

## Chapter 1 Successful Design

This chapter gives you an introduction to designing enclosures for electronic products and defines a “successful design.” We’ll discuss the designer’s role in the setting of product requirements, where the designer fits into the overall product development picture, the importance of communication, and the initial factors to consider when beginning a design. Before we get started, let’s briefly define what we mean when we talk about an “electronic product.” It is a product that has a circuit board in it and usually has some input/output device such as an LCD. Examples of electronic products include cell phones, digital cameras, and the ultrasonic toothbrush. An electronic product enclosure is the item that surrounds and supports the circuit board. The enclosure is what makes the device usable to the consumer. The enclosure is necessary for a number of reasons – to protect the electronics (the circuit board and LCD) from the environment or from a physical jolt (such as dropping the product). The enclosure provides access to input information to the device, via keys or buttons perhaps, and allows information to be transferred from the device. The enclosure provides structure so that the circuit board logic is supported and protected. Examples of some very effective product enclosures that have been developed in recent years are the Apple iPhone 7 or the HP Spectre laptop computer (both, circa 2016). In essence, a successful design of an enclosure will be the one in which the design has conformed to the product’s written specification (spec) and has been done within the cost and time parameters that were set. Let’s now begin our exploration of the process of designing these enclosures.

本章為您介紹了電子產品外殼的設計，並定義了“成功的設計”。我們將討論設計師在設置產品要求方面的角色，其中設計師適應了整個產品開發圖，溝通，以及開始設計時要考慮的初始因素。在開始之前，我們先簡單地定義當我們談論一個“電子產品。”它是其中裝有電路板的產品，通常具有一些輸入/輸出設備，例如 **LCD**。電子產品的例子包括手機，數碼相機和超聲波牙刷。電子產品外殼是包圍並支撐電路的物品板。外殼使設備對消費者可用。外殼出於多種原因，這是必要的—保護電子設備（電路板和 **LCD**）從環境或物理顛簸（例如掉落產品）。機箱可通過按鍵或按鈕訪問設備的輸入信息也許，並允許從設備傳輸信息。外殼提供結構，以便支持

和保護電路板邏輯。已開發出一些非常有效的產品外殼的示例 近年來出現的是 Apple iPhone 7 或 HP Spectre 筆記本電腦（兩者 2016）。從本質上講，一種成功的外殼設計將是 設計已符合產品的書面規格書（spec）並已 在設置的成本和時間參數內完成。現在讓我們開始探索這些外殼的設計過程。

Design Guide

設計指南

This text is intended to place in a single reference, a design guide for the successful mechanical design of an electronic product enclosure.

本文旨在作為成功的設計指南，以單一參考文獻的形式提供。

電子產品外殼的機械設計。

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Let's break down some of the words of the above sentence for further definition (with the word "successful" defined in its own subtopic). Design Guide This text is a starting point, a point of reference. The designer will be using many guides in their work; this text is intended to be a general help and serves to augment the designer's entire past experience and their present organization's established processes. Electronic Product Enclosure (EPE = Electronic Product Enclosure) The electronic product enclosure consists of both the external and internal structural elements of a product. It includes any of the hardware used for user interfacing, any of the connectors used to interface cables, and any elements that the user will physically feel and see. Many electronic enclosures contain one or more PCBA (Printed Circuit Board Assemblies), and these must be protected against the rigors of normal usage. An enclosure could be very simple or be extremely complicated with thousands of separate parts. One of the designer's first tasks will be to define the

“system” that they are designing, and that is covered in a later chapter. The term “enclosure” (in this text) will be on the less complicated end of the spectrum, and the methodology explained can be extended into the more complicated design situations. The EPE Designer This is the person responsible for the design of the enclosure for an electronic product. In many cases, it is a mechanical engineer, but it can be someone with a background in mechanical engineering or who has the experience of the discipline. A good EPE Designer will have the following characteristics: • Ability to understand and conform to the product specification • Be able to add to and help create the product specification • Create inventive solutions to the problems presented by the product Thus, the EPE Designer must be able to both be creative and still follow the major objectives of the project.

讓我們分解上面句子中的一些詞以進一步定義  
（在其子主題中定義了“成功”一詞）。

### 設計指南

本文是一個起點，一個參考點。設計師將使用許多指導他們的工作；此文本旨在提供一般幫助，並有助於擴大

設計師過去的全部經驗以及他們現在的組織的建立流程。

電子產品外殼（**EPE** = 電子產品外殼）

電子產品外殼由內部和外部結構組成

產品的要素。它包括用於用戶接口的任何硬件，用於連接電纜的連接器，以及用戶會感覺和看到的任何元素。許多電子機箱包含一個或多個 **PCBA**（印刷電路板組件），並且必須防止這些組件受到正常情況的影響

用法。

外殼可能非常簡單，也可能非常複雜，有數千個外殼分開的部分。設計人員的首要任務之一是定義“系統”他們正在設計，這將在下一章中介紹。術語“外殼”（在該文本）將處於較為簡單的範圍內，其方法論

解釋可以擴展到更複雜的設計情況。

## EPE 設計師

這是負責設計電子產品外殼的人員。在許多情況下，它是機械工程師，但也可以是具有機械工程背景或具有該領域經驗的人員。一個

優秀的 EPE 設計師將具有以下特徵：

- 理解並符合產品規格的能力
- 能夠添加並幫助創建產品規格
- 為產品提出的問題創建創造性的解決方案

因此，EPE 設計人員必須既有創造力，又要遵循項目的主要目標。

1.2 Defining the Overall Team The intent of this section is to show that engineering (and mechanical engineering in particular) doesn't design products by themselves; they are certainly a part of a team. Characteristics of the overall team are that the team can be: • Of a small or large size • Located in one location or distributed worldwide • Limited in resources or have access to almost unlimited resources • In possession of the latest tools, or not • Motivated by a variety of reasons for accomplishing their goal 1 Successful Design 3 • Varying in experience The entire engineering effort consists of an amalgam of design among several disciplines. These disciplines include: • Electrical engineering • Software and firmware engineering • Mechanical engineering (including structural and thermal) • Industrial engineering • System engineering Therefore, it is recognized that mechanical engineering is only a part of the overall engineering design of an electronic product, and many of the decisions made are in cooperation with the other disciplines. Contemporary product design should balance various trade-offs among all of the factors that go into the production released product. Indeed, the entire engineering effort (all of the disciplines from Sect. 1.2) is only a part of the overall effort that goes into the release (sale) of a product. Besides the engineering effort, contributions result from the following groups: Each group is defined, followed by how specifically the mechanical design "interacts" with that group. All of this is meant to emphasize that the mechanical design is not done "in a vacuum" but rather as part of a multitasked product delivery team. Marketing (Including Input from Sales) This organization is responsible for the product definition, that is, defining what the customer wants and what the product will be from the customer viewpoint. This "product definition" usually takes the form of a document that engineering will accept as the product requirements. Marketing also has the responsibility of overseeing how a particular product will fit into the overall product line of the company (or division of the

1.2 定義總體團隊本節的目的是表明工程（尤其是機械工程）不是自己設計產品；他們當然是團隊的一部分。整個團隊的特徵是團隊可以：•規模較小•位於一個位置或分佈在世界各地•資源有限或可以使用幾乎無限的資源•是否擁有最新工具•有動力出於多種原因實現目標 1 成功的設計 3•經驗豐富整個工程工作包括多個學科之間的設計融合。這些學科包括：•電氣工程•軟件和固件工程•機械工程（包括結構和熱工程）•工業工程•系統工程因此，人們認識到機械工程只是電子產品整體工程設計的一部分，並且許多決定是與其他學科合作進行的。當代產品設計應在投入生產的產品的所有因素之間權衡取捨。確實，整個工程工作（來自第 1.2 節的所有學科）只是產品發布（銷售）的全部工作的一部分。除了工程上的努力外，還有以下幾組的貢獻：定義了每個組，然後具體說明了機械設計與該組“交互”的方式。所有這些都是為了強調機械設計不是“在真空中”完成的，而是作為多任務產品交付團隊的一部分。市場營銷（包括來自銷售的投入）該組織負責產品定義，即從客戶的角度定義客戶想要什麼以及產品將是什麼。該“產品定義”通常採用工程形式將作為產品要求接受的文檔的形式。營銷還負責監督特定產品如何適合公司的整體產品線（或

company). The EPE Designer interacts with Marketing in the effort to define how the product will function, how that functionality will present itself to the customer (user interface), and how the product will look to the customer (industrial design). Operations (Manufacturing) This organization is responsible for the complete flow of materials for individual components and how those individual components get fabricated, assembled, and delivered to the customer. If engineering's responsibility is to produce the product documentation, operations should be able to take that



公司)。EPE 設計人員與市場營銷人員進行交互，以定義產品的功能，向客戶展示該功能的方式（用戶界面）以及產品對客戶的外觀（工業設計）。運營（製造）該組織負責單個組件的完整材料流程，以及如何製造，組裝和交付這些單個組件給客戶。如果工程部門負責製作產品文檔，則操作人員應該能夠

documentation and get that product produced that meets the product specifications. The EPE Designer intersects with operations by making decisions on part fabrication techniques, vendor (supplier) selection, and any trade-offs between quality/cost/appearance. Testing (Design Verification) This organization is responsible for testing both the prototyping and mature designs. This can be accomplished by resources within the mechanical design group (itself) or by an independent group setup for this particular function. 1.2 Defining the Overall Team 4 The EPE Designer intersects with the test function by either conducting or reviewing test results. The testing done on the product is actually a part of the product requirements document (PRD) and that it must be proven that the product passes testing as defined in that document. For example, if the PRD states that a product must survive a one meter drop, then a test must be defined that states considerations such as: • How many drops of a single item (under test) • Impact faces or corners of that item • Environment that testing is to take place (such as ambient temperature) • Statistical concerns (such as how many single items must pass testing) • Order of testing (among various tests that unit will undergo) • Definition of “survive” (degree of functionality or appearance after test) Quality Control/Quality Assurance This

文檔並獲得符合產品規格的產品。EPE 設計人員通過對零件製造技術，供應商（供應商）選擇以及質量/成本/外觀之間的任何取捨做出決策來與運營相交。測試（設計驗證）該組織負責測試原型設計和成熟設計。這可以通過機械設計組（本身）中的資源或為此特定功能的獨立組設置來完成。 1.2 定義總體團隊 4 EPE 設計器通過執行或查看測試結果來與測試功能相交。在產品上進行的測試實際上是產品需求文檔（PRD）的一部分，必須證明該產品通過了該文檔中定義的測試。例如，如果 PRD 聲明產品必須承受一米高的跌落，則必須定義一項測

試，其中應考慮以下因素：•單個物品跌落了多少(被測)•該物品的撞擊面或拐角•要進行測試的環境(例如環境溫度)•統計問題(例如必須通過多少個單個項目)•測試的順序(設備將要進行的各種測試)•“生存”的定義(功能程度)或外觀經過測試) 質量控制/質量保證

organization determines whether the acceptability limits of the individual parts (or entire assemblies) meet the standards both specified in the individual product specification (the drawing) and in the established overall corporate standards. Quality control would be concerned with tactical situations, while (corporate) quality assurance would be more concerned with strategic situations. Most companies have various ways of both controlling and monitoring the quality of the product and certainly get involved with customer satisfaction and service issues. The EPE Designer intersects with this organization by specifying on their documentation the acceptability limits of each part and can go all up to include assemblies. Typically, acceptability limits take the form of: • Size (geometry) control as specified in drawing tolerances • Material and plating specifications stated on drawing • Cosmetic flaw rejection criteria stated on drawing • Functional specification as stated on drawing • Determining the “critical” nature of some aspect of the part documentation. Service This organization is responsible for the repairing, warranty, and return of product functions. They help determine course of action for field problems with the equipment. The EPE Designer intersects with this organization by designing-in a reasonable process for the disassembly and repair of the product. Of course, a design with a designed-in high reliability will have less reason to repair. It's also possible to provide for methodology to determine misuse of the product. Project Management This organization is responsible for tracking the project for: • Time allocation – meeting deadlines that are committed • Resource allocation

組織確定單個零件（或整個組件）的可接受性極限是否滿足單個產品規格（圖紙）和已建立的總體公司標準中指定的標準。質量控制將與戰術情況有關，而（公司）質量保證將與戰略情況有關。大多數公司都有控制和監視產品質量的各種方法，並且肯定會涉及客戶滿意度和服務問題。 **EPE** 設計人員通過在其文檔中指定每個零件的可接受性限制來與該組織相交，並且可以一併包括裝配。通常，可接受性限制的形式為：•

圖紙公差中規定的尺寸（幾何形狀）控制•圖紙上規定的材料和鍍層規格•圖紙上規定的外觀缺陷排除標準•圖紙上規定的功能規格•確定“關鍵”性質部分文檔的某些方面。服務該組織負責產品功能的維修，保修和退貨。它們有助於確定設備現場問題的解決方案。

**EPE** 設計人員通過設計合理的過程來拆卸和維修產品，從而與此組織相交。當然，設計可靠的設計將減少維修的理由。還可以提供確定產品濫用的方法。項目管理該組織負責跟踪項目，以進行以下工作：•時間分配-遵守承諾的期限•資源分配

• Priority management (for a single project and relative to projects competing for the same resources) • Compliance to specifications for the product • Meeting cost goals • Reporting status of project The EPE Designer intersects with this organization by reporting estimates of time and resources for all separate line items of the mechanical part responsibility. This starts with product conceptualization, design, prototyping, and testing and continues on into final release documentation. Estimates of time and resources are updated as milestones are met. Upper Management Included in this group is anyone who is responsible for the project and has a need to understand the project. Project updates would be provided to this group at specific times during the project. Upper management would provide leadership and vision to the project. The EPE Designer intersects with upper management in an indirect manner. Reporting of project status is relevant at any time and is usually provided thru the project manager.

•優先級管理（針對單個項目以及與之競爭的項目相同的資源）

•符合產品規格

•實現成本目標

•項目報告情況

**EPE** 設計器通過報告對 **EPE** 的估計與該組織相交機械零件責任的所有單獨行項目的時間和資源。

這從產品概念化，設計，原型設計和測試開始，一直到最終版本文檔。時間和資源的估計是



在達到里程碑時更新。  
包括在此組中的是負責  
項目，並且需要了解該項目。將提供項目更新  
在項目期間的特定時間加入該小組。高層管理人員將提供  
對項目的領導力和遠見。  
EPE 設計器以間接方式與高層管理人員相交。  
項目狀態的報告在任何時候都是相關的，通常是通過  
專案經理。

### 1.3 Product Requirements

Determining success is a matter of meeting (or exceeding) the requirements of the project. This is a simple statement but is actually very complicated in its interrelated aspects.

A project could be determined successful if it met its goals. These goals can be addressed in (one or more of) the following written documents.

Product Requirements Document (PRD) This document can go by a variety of names (it will vary by company). Basically, it is a “contract” of sorts that attempts to specify the basic functionality of the product. It can be as simple as a few paragraphs or extremely complicated. It can contain:

- (a) A description of what the product will accomplish for the customer – it usually does not specify exactly how the product will work.

That is, details on “how to get there, from here” are not explicit. This description uses words on the “final outside appearance” of the product rather than the details of the “inner workings.” Follow-on documents (or specifications) can also specify details of the product. Again, the PRD forms an agreement between marketing and engineering as to what the product will be. The PRD can vary in its content detail. It is (should be) updated, during the course of the project, as elements get revised or added to. At each overall product review, it should be compared on the extent of how the design is conforming to the PRD.

**1.3 產品要求** 確定成功是滿足(或超越)要求的問題。項目。這是一個簡單的聲明，但實際上在相互關聯方面非常複雜 方面。 如果項目達到了目標，則可以確定為成功。這些目標可以是 在以下（一個或多個）書面文件中解決。 產品需求文檔（**PRD**）該文檔可以有多种形式 名稱（因公司而異）。基本上，這是嘗試的“合同” 指定產品的基本功能。它可以簡單到幾段，也可以非常複雜。它可以包含： （**a**）產品對客戶的成就的描述-通常 沒有確切說明產品的工作方式。也就是說，有關“如何 從這裡到達那裡”並不明確。此說明在“最終 產品的外觀”而不是“內部工作原理”的細節。後續文件（或規格）也可以指定 產品。同樣，珠三角在市場和工程之間就產品的形式達成協

議。 **PRD** 的內容詳細信息可能有所不同。它是（應）在項目過程中隨著要素的修改而更新或 添加到。在每次整體產品審核時，應在以下方面進行比較： 設計如何符合 **PRD**。

A description of how the product will interface with the customer. This would include:

- How information is displayed to the customer or how the information will get from the customer, to the product. This can be visual, auditory, or tactile.
- Various interfaces to the product, such as connectors, switches, or buttons.
- Labeling or icons intended to provide information to the customer.

(c) A description of the various components of the product. That is, if the product (the product being designed) needs additional equipment or cables to function in a larger system, then a description of the various parts of the “system” will need to be described. Thus, one will need to “draw a boundary” around exactly what this product (being designed) is. What exactly is the “deliverable” to the customer?

(d) Indication of the final aesthetic (visual appearance) of the product. Colors, textures, and industrial design are usually very well-specified.

(e) A listing of the environments that the product will both operate and be stored in. This includes temperature, shock, drop, vibration, humidity, water egress protection, shipping conditions, altitude, and specific corrosive atmospheres.

(f) A listing of any standards that the product will need to pass. This includes both safety and regulatory standards such as Underwriters Laboratory (UL) for safety, federal communication compliance (FCC) for electromotive magnetic interference (EMI), and the (literally) hundreds of other compliance standards that are a real part of today’s design world. Some of these standards are country specific, while others are accepted on a worldwide basis. Obviously, anything to do with medical, food, or children’s toys will have their own rigorous testing standards to pass.

**Internal Test Reports** These indicate positive test results. These are the results of testing done to show that the requirements as set forth in the PRD have been passed.

If the tests haven’t been passed, then there are action plans initiated to improve the product and conduct further testing.

**Reports from Initial Customers** This is “alpha” or “beta” testing where customer feedback is positive or negative. It is hoped that customers are gaining measureable value from the product. Reasonable improvements to the product can be made when

this “real-world” feedback is available. “Alpha” testing is usually done with inhouse personnel who are simulating the actual customer, while “beta” testing is

usually done with existing customers before shipment to actual (paying) customers.

#### Project Management Reports

(a) On expenses (expected vs. actual). This includes expenses for salaries, capital equipment, tooling, etc. Monitoring of expenses can lead to analysis of the true

產品如何與客戶互動的說明。這個會包括：

- 如何向客戶顯示信息或信息將如何顯示從客戶那裡獲取產品。這可以是視覺，聽覺或觸。

- 產品的各種接口，例如連接器，開關或按鈕。

- 用於向客戶提供信息的標籤或圖標。

(c) 產品各個組成部分的說明。也就是說，如果產品（正在設計的產品）需要其他設備或電纜才能起作用在較大的系統中，則將對“系統”的各個部分進行描述需要描述。因此，人們將需要準確地“劃定邊界”該產品（正在設計）是什麼。到底什麼是“可交付成果”？

顧客？

(d) 表明產品的最終美學（外觀）。顏色，紋理和工業設計通常是非常明確的。

(e) 產品將在其中運行和存儲的環境的清單。這包括溫度，衝擊，跌落，振動，濕度，進水保護，運輸條件，高度和特定的腐蝕性氣氛。

(f) 產品需要通過的任何標準的清單。這既包括安全和監管標準，例如美國保險商實驗室（UL）安全，符合聯邦電磁通訊規範（FCC）干擾（EMI）以及數百種其他合規標準

這是當今設計界的重要組成部分。其中一些標準是國家/地區

具體而言，而其他人則在全球範圍內被接受。顯然，使用醫療，食品或兒童玩具進行嚴格的測試通過標準。

內部測試報告這些表示積極的測試結果。這些是結果完成測試以顯示珠三角上的要求已通過。

如果尚未通過測試，則將啟動行動計劃以改善產品並進行進一步測試。

初始客戶的報告這是“alpha”或“beta”測試，其中客戶

反饋是正面還是負面。希望客戶變得可衡量

產品的價值。何時可以對產品進行合理的改進

此“實際”反饋是可用的。“Alpha”測試通常由模擬實際客戶的內部人員完成，而“beta”測試則是通常在發貨到實際（付款）之前與現有客戶進行顧客。

項目管理報告

（a）支出（預期與實際）。這包括工資，資本支出設備，工具等。費用監控可以導致對真實情況的分析

“payback periods” of the project and better predictions on expenses for future projects. (b) Status on milestone dates (expected vs. actual): as with expenses, monitoring of how well the project achieved its time commitments leads to an indication of the true “payback period” of the project. Analyzing where milestones were not met can lead to better predictions for future projects. Ongoing analysis of “success” (as the product matures in the field) can be measured by: Quality Assurance Reports These contain information about customer satisfaction and warranty returns: any issues or problems with the product must be quickly addressed so as to protect the company’s reputation in the industry. If revisions need to be made, they must be implemented with great urgency. Thus, if customer satisfaction reaches some set level of reliability, the product design team will have



achieved success. Analysis of “Lessons Learned” From all disciplines on the project: every project will contain items where things could have been done better. Continuous improvement should be strived for. There should be a way to gather feedback from everyone in the product design process on what items would need to be improved. This will enhance the success rate of future projects. More on this subject is presented in Chap. 13. Sales Expected vs. actual. Sales figures can indicate the success of the project – in the sense that marketing has predicted the need for the product, engineering/operations has delivered that product to the customer, and the customer does (indeed) value that product. Or, in the opposite case, sales can be less than expected (predicted). This could have happened for a variety of reasons (such as): • Product is not (exactly) what the customer needed (price too high/performance features too low). • Product is too late out into the market, that is, it took too long to get the product out into the market, and the customers now have better choices. • Product is too early into the market (not enough “early adopters”). This happens when the technology of the product doesn’t match what customers (at the time) value or other supporting technology isn’t available as yet that would make this particular product fully useful. • Low reliability. All of the above reasons should be placed in the “competitive arena.” That is, most products have competition in their markets. Customers will choose purchases based on their needs for performance, price, and quality. New technology solutions must compete against the older solutions. It would be rare to have all of the data available at product release to determine how “successful” the product design effort is. Product design usually has increased risk of success if: Milestone completion dates are unreasonably shortened.

- The design has a high content of brand new components.
- Changes (additions) to the project occur at an unmanageable rate.

Successful design has been simply described as:

1. Function to specification
2. Delivery on time to project schedule
3. Delivery at predicted costs

Of course, projects can exceed functionality, be delivered ahead of time, and perhaps be even at a lower cost. This would be cause for celebration (although some examination needs to go into why “actuals” didn’t match “predictables”).

Behind the above “simple statements” for successful design is however some very large implications and that they are not so “simple.” Let me break down the above three variables a bit. All three are interrelated on several levels.

項目的“投資回收期”以及對未來費用的更好預測 項目。  
（b）里程碑日期的狀態（預期與實際）：與支出一樣，  
監測 項目完成其時間承諾的程度如何表明 項目的真正  
“投資回收期”。分析沒有里程碑的地方 滿足可以為將來

的項目帶來更好的預測。對“成功”的持續分析（隨著產品在現場的成熟）可以通過以下方法進行衡量：質量保證報告這些包含有關客戶滿意度的信息 和保修退貨：產品的任何問題必須迅速 解決這個問題，以保護公司在業界的聲譽。如果需要修訂 要做到這一點，必須立即執行。因此，如果客戶滿意度達到一定的可靠性水平，則產品設計團隊將擁有 取得成功。分析項目中所有學科的“經驗教訓”：每個項目都將 包含本可以做得更好的項目。連續的提高 應該努力。應該有一種方法可以收集 產品設計過程中哪些項目需要改進。這將增強 未來項目的成功率。有關此主題的更多信息，請參見第 5 章。

**13 預期銷售額與實際銷售額。**銷售數字可以表明該項目的成功— 營銷已預見到產品需求的感覺，工程/運營已將產品交付給客戶，而客戶確實（確實） 重視該產品。或者，在相反的情況下，銷售額可能會低於預期（預測）。發生這種情況可能有多種原因（例如）：

- 產品並非（確切地）滿足客戶需求（價格太高/性能太高） 功能太低）。
- 產品進入市場的時間太晚，也就是說，花費太長時間才能獲得產品 進入市場，客戶現在有了更好的選擇。
- 產品進入市場為時過早（“早期採用者”不足）。

有時候是這樣的 產品的技術與當時的客戶不匹配時 價值或其他支持技術尚不可用，因此 特定產品完全有用。

- 低可靠性。

以上所有原因都應放在“競爭舞台”上。那是， 大多數產品在其市場中都有競爭。客戶將選擇購買 根據他們對性能，價格和質量的需求。新技術解決方案 必須與較舊的解決方案競爭。很難在產品發佈時獲得所有數據來確定 產品設計工作多麼“成功”。產品

設計通常有所增加 成功的風險，如果：里程碑完成日期被不合理地縮短了。

- 設計中包含大量的全新組件。
- 對項目的更改（添加）以難以控制的速度發生。

成功的設計簡單描述為：

- 1.功能規格
- 2.準時按計劃進度交付
- 3.以預計的成本交貨

當然，項目可以超越功能，可以提前交付，並且甚至可以降低成本。這將值得慶祝（儘管有些需要檢查為什麼“實際”與“可預測的”不匹配）。然而，在上述“成功設計的簡單陳述”的背後有一些影響很大，而且不是那麼“簡單”。讓我分解一下以上三個變量有點。這三個方面在幾個層面上相互關聯。