechanical representation of the Board Schematic Diagram

Documentation

This category of deliverables covers a wide variety of documents that directly describe the physical properties of the item. This may include but is not limited to design specifications, design manuals, and analysis result reports.

Iterations and Versions

While the end goal is to develop the final versions of the design content and structures, it is necessary to keep the trail of prior versions of the data for several reasons:

- It may be necessary to regress to a previous version and move forward from that point, based on new assumptions or direction.
- A fully traceable history is valuable in creating next-generation products. A branch in the design decision tree, represented by a certain version of the digital product data, can be used as a starting point for a new design.

To accommodate these needs, iterations or versions of the documents are maintained.

Iterations represent incremental changes to an object, such as part or document. A new iteration is created each time the object is checked in, at which time the working copy that you have edited supersedes the original object. At this time, the iteration is incremented (for example from A.1 to A.2). When this object is again checked out, a working copy is created that can be edited before being checked back in and iterated once more. The latest iteration of a version represents its current condition; previous iterations represent its history.

A new *version* is created each time you revise a part or document. Creating a new version (for example, A.4 becomes B.1) allows you to maintain, and create new iterations in, different versions of an object. While iterations are small incremental changes to an object, versions have business significance. For example, the writer of an owner's manual would revise the manual when a new model of the product is developed, and version A would maintain the manual for the first model, while version B would maintain the manual for the new model.

Access Control

Within the context of the Top Down Planning and Design process, access control is used for two distinct purposes.

First, access control is used to manage work-in-progress creation of design deliverables. Specific teams or individuals are given the ability to create and update product data. Access permissions can be based on the structure as well as on folder, which can be used to group like deliverables together.

Second, access control is used to control the visibility of data to downstream participants. It governs when and how the teams or individuals that will make tooling, machine code, or other derived product data can see the design deliverables.

In practice, downstream participants are provided visibility once the design content is relatively mature to ensure that they do not start creating downstream content when the design content is still very dynamic. Of course, the point at which design content becomes accessible to other process participants is determined by an organization’s business rules; for example, many organizations try to “design for manufacturability”, which may affect the speed with which they allow downstream participants to view design content. In any case, access control is the tool that governs this visibility.

Structures

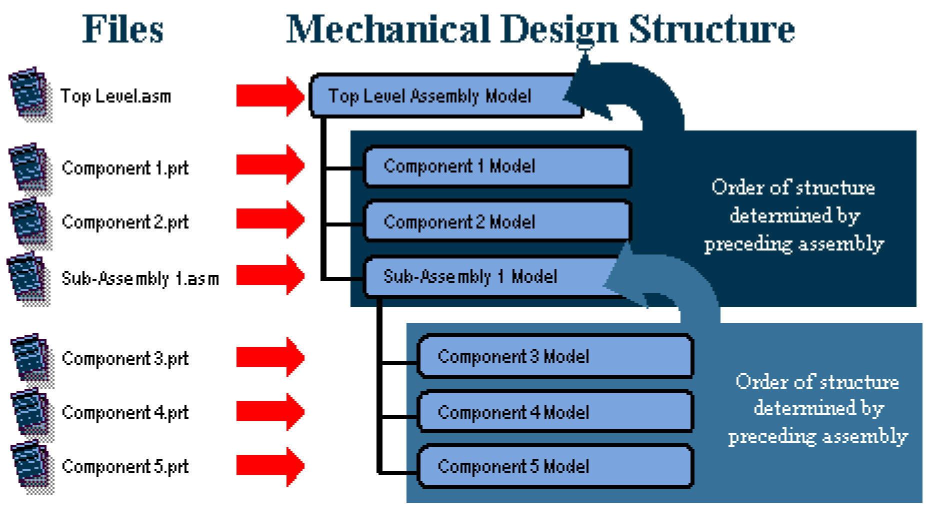
In its simplest context, the term structure is easy to define. A *structure* is a hierarchical list of all the items in a product; however, this definition quickly grows complicated within the context of modern products that include a variety of multidisciplinary designs.

The development of these designs is commonly delegated to a set of design teams, each specializing in and focusing on one discipline. These specialist teams use structures to organize and manage the creation of their discipline-specific design content. The resulting design structures are developed in a form most practical and convenient to that team and the related discipline. As a result, the creation of these multiple, discipline-specific structures inherently leads to differences in the hierarchy or order of the structure.

In the end, these differences between these design structures are aggregated and reconciled against a single structure--the enterprise structure--to gain agreement. Once complete, this enterprise structure becomes the deliverable for the next process, as it is the list of items to be fabricated or ordered to physically manufacture the product.

Mechanical Design Structures

The simplest definition of a *mechanical design structure* is that it is an ordered list of mechanical design content. However, this ordered list is somewhat unique in that definition of the hierarchy is represented primarily within the mechanical design content.

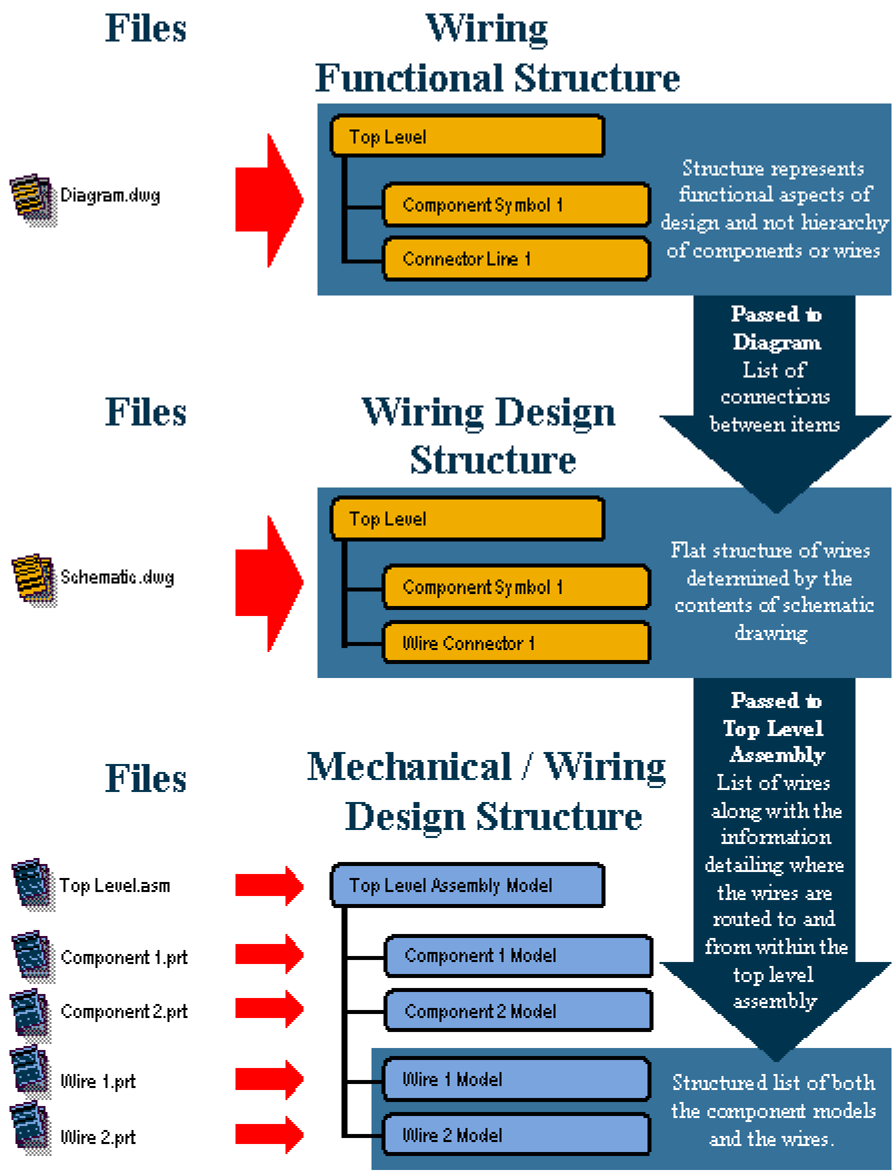


The basic building block of the ordered list is the assembly model. Each assembly model contains a number of component models and also other assembly models. By placing an assembly model within another assembly model, the mechanical design structure can be nested and thus extended. As a result, the aggregation of these nested assembly models becomes the backbone of the mechanical design structure. Other types of mechanical design content and tools are referenced in the assembly model and included in the mechanical design structure.

In practice, the hierarchy of the mechanical design structure is often organized into major functional subsystems, each represented by a single assembly, so that a given subsystem can be delegated to a team or individual for development. In this way, a number of teams or individuals can develop various subsystems concurrently.

Wiring Design Structures

A *wiring design structure* is an ordered list of the wires, harnesses, and connectors within a design. This hierarchy is unique in that it has two distinct, yet synchronous, mechanical and electrical representations.



The electrical representation is captured within the wiring design content, which consists of the diagram and schematic drawings. Unlike the assembly models that reference each other and thereby create a nested network that becomes the mechanical design structure, these drawing files are singular and do not reference one another. However, each of these drawings contains connection information, which actually represents the wiring design structure and much more. This information includes the hierarchy of the wires and the appropriate from-to connector destinations for each wire.

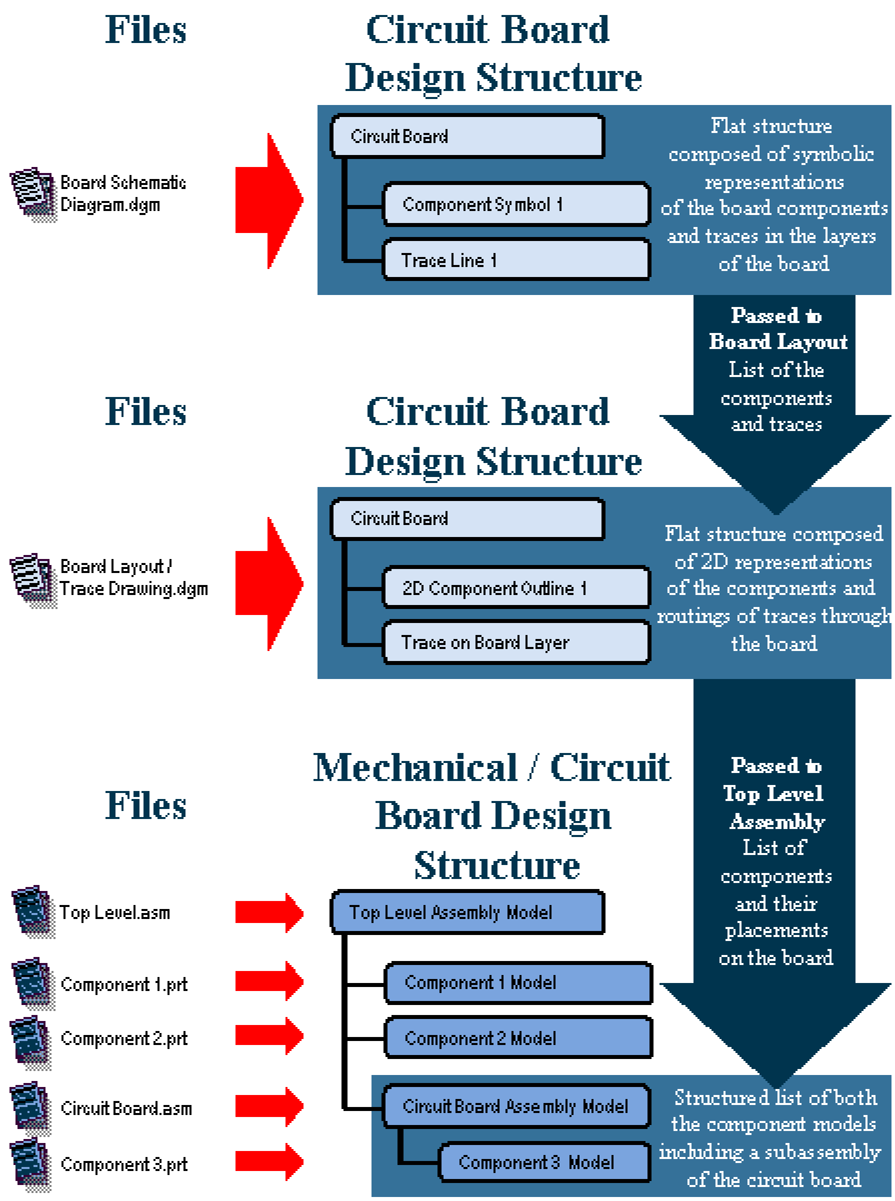
It is this information that is used to build the mechanical representation of the wiring design content and structure. This information is fed into an assembly model to route wirings, which are component models, to and from specific connector component models. Additionally, individual wires are grouped together to make harnesses.

In this way, the connection information from the diagram and schematic drawings and the assembly model become two distinct yet synchronous representations of the same wiring design structure.

In practice, the electrical wiring design structure is commonly split off into its own subsystem; it can be further subdivided, especially on larger efforts and more complex products. Again, this is mostly done to facilitate delegation to teams and individuals for development.

Circuit Board Design Structures

A *circuit board design structure* is an ordered list of electrical components that will be placed on the circuit board. The definition of this hierarchy comes directly from the assembly file, as part of the circuit board design content.



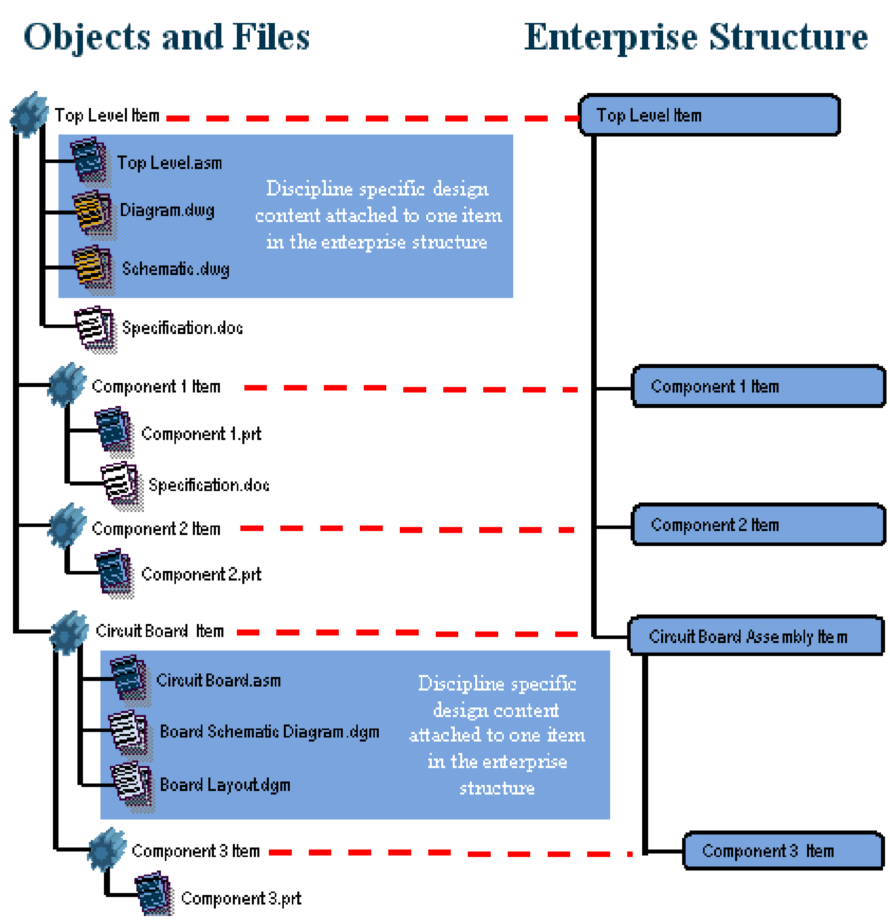
Compared to other design structures, circuit board design structures are unique in several ways. First, all of the electrical components are standard and come from an approved library. Few, if any, new electrical components are created during the process of designing a circuit board. Second, the hierarchy of the circuit board design structure is not nested: It is always one level deep.

As mentioned previously, the information in a board schematic can be passed to a mechanical assembly model to build out a mechanical representation. This in turn creates a mechanical design structure as it creates the mechanical assembly model. Once this is done, the circuit board design structure and mechanical design structure must be synchronized periodically to ensure agreement.

A single circuit board design structure is commonly assigned to its own subsystem so that its development can be delegated to one team or individual.

Enterprise Structure

An *enterprise structure* is a business representation of a product. While the nature of that representation varies from business to business, in general it is an ordered list of the physical items that must be fabricated and assembled to make the final product. Furthermore, the discipline specific design structures are reconciled against this enterprise structure.

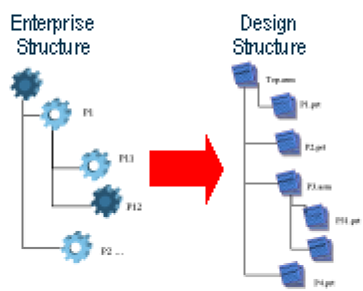


Approaches for Structures: Create Design or Enterprise First?

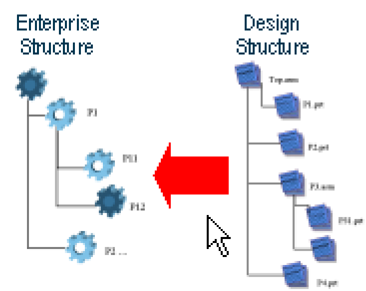
In this document, design and enterprise structures have been described. Design structures represent the discipline-specific hierarchy inherent in different types of design content. An enterprise structure is a business representation listing the physical items required to make a product. Furthermore, these two structures are related. All of the discipline-specific design structures are reconciled against the enterprise structure.

Given this information, it is natural to ask: which structure do you create first? While either type of structure can actually be created first, the answer is, in part, dependent upon who is doing the work.

While the specific steps vary from tool to tool, the Enterprise First, Design Second approach generally accommodates a user who does not have access to or the skill to use a design tool. This user can create the enterprise structure and then hand it off to one of the discipline-specific teams to create the design structure.



Enterprise First, Design Second



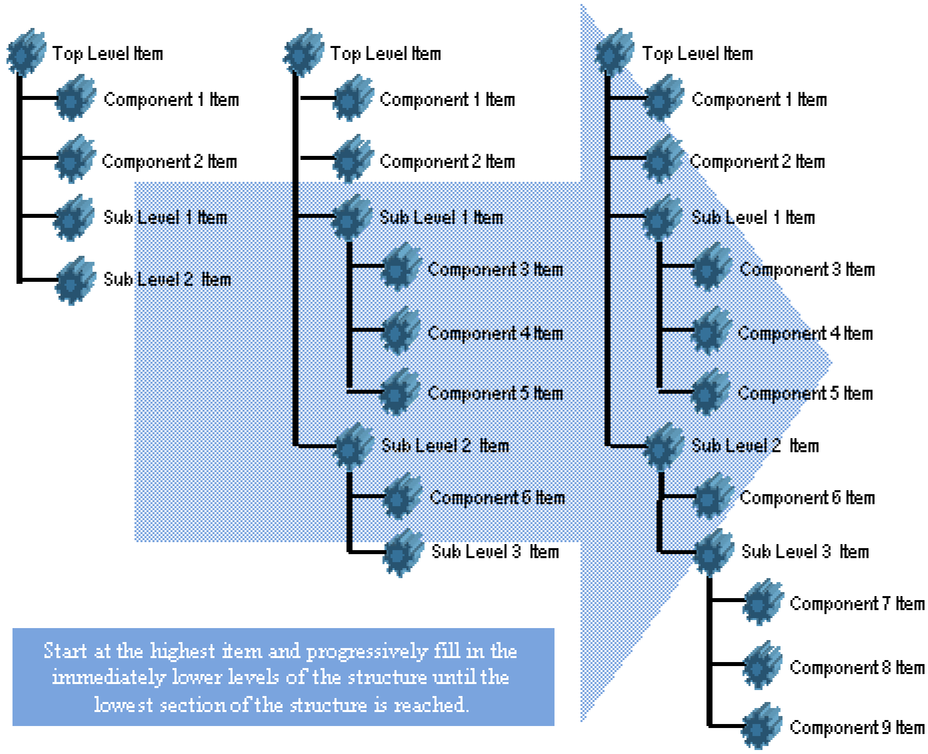
Design First, Enterprise Second

On the other hand, the Design First, Enterprise Second approach requires a user with access and the skill to use the design tool for all of the steps. It demands that the design structure be created first. The enterprise structure can then be derived directly from it. However the various discipline-specific design structures must be aggregated and reconciled against this enterprise structure.

Throughout the rest of the document where the steps in the Top Down Planning and Design process are described, references will be made to these two different approaches. As you will see, some of the steps in this process are naturally lend themselves more to one of these two approaches than the other.

Approaches for Structures: Top Down and Bottom Up

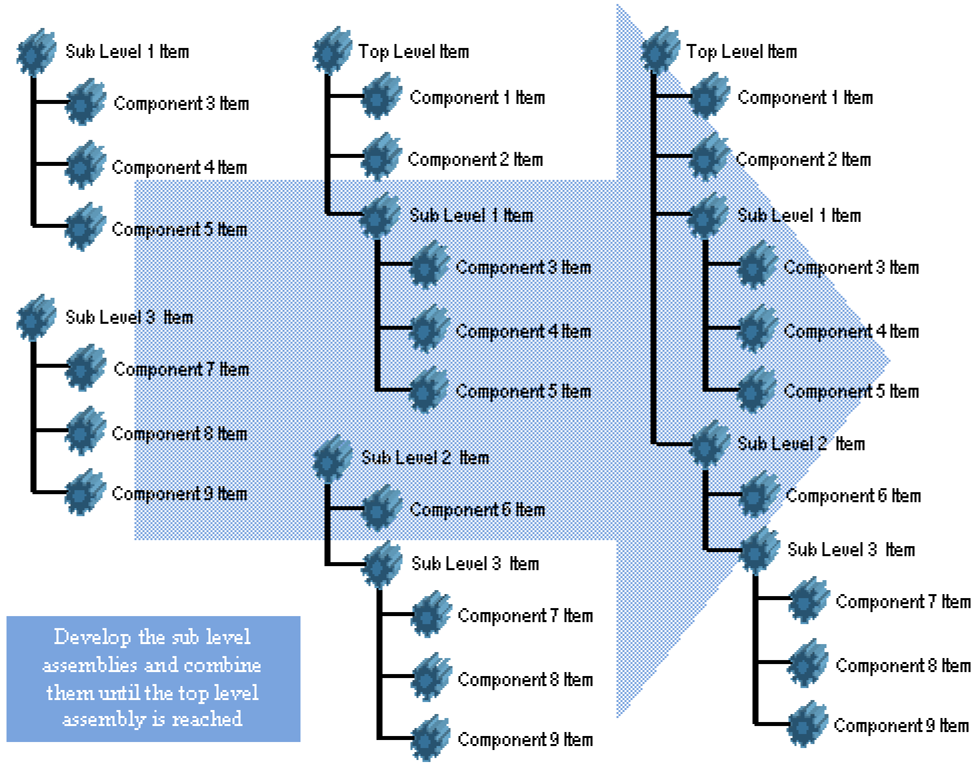
Just as interactions differ among structure types, there are also different approaches to creating them. Regardless of the type of a structure, it can be created in a top down manner, a bottom up manner or a combination of both approaches. The following outlines the two approaches.



Top Down Structure Modeling

In the top down structure approach, the following steps should be followed.

1. Create the highest-level artifact or document in the structure.
2. Create the artifacts or documents that make up the structure immediately below the highest-level artifact or document.
3. Attach these lower-level artifacts or documents to the highest-level artifact or document.
4. Repeat, moving downward in the structure until the lowest level of the structure is reached.



Bottom Up Structure Modeling

In the bottom up structure approach, the following steps should be followed.

1. Create the lowest-level artifacts or documents in the structure. This will involve the creation of many artifacts and documents.
2. Create the artifacts and documents that make up the structure immediately above the lowest-level artifacts or documents.
3. Attach the lowest-level artifacts or documents to the next higher-level artifact or document.
4. Repeat, moving upward in the structure until the highest level of the structure is reached.

In practice, neither approach is used exclusively. A mixture of the two is almost always used to develop different parts of the structure. The higher levels of a structure are more easily created with the top down approach, while creation of lower levels lends itself to the bottom up approach.

Tools and Approaches for the Process

While creating design content and structures, a variety of tools and approaches may be needed to support accompanying goals for the product. This section describes tools and techniques that are used to aid in the development of the design.

Tool for Mechanical Design Content: Design Criteria

The design of today's products is truly a collaborative effort.

Individuals on teams must work in concert to ensure components and subassemblies within their subsystem match and mate accordingly. Between subsystems, entire teams must coordinate their designs to ensure integration. Further complicating the effort is the fact that work-in-progress change in this environment is constant, and the results of adjustments often ripple across many subsystems, affecting the design work of many teams.

Given this dynamic environment, how do you begin to coordinate these efforts? For example, how do you design two mating components such that when a modification is made to one, you do not have to manually adjust the other to match? In a more complex example, how do you clearly identify and communicate the space that occupies a new subsystem to all teams? The answers to these questions lie in how design criteria are captured.

The term *design criteria* refers to sets of drawings or models that contain geometry and parameters, which are used in one of these two ways:

- Visually communicates the spatial organization, location, and size of designs. Ultimately this communicates spatial areas for teams to develop their designs in or vice versa to keep their designs out of spatial areas.
- Users reference the geometry and parameters in their designs as landmarks. As a result, this enables large-scale change by cascading a single modification to the design criteria to all the detailed designs that reference its geometry or parameters. In this case, a strong reliance on references is used as an enabler. References can either be internal or external.

Internal references are dependencies created among features within the same assembly model or component model. These references can be used to embed design intelligence that is similar to configuration on a component level. This allows the design to react intelligently to change based on the original goal of the designer.

External references are dependencies created among features that exist in two separate assembly models or component models. This type of dependency results in one file requiring another. From a structure view, these references are commonly between immediate subordinate assembly models or component models. As a result, a modification to design criteria can cascade sequentially through each level of a hierarchy from one subordinate to another, thereby enabling global changes.

Layouts

A layout is a type of drawing that contains only critical geometry and parameters, which then drive geometry and parameters within an assembly or component model. This provides an abstracted level of control and is useful for large-scale changes.

Skeleton Models

A skeleton model is a component model that contains design criteria geometry and parameters. The skeleton model is not considered part of the deliverable from the process, but more of a tool used to create and change other design content. The following are the types of design criteria geometry that can be included in a skeleton model.

- **Space Claim Geometry** – This geometry, which is created like geometry in any other component model, is used early in development to clearly define the space that will be occupied by the design once it is completed.
- **Interface Geometry** – This geometry represents the outline and other geometric characteristics of an interface between two major assemblies in a design. During the design of the two assemblies, this geometry is used as a reference. If this reference geometry changes, then that change will cascade through all the other designs that reference it, resulting in a global change in the two major assemblies that referenced it.
- **Industrial Design Surfaces** –In consumer products, one styled surface is often composed of many components. With design criteria, one surface can be created and then copied into many assembly models or component models where it is used in the construction of geometry. Furthermore, if the styled surface is modified, the change cascades through all the assembly models and components models referencing it.
- **Circuit Board Layout** – The design of a circuit board starts with its outline defined within the context of a mechanical assembly model, where the mounting pattern can be determined. Additionally, a representation of the space claim of the circuit board, referred to as keep-in and keep-out areas, is also defined. This information is then transferred to the Board Outline and Trace Drawings. There it can be used as a basis for placing electrical components on the board.

Parameters and Relationships

Parameters are used in assembly models and component models to represent geometric or non-geometric variables and their values. Equations can then be written that make these parameters dependent and independent variables representing design criteria and intelligence. These parameters can in turn be used to drive the values of feature dimensions and component placement values. In this way, intelligent and programmatic control of designs is possible.

In regard to skeletons, the high-level, non-geometric variables can be represented by skeleton parameters. Other assembly models and component models can reference these parameters through equations to create dependencies. Again, modifications to the skeleton parameters will cascade change to all of the assembly models and component models that used it as a reference.

Tools for Mechanical Design Content: Reference Control

As described in the previous section, referencing design criteria to drive and manage global changes is powerful tool. Overuse of one of its enabling functionalities, external references, can be detrimental. When too many references are used in a design, it causes it to be over-constrained making it inflexible. As a result, adjustments to the design become exceedingly difficult as well as potential for reuse declines.

The concluding thought that is ultimately reached is this: how do you control how and where design references are made? The answer is reference control.

The term *reference control* describes a set of tools that allows managers of design teams to determine what types of references can be created between which models. By defining when, how and where references are created, these managers are in effect defining the paths in which changes is propagated within the design.

Tools for Wiring Design Criteria: Harness Highways

Designers can clearly identify the locations through which harnesses should be routed in an assembly, based on clearances for mechanisms and other protected areas within a design. These areas can be identified as *highways* in the assembly model. As these highways are relocated, the harnesses also move, allowing for high-level, large-scale changes.

Tools for Circuit Board Design Criteria: Constraints

In the development process, designers face significant challenges due to the extremely complex interaction of electrical, mechanical and thermal properties within a printed circuit board (PCB). Constraint driven designs allow these complex interactions to be controlled in an automated and simpler fashion compared to manually managing these properties.

These constraints exactly specify the electrical, mechanical and thermal characteristics as well as any other physical limitations associated with the PCB layout. Understanding the constraints up front and designing with them in mind reduces the number of design iterations.

Tools for Downstream Deliverables: References to Designs

In conjunction with the effort to develop more innovative designs, downstream participants in product development try to get started earlier in order to reduce time to market, often by using relationships created between designs and the downstream sequences and design tools used to manufacture them. This allows modifications made to designs to automatically propagate to and update these downstream deliverables. The following are common types of downstream relationships.

Design geometry is commonly used to define the geometry of the tooling that is used to manufacture the design. As a result of this relationship, any time the design geometry changes; the geometry of the tooling also changes. While this relationship can be removed, it is unwise to do so, as it dramatically automates the effort to update the tooling during a change.

Design geometry and *tooling geometry* are both used to create machining sequences. This relationship allows changes made to the design geometry to update the sequences directly or through the tooling geometry, once it is updated from the design geometry. Again, while this relationship can be removed, it is unwise to do so, given the advantage it provides in reacting to changes automatically.

In these progressive cases, the downstream deliverables should be reviewed to ensure that the relationships are understood. This is particularly important when reconfiguring an existing design into a new design, as the existing design will commonly have dependent deliverables downstream in the process.

3

Details of the Top Down Planning and Design Process

This chapter presents detailed steps of the Top Down Planning and Design process.

Step 1: Establish Starting Design Configuration

Goals

The goal of this step is select the starting configuration for the design.

Overview of Activities

This step starts with the definition of development possibilities for each of the immediate designs. The specific activities will vary depending upon whether the design is reconfigured from an existing one or created new.

Next, the candidates for each of the designs should be listed. Once listed, they can be considered in comparison to the needs and requirements of the entire product. This allows this list to be reduced to the candidates for each design that should be included in some design configuration.

From the candidates defined for each design, candidate design configurations are built to represent each permutation that should be considered for the starting design configuration. Mockups for each of the candidate design configurations should be constructed.

Subsequently, development efforts and costs are estimated for each of the design configurations and corresponding mockups. This information is then used to assist in selecting the one design configuration that is to be used as the starting point for the design.

Benefit

The benefits of this step are as follows:

- Accurate estimates enable better decisions – Making the right decision regarding the selection of a starting design configuration is dependent upon the accuracy of the estimates and the compatibility and flexibility of the design data. Therefore, technical due diligence at this step determines the ultimate efficiency rendered from the starting design configuration.
- Selection decision in light of full technical disclosure – By the time the candidate design configurations are built, the technical feasibility, production costs, and development efforts have all been carefully considered and reviewed by a cross-functional representation of the company.
- Best starting configuration – This step contains activities with a very specific purpose. By reviewing the candidate design configurations and their associated development and production cost estimates, a well-informed decision can be made for the product that will ultimately lead to the best combination of the development effort and product costs.

Fundamental Concepts

Types of Costs – Hard and Soft, Recurring and Non-Recurring

The selection of one candidate design configuration over another is in part dependent upon the effort and cost associated with each. This cost or effort falls into two general categories.

First, costs are either *hard* or *soft*. Hard costs are the costs to make physical items, such as raw materials. Soft costs are generally the money spent on people performing some activity (such as updating a document). Both types of costs must be included in the estimates for a proposed change.

Second, costs are also either *recurring* or *nonrecurring*. A recurring cost is one that repeats consistently within a time cycle. For example, a change in materials might increase the cost of the product it is in every time you make that product. A nonrecurring cost is a one-time cost, such as the cost to manufacture new tooling required to make a product, including activity time and scrap time. Again, both types of costs must be included in the estimates for a proposed change.

Configuration Mockups from Heterogeneous Data

In this step, there is a need to visually check the mechanical, wiring, and circuit board compatibility. In many cases, the data within a specific discipline may very well be spread within a variety of authoring tool formats. For example, one design may reside in a Pro/ENGINEER Wildfire format, while another resides in a CATIA format, and yet another in a Unigraphics format. For the purposes of candidate design configuration mockups, conversions do not necessarily need to be made into a common authoring tool format. However it is important to spatially place them so the compatibility can be checked. In this case, visualization tools can be used to perform these studies for each candidate design configuration.

Paths Through This Step

There are two paths through this step, with the difference based on how the step begins. Either the design can be based on an existing one, or a new design is created. The following sections explain these two options in greater detail.

Reconfigure an Existing Design into a New Design

The first path, reconfiguring an existing design into a new design, is also the one that will typically require less development effort. This is due to the fact that the existing design is already completely populated and requires effort only for the changes. Most often these changes are focused on the subordinate designs. In general, there are five options for each of these subordinate designs.

- Reuse the existing subordinate design – In this case, the existing subordinate design is simply used, as it exists. This requires no more work, other than minor location adjustments to other new subordinate designs located near it. This option relies on the capabilities described in the *Product Development System Search and Reuse process guide*.

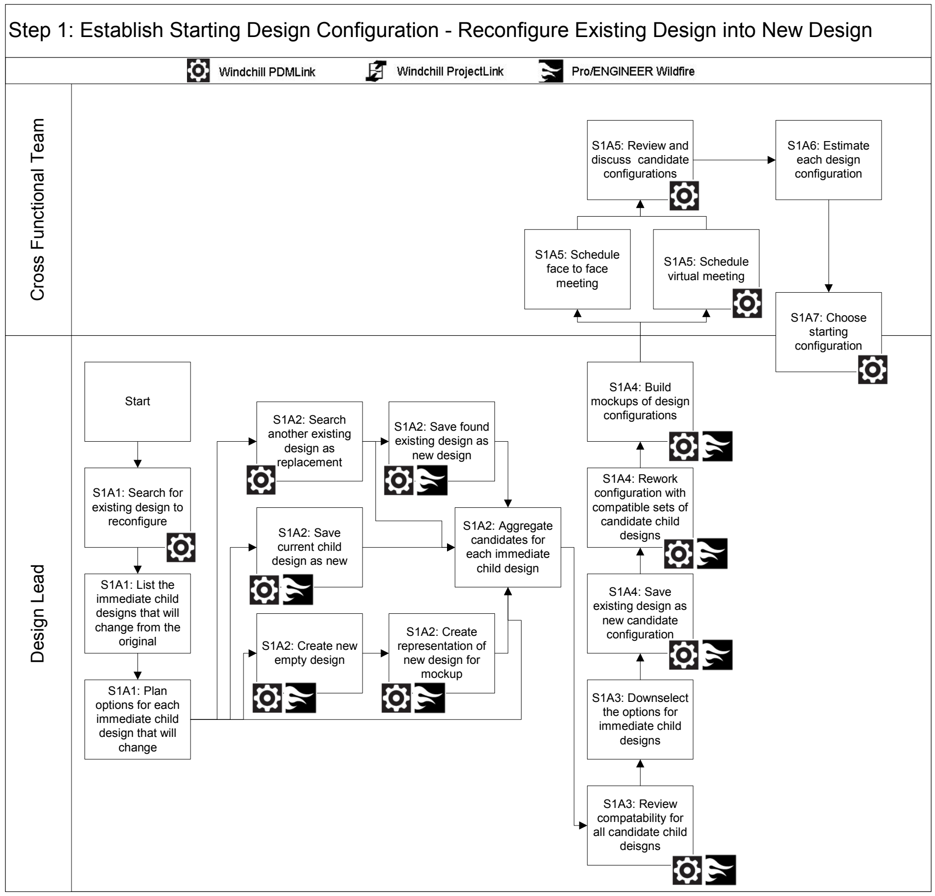
- Replace a current subordinate design with a different existing subordinate item – Another option is to replace one of the subordinate designs with another unchanged, existing design. This involves searching for or navigating to the appropriate existing design. This option relies upon the capabilities described in the *Product Development System Search and Reuse process guide*.
- Save the current subordinate design as a new design – With this option, the current subordinate design is saved as a new design that can subsequently be changed. Additionally, this requires the replacement of the existing subordinate design with the derived one.
- Save an existing design as a new design – In this case, an existing design that is not currently a member if the existing design is saved as new and subsequently changed. This new design is then placed. This option relies on the capabilities described in the *Product Development System Search and Reuse process guide*.
- Create a new design – The last option is to create a new, empty design and then place it.

Create and Configure a New Design

The second path, creating and configuring a new design, requires more development effort, as it requires that existing or new designs be placed together as subordinates of this new design. There are three options for these subordinate designs.

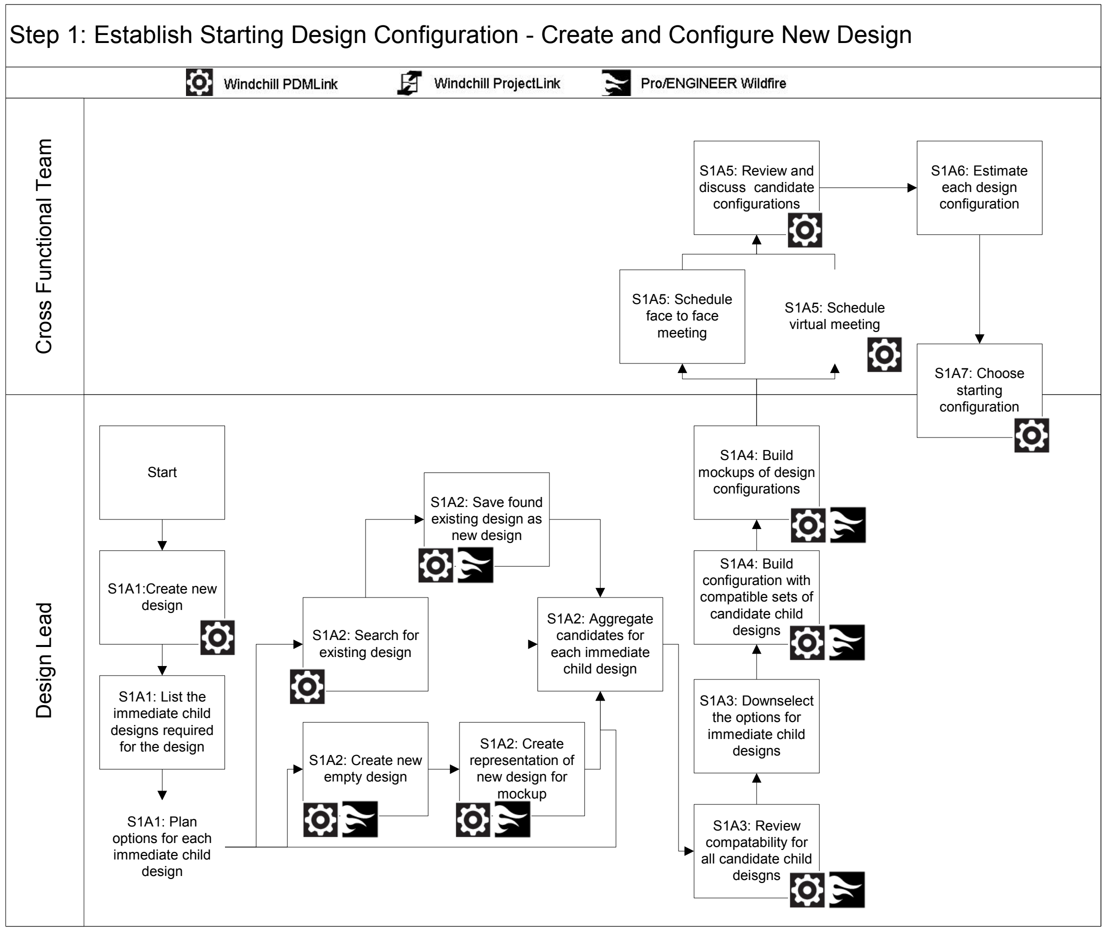
- Reuse an existing subordinate design – The first option is to search for or navigate to an existing design and place it, without changes. This option, which requires the least amount of development effort, relies upon the capabilities described in the *Product Development System Search and Reuse process guide*.
- Save an existing design as a new design – In this case, an existing design is saved as new and subsequently changed. This new design is then placed. This option relies upon the capabilities described in the *Product Development System Search and Reuse process guide*.
- Create a new subordinate design – The last option is to create a new empty design and then place it.

Activity Map: Establish Starting Design Configuration – Reconfigure an Existing Design into a New One



S1A1: Plan development options for designs
S1A2: Create or find candidates for designs
S1A3: Downselect candidate designs
S1A4: Build candidate design configurations
S1A5: Estimate each design configuration
S1A6: Select starting design configuration

Activity Map: Establish Starting Design Configuration – Create and Configure New Design



S1A1: Plan development options for designs
S1A2: Create or find candidates for designs
S1A3: Downselect candidate designs
S1A4: Build candidate design configurations
S1A5: Estimate each design configuration
S1A6: Select starting design configuration

Step 2: Finalize Design Preparation for Concurrent Development

Goals

The goal of this step is finish all the design preparation work before any of it is delegated.

Overview of Activities

Once the starting design configuration has been established, a set of activities must be completed before detailed design work can be delegated to teams or individuals.

First, the placements of the designs must be finalized, based on the mockups that were generated for each design configuration. Additionally, the structures of these designs need to be finalized at least to the level of the structure that will be delegated.

Once the placements and structure are set, then the design criteria can be created or modified. This design criterion should then be propagated throughout the structure as necessary. Again, like the structure, this should be extended to the level of the structure that will be delegated.

Finally, product and modeling standards should be defined for the effort. Also, libraries that contain standard parts should be identified so they can be referenced once design activities have been delegated.

Benefit

The benefits of this step are as follows:

- Mechanical design criteria coordinates the design effort – When space claims and interfaces are defined early in the process, the boundaries and references for the creation of detailed designs are clearly found and understood. Even as different designs progress, all of the participants in a particular design references the same design criteria. As a result, the development of the product is coordinated throughout many designs.
- Mechanical design criteria enables large-scale modifications – When detailed designs reference design criteria, a network of references is build around a single source of modification. When the design criteria is modified, that modification then cascades through all of the related designs, enabling adjustments on a large scale.
- Mechanical reference control promotes reuse – When the scope in which detailed designs can reference other detailed designs is clearly defined, external references are minimized to only those that are required for large-scale modifications. As a result, designs are more portable and reusable.

Fundamental Concepts

Standards: Definitions and Types

Standards have always been a point of emphasis in developing new products. Generally, these standards can be applied in two ways.

First, the standards are applicable to the end products. These could be standards defined by a government agency or industry watch-group. Alternatively, they could be derived from best practices that have been codified within a company. Furthermore, they may be specific to a particular product or set of product lines.

Second, the standards are applicable to the data. Standards can be applied to the fidelity or flexibility of design models (geometric best practices or model settings), or perhaps to the format and types of information within the data (parameters, document formats, and so on). At one time, drafting checkers enforced standards for hard-copy drawings; currently, similar standards seem to be emerging around design data.

Paths Through This Step

There is one path through this step. However, there are different ways and means to complete some of the activities regarding structures and design criteria. The following explains the variations for those activities.

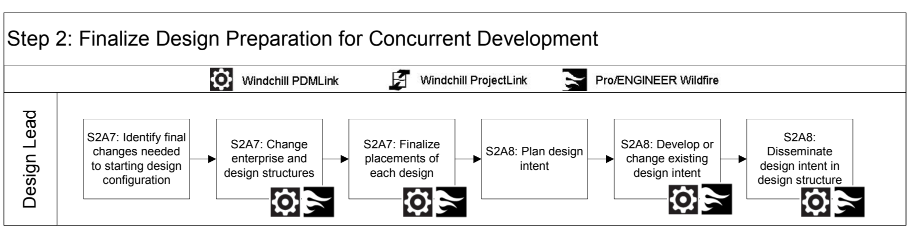
S2A7: Change enterprise and design structures

- Enterprise First, Design Second – see detail in the Approaches for Structures: Which to create first? Design or Enterprise? section of this guide.
- Design First, Enterprise Second – see detail in the Approaches for Structures: Which to create first? Design or Enterprise? section of this guide.
- Top Down Approach – see detail in the Approaches for Structures: Top Down and Bottom Up Approaches section of this guide.
- Bottom Up Approach – see detail in the Approaches for Structures: Top Down and Bottom Up Approaches section of this guide.

S2A8: Develop or change existing design criteria

- Mechanical Design Criteria – see detail in the Tool for Mechanical Design Content: Design Criteria section and the Tool for Mechanical Design Content: Reference Control sections.
- Wiring Design Criteria – see detail in the Tools for Wiring Design Criteria: Harness Highways section
- Circuit Board Design Criteria – see detail in Tools for Circuit Board Design Criteria: Constraints.

Activity Map



S2A7: Finalize structure and design placement
S2A8: Develop and disseminate design intent

General Suggestions

What Is the Best Way to Build Structures in Support of This Step?

The best overall approach will vary, depending upon whether a given design was created by reconfiguring an existing product or creating a new product.

If creating a new product, a good approach is to build in a top down manner, filling out the structure while proceeding from higher to lower levels. Using the

Enterprise First, Design Second approach will provide an early framework for various disciplinary groups to reference and thus be coordinated at a base level.

If reconfiguring an existing product into a new one, the sections of the existing structure is best developed using bottom up approach and Design First, Enterprise Second approaches. When dealing with the new sections of the product structure, rather than saving existing sections as new, it is easier to treat the relevant design structure as a new product, as described in the preceding paragraph.

Step 3: Plan Development Schedule and Delegate Assignments

Goals

The goal of this step is to develop a full schedule and allocate assignments.

Overview of Activities

With the design preparation finished, the overall schedule and individual assignments can be created. The schedule should include appropriately timed stages and gates, along with periodic design progress and status meetings. The assignments should consist of derived and discrete amounts of the total work that is required, and should be sequenced as predecessors and successors. Additionally, assignments should be developed with well-documented work instructions, as they will be assigned to a specific team or individual in the next step.

After the schedule and assignments have been defined, those assignments can be given to specific teams or individuals. Along with the assignment, the access control for the design must be altered so that the team or individual can do the design work.

Once the assignments have been given out, a design kick-off meeting should be held to officially start the development effort and communicate critical information.

Benefits

The benefits of this step are as follows:

- Efficiently planned usage of design resources – In many designs, it is necessary to complete some portion of one design before another design can be started. This relationship between predecessor and successor affects the start and end dates of work and, therefore, affects the timing in the overall schedule. This step allows for the assignments to be sequenced in the correct order considering these relationships. As a result, managers can accurately plan when and how participants will become engaged and disengaged with a design effort. This in turn maximizes productivity.
- Minimize corrective action – For some design assignments, a simple text description does not adequately describe the objective of the assignment.

More visually descriptive instructions like markups communicate more clearly. When these instructions are clearly and concisely documented, it greatly improves the chances the task will be correctly the first time instead of fixing issues in a change process after the design has been released.

Fundamental Concepts

Real Time and Asynchronous Meetings

Meetings are either held in real time or asynchronously. First, there are two ways to hold a real time meeting in which the topics are discussed in real time.

In face-to-face meetings, the meeting participants gather in a room. Audible and visual communication is carried out physically. This is commonly done when all the participants are at one geographic location.

In virtual meetings, the meeting participants do not physically gather in a room. Audible communication is through a conference call, while visual communication is carried out through digital media on a computer.

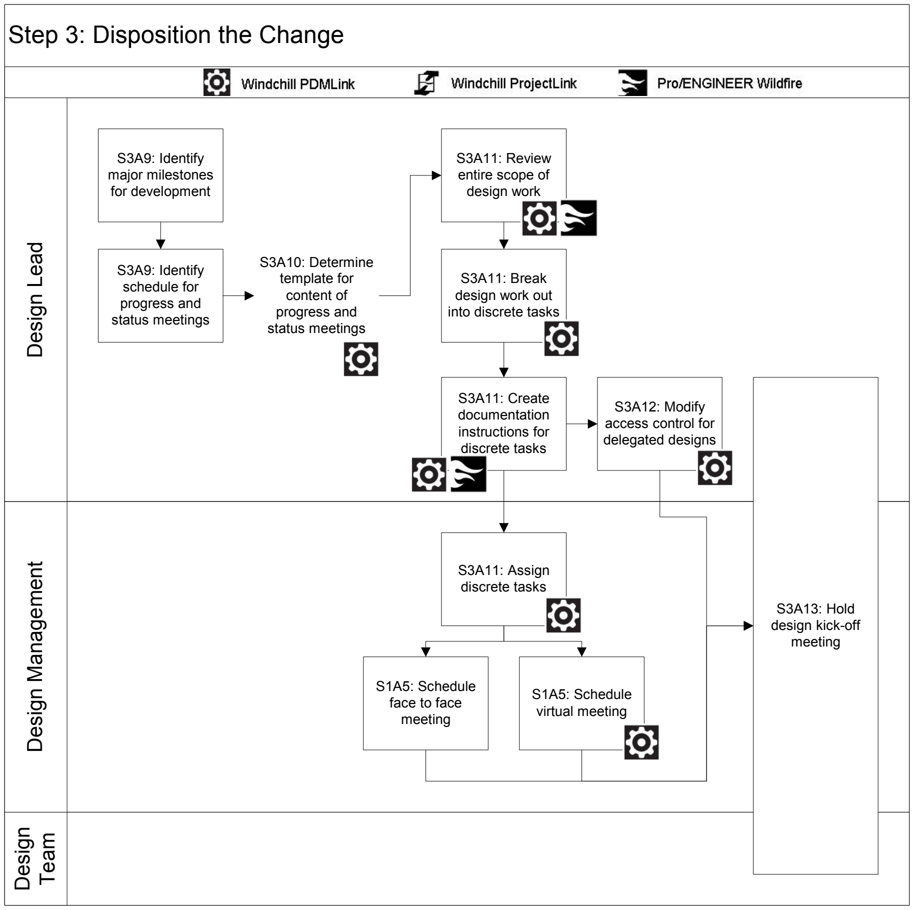
Asynchronous meetings are held in discussion forums where the participants post their comments asynchronously. In this case, there is no audible communication. Visual communication is through the discussion forums and through the data, which are accessible at any time.

Paths Through This Step

There are four paths through this step. On one hand, these paths are split based on whether the participants are internal or external to the company. On the other hand, the paths are split based on whether the rest of the development is managed with simple tasks or through formal project management. The following lists references for some of these paths.

- The two paths involving project management of the rest of the development, whether with internal or external participants, is detailed in the *Product Development System Project Manage an Engineering Team process guide*.
- The path with simple tasks but external participants is detailed in the *Product Development System Global Design Collaboration process guide*.
- The last path, with internal participants and simple tasks, is detailed below, in the activity map.

Activity Map



S3A9: Create development schedule
S3A10: Define communication and status procedures
S3A11: Break out and allocate individual assignments
S3A12: Delegate design control
S3A13: Design kick-off meeting

General Suggestions

Things to Consider When Building the Plan

When the designs are assigned and delegated to the design team, the following should be carefully considered.

- Gain a clear understanding of the modifications required to reconfigure the design in order to satisfy the requirements for the new product.
- Break up the modifications of the subsystem into pieces of work that are discrete and easily delegated. Additionally, ensure that this breakdown of the work is clearly communicated and agreed upon.
- What is the next step for the design? Is it to be delegated again, or will it be directly populated and detailed? Are there any implications that need to be considered?

Planning Tasks in a Just-In-Time Manner

Tasks should be planned so that their deliverables have an effectivity date immediately prior to that of the next successor task. This means that the deliverables from the task are completed just in time for the next task that is dependent on that deliverable to start. When planning is done in this manner, situations that require adjustments to the plan or the design can be accommodated and handled in an efficient fashion.

How Detailed Should Instructions Be?

As simplistic as it sounds, instructions should be only as detailed as they have to be. You want to provide the person doing the work with enough flexibility to be as creative as possible and to reuse as much as possible. In this way you can leverage existing investments (in terms of digital development) and the skills of your employees.

What to Communicate in the Design Kick-Off Meeting

Consider clearly communicating the following at the design kick-off meeting so that the entire development effort can be coordinated. Additionally, having this information readily accessible for reference internally is often desirable.

- Review schedules ranging from development of this design to the highest level.
- Review spheres of responsibility and ownership.
- Describe design criteria and how it interacts within each design. In some cases, a diagram may prove useful in communicating these complicated concepts.
- Identify standards and libraries that should be used.
- Outline the communication methods, such as discussion forums and status updates, to be used during the development cycle such as.

Step 4: Detail and Populate Design

Goals

The goal of this step is to develop detailed designs and fully populate each design.

Overview of Activities

After the overall schedule is defined, individual assignments are given out, and the design kick-off meeting is held, the detailed design work begins. To begin, the user reviews the assignments and its associated work instructions. Once the workload is fully understood, the user can start creating the discipline-specific structures and design content. This varies widely from discipline to discipline and breaks down into the following activities.

- Authoring Mechanical Designs – For mechanical design, this step mainly focuses on creating subassemblies, components and detailed geometry as described in the Mechanical Design Content and Mechanical Design Structure. During these activities, the user will frequently use existing Mechanical Design Criteria as a landmark for organizational purposes and to create references to enable global changes.
- Authoring Wiring Designs – The process of creating wiring designs follows the progression from wiring drawing to a schematic drawing and finally the creation of wires and harnesses within the appropriate assembly model as described in the Wiring Design Content section. The structures are generated during these activities as described in the Wiring Design Structure section. As this is done, harness highways are utilized for Wiring Design Criteria.
- Authoring Circuit Board Designs – The creation of circuit board designs follows close interaction with mechanical designs in importing a board outline, populating that board with electrical components and then exporting that assembly back to the mechanical design as described in the sections on Circuit Board Design Content and Circuit Board Design Structures. Constraints are used for functionally driven circuit board designs as detailed in the section on Circuit Board Design Criteria.

As work is done on the design content, the assignments should be updated to reflect the progress. This is done to ensure corrective action can be taken in the periodic meetings to adjust schedule or reapply resources as needed.

Once the work is finished, the assignment can be completed and the process proceeds to the next step.

Benefit

The benefits of this step are as follows:

- Coordinated Development of Design Content – Rarely developed solely inside a single company, development of designs demand tight coordination between various design teams. Design criteria provides a means to organize and coordinate design teams at the common interfaces between designs regardless of who develops them.
- Efficient Development of Discipline-Specific Design Content – Different design teams think differently. As a result, different teams have a need to organize their efforts uniquely to maximize their efficiency and interaction. Design structures afford these teams that flexibility by allowing them to uniquely define a hierarchy that makes them most efficient.

Fundamental Concepts

Referencing Design Criteria

Once a design has been delegated to the design team, the task becomes one of detailing and completing the design. In many cases, this task comes with many constraints, one of which is referencing design criteria.

As described in the Tool for Mechanical Design Content: Design Criteria section, design criteria is defined at a high level and passed down throughout the design structure so that it can be referenced. Once referenced, this design criteria can be used to initiate large-scale changes across the entire design.

As a further complication, not all design content is applicable to a single design. The majority of the time, a small subset of the design criteria is applicable. This being the case, the design criteria must be clearly documented to describe its purpose.

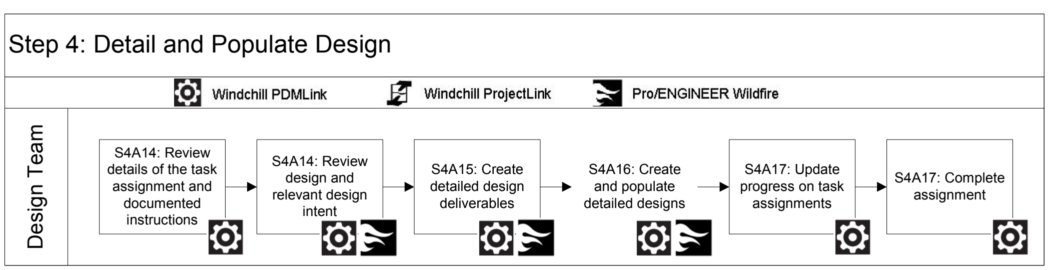
Paths Through This Step

There are four paths through this step, based on internal/external participants, and simple task management and project management. For purposes of this step, the emphasis is not on developing a plan that includes external participants or requires formal project management, but rather executing a plan that includes external design content authors and managing that execution. The following list references for some of these paths.

- The two paths involving project management of the rest of the development, whether with internal or external participants, is detailed in the *Product Development System Project Manage an Engineering Team process guide*.
- The path with simple tasks but external participants is detailed in the *Product Development System Global Design Collaboration process guide*.
- The last path, the one with internal participants and simple tasks, is detailed in the activity map below.

Additionally, the activities Author and populate detailed designs and Author design deliverables, are described generically in the activity map below, as these activities will range widely within a single application and from application to application. Additionally, searching capabilities, as described in the *Product Development System Search and Reuse process guide*, will be used. Finally, standards, in the form of libraries and modeling practices, should be used as much as possible.

Activity Map



S4A14: Review assignments
S4A15: Author and populate detailed designs
S4A16: Author design deliverables
S4A17: Update progress and complete assignments

General Suggestions

What Is the Best Way to Build Structures in Support of This Step?

Given that this step is where the design content is created or authored, the members of the design team will be using the design application. Therefore, the structures will be created in a Design First, Enterprise Second manner. Beyond that, the same general suggestions apply here as in the second step in the process.

If creating a new product, a good approach is to build in a top down manner; filling out the structure the deeper you go. If reconfiguring an existing product into a new one, a good approach is to use a bottom up approach if doing anything other than creating new sections of structures.

Continuous Checking Against Modeling Practices

The benefits of continuously checking for data quality, including modeling practices and design criteria, notifies users early in the design process of potential downstream issues. Discovering these issues early enables users to easily resolve them without a lot of backtracking or wasted time to discover the root of the problem.

Measuring the value of continuously checking data against modeling practices and design criteria can easily be calculated by determining the penalty of missing a delivery schedule or releasing to manufacturing poor quality data. Finding, resolving and improving design quality will help proliferate good modeling practices and streamline the overall design process, enabling users to build better products.

Step 5: Track Design Progress and Status

Goals

The goal of this step is to track the progress of the detailing and population of the design.

Overview of Activities

As the detailed design and deliverable work moves forward, several things should be tracked. First the status and current progress of the detailed design activities and deliverables should be understood. Second, the number of new parts that are introduced should be tracked in an effort to minimize them.

Benefit

The benefits of this step are as follows:

- Reduce costs through minimal new part introductions – A major source of savings is to reuse both existing physical items to fabricate new products and the associated design data. A particularly important activity in this step is to review the new parts included in the design in an effort to correctively replace them with existing ones.
- Visibility into oncoming schedule lags and changes – Inevitably, progress for some designs will lead while others lag. In either case, this progress or lack thereof needs to be tracked and understood so that appropriate corrective action can be taken to adjust the successor assignments as necessary.

Fundamental Concepts

Tracking External Relationships

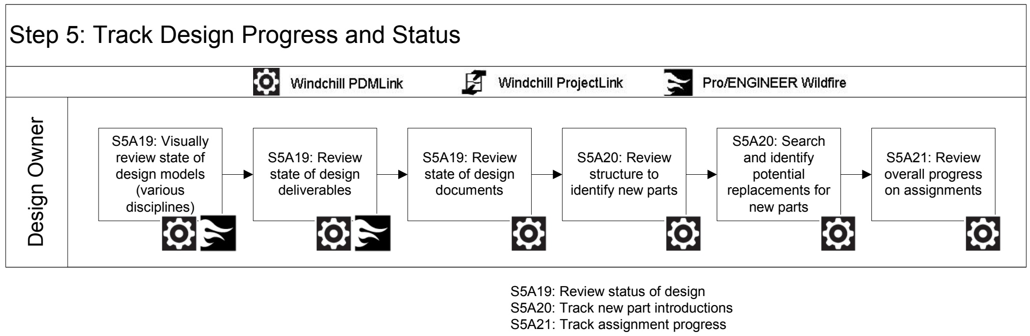
As described in the Tools for Mechanical Design Content: Reference Control section, a powerful capability of feature-based parametric CAD applications is the ability to create external references. This design should react intelligently to work-in-progress changes. On the other hand, however, too many unnecessary relationships of this type can make a design inflexible and difficult to reuse.

As a result, when design models are reviewed during this step, it is good to also review their references in some type of viewer. For Pro/ENGINEER, this is the global reference viewer.

Paths Through This Step

There is one path through this step, as it is relatively sequential and limited in its scope. However, these activities can be executed in a variety of ways, including periodic meetings to review the design content and review of metrics such as new part introductions. One particular method for executing this step is to conduct a design review, as described in the *Product Development System Design Review process guide*.

Activity Map



Step 6: Review for Approval

Goals

The goal of this step is to execute a final review of the design content and deliverables prior to proceeding to the subsequent process, such as release to manufacturing.

Overview of Activities

After all the design assignments are completed, the approvers must review the development plan along with the completed detailed designs and deliverables. This is done to ensure that the requirements for the product are met. Additionally, the number of new parts introduced in the detailed design should be reviewed in an effort to minimize them.

Once these reviews are done, approval is given by signing off on the detailed designs and deliverables. After this, the data is released.

Benefit

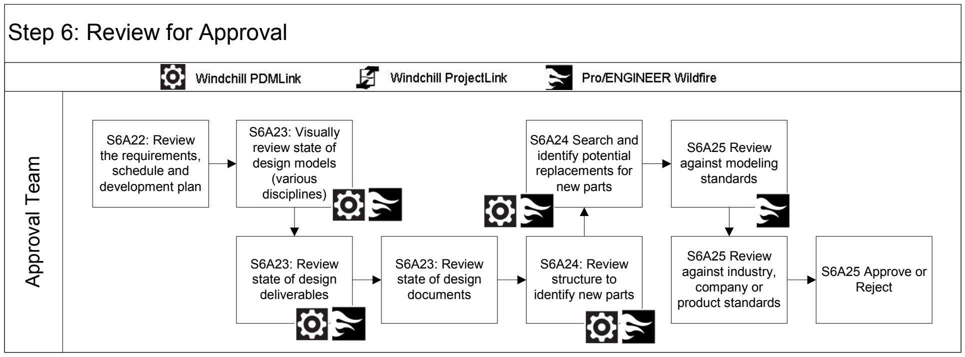
The benefits of this step are as follows:

- Ensure conformance to original requirements – In the end, the product must satisfy the original requirements. This is a final check to see if this is the case.
- Reduced cost through minimal new part introductions – A major source of savings is to not only use existing physical items to fabricate new products but also the design data. This step includes one final review of the new parts introduced with this product to ensure that they are absolutely needed.

Paths Through This Step

There is one path through this step as it is relatively sequential and limited in its scope. One particular set of capabilities that can be used to execute this step is a design review as described in the *Product Development System Design Review process guide*.

Activity Map



S6A22: Review development plan
S6A23: Review design
S6A24: Review new parts introduced
S6A25: Review against standards
S6A26: Final approval

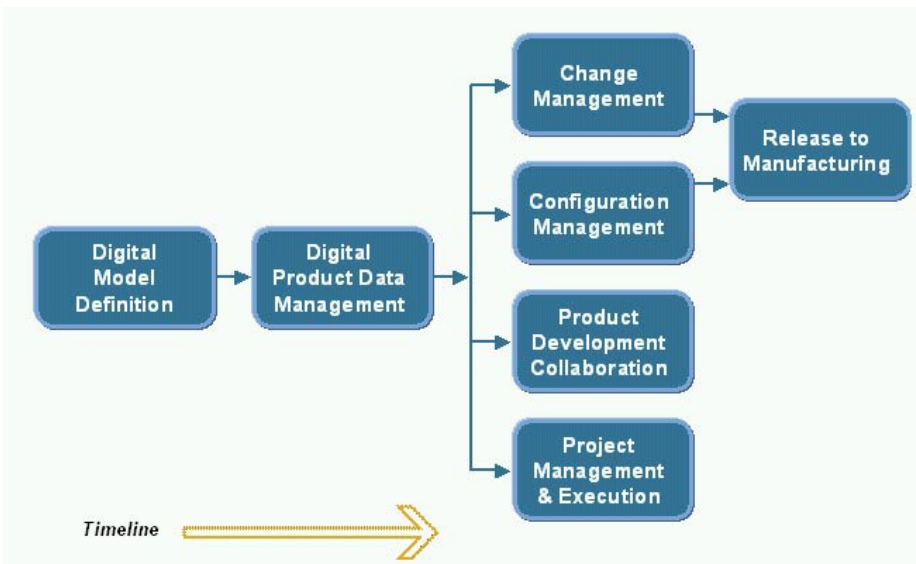
4

PDS Adoption Roadmap and the Top Down Planning and Design

This chapter defines the relationship between the PDS Adoption Roadmap and the Top Down Planning and Design process.

The PDS Adoption Roadmap

The PTC Product Development System is designed for interoperability, quality, and ease of deployment. Companies that have experienced long implementations of enterprise software systems are now looking to ensure that the scope of their technology investments is more clearly defined and manageable. One of the key benefits of the PTC Product Development System is that it is designed both to work as an integral system and to be implemented incrementally. In order to help our customers determine how to best implement our Product Development System, PTC has created an adoption roadmap that helps a company see how they can implement the system in a logical and organized way. The adoption roadmap is based on how the Product Development System can optimize certain key product development process areas. Optimizing these product development process fundamentals is critical to realizing the value in product development. Product First strategies and initiatives are only successful when these product development process fundamentals are optimized. The product development process fundamentals are: digital model definition, digital product data management, change management, configuration management, product development collaboration, project management and execution, and release to manufacturing.



What are Processes and Scenarios?

A business *process* is a structured series of documented steps organized to achieve a specific business objective. Typically, the full capabilities and benefits of a business process are enabled when multiple process fundamentals are adopted.

A business process can be broken down into significant subsets (subprocesses) that add real business value called *scenarios*. A given process fundamental enables many scenarios from multiple business processes.

Growing the Top Down Planning and Design Process

As described, the stages of the PDS Adoption Roadmap offer a means to incrementally implement a Product Development System. However, the order of the implementation of the different stages has implications for the Top Down Planning and Design process.

First, the Digital Model Definition and the Digital Product Data Management stages must be implemented at a minimum to support the Top Down Planning and Design process. The figure immediately below shows these two stages at the top as the first and second columns. These two stages provide the core capabilities necessary to execute the process.

Second, the implementation of the other stages, namely the Product Development Collaboration and Project Management and Execution Stages layer supplementary capabilities on top of those required for the Top Down Planning and Design process. These capabilities can be optionally used in the Top Down Planning and Design process but are not fundamentally necessary.

The following figure graphically shows relationships between the scenarios in the stages and the steps in the Top Down Planning and Design process: