Prototype

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A **prototype** is an early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is designed to test and trial a new design to enhance precision by system analysts and users. Prototyping serves to provide specifications for a real, working system rather than a theoretical one.[1] In some workflow models, creating a prototype (a process sometimes called **materialization**) is the step between the formalization and the evaluation of an idea.[2]

An array of prototypes leading to the final design.

The word *prototype* derives from the Greek πρωτότυπον *prototypon*, "primitive form", neutral of πρωτότυπος *prototypos*, "original, primitive", from πρῶτος *protos*, "first" and τύπος *typos*, "impression".[3]

Contents

Basic prototype categories

There is no general agreement on what constitutes a "prototype" and the word is often used interchangeably with the word "model" which can cause confusion. In general, "prototypes" fall into five basic categories:

Proof-of-Principle Prototype (Model) (in electronics sometimes built on a breadboard). A Proof of concept prototype is used to test some aspect of the intended design without attempting to exactly simulate the visual appearance, choice of materials or intended manufacturing process. Such prototypes can be used to "prove" out a potential design approach such as range of motion, mechanics, sensors, architecture, etc. These types of models are often used to identify which design options will not work, or where further development and testing is necessary.

Form Study Prototype (Model). This type of prototype will allow designers to explore the basic size, look and feel of a product without simulating the actual function or exact visual appearance of the product. They can help assess ergonomic factors and provide insight into visual aspects of the product's final form.

Differences between a prototype and a production design

In general, prototypes will differ from the final production variant in three fundamental ways:

Materials. Production materials may require manufacturing processes involving higher capital costs than what is practical for prototyping. Instead, engineers or prototyping specialists will attempt to substitute materials with properties that simulate the intended final material.

Processes. Often expensive and time consuming unique tooling is required to fabricate a custom design. Prototypes will often compromise by using more variable processes, repeatable or controlled methods; substandard, inefficient, or substandard technology sources; or insufficient testing for technology maturity.

Lower fidelity. Final production designs often require extensive effort to capture high volume manufacturing detail. Such detail is generally unwarranted for prototypes as some refinement to the design is to be expected. Often prototypes are built using very limited engineering detail as compared to final production intent, which often uses statistical process controls and rigorous testing.

Characteristics and limitations of prototypes

Engineers and prototyping specialists seek to understand the limitations of prototypes to exactly simulate the characteristics of their intended design.

It is important to realize that by their very definition, prototypes will represent some compromise from the final production design. Due to differences in materials, processes and design fidelity, it is possible that a prototype may fail to perform acceptably whereas the production design may have been sound. A counter-intuitive idea is that prototypes may actually perform acceptably whereas the production design may be flawed since prototyping materials and processes may occasionally outperform their production counterparts.

A prototype of the Polish economy hatchback car Beskid 106 designed in the 1980s.

In general, it can be expected that individual prototype costs will be substantially greater than the final production costs due to inefficiencies in materials and processes. Prototypes are also used to revise the design for the purposes of reducing costs through optimization and refinement.

It is possible to use prototype testing to reduce the risk that a design may not perform as intended, however prototypes generally cannot eliminate all risk. There are pragmatic and practical limitations to the ability of a prototype to match the intended final performance of the product and some allowances and engineering judgement are often required before moving forward with a production design.

Building the full design is often expensive and can be time-consuming, especially when repeated several times—building the full design, figuring out what the problems are and how to solve them, then building another full design. As an alternative, "rapid-prototyping" or "rapid application development" techniques are used for the initial prototypes, which implement part, but not all, of the complete design. This allows designers and manufacturers to rapidly and inexpensively test the parts of the design that are most likely to have problems, solve those problems, and then build the full design.

This counter-intuitive idea —that the quickest way to build something is, first to build something else— is shared by scaffolding and the telescope rule.

Engineering sciences

In technology research, a technology demonstrator is a prototype serving as proof-of-concept and demonstration model for a new technology or future product, proofing its viability and illustrating conceivable applications.

In large development projects, a testbed is a platform and prototype development environment for rigorous experimentation and testing of new technologies, scientific theories and computational tools.

With the recent advances in computer modeling it is becoming practical to eliminate the creation of a physical prototype (except possibly at greatly reduced scales for promotional purposes), instead modeling all aspects of the final product as a computer model. An example of such a development can be seen in Boeing 787 Dreamliner, in which the first full sized physical realization is made on the series production line. Computer modeling is now being extensively used in automotive design, both for form (in the styling and aerodynamics of the vehicle) and in function — especially for improving vehicle crashworthiness and in weight reduction to improve mileage.

Mechanical and electrical engineering

The most common use of the word prototype is a functional, although experimental, version of a non-military machine (e.g., automobiles, domestic appliances, consumer electronics) whose designers would like to have built by mass production means, as opposed to a mockup, which is an inert representation of a machine's appearance, often made of some non-durable substance.

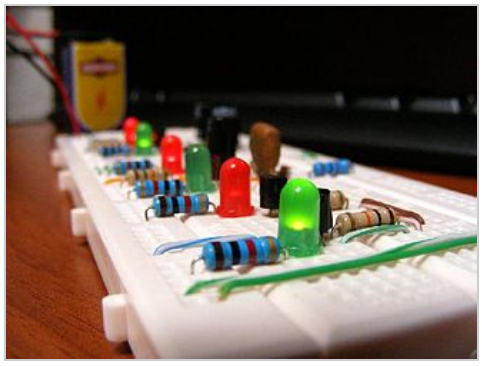
An electronics designer often builds the first prototype from breadboard or stripboard or perfboard, typically using "DIP" packages.

However, more and more often the first functional prototype is built on a "prototype PCB" almost identical to the production PCB, as PCB manufacturing prices fall and as many components are not available in DIP packages, but only available in SMT packages optimized for placing on a PCB.

Builders of military machines and aviation prefer the terms "experimental" and "service test".

Electronics prototyping

In electronics, prototyping means building an actual circuit to a theoretical design to verify that it works, and to provide a physical platform for debugging it if it does not. The prototype is often constructed using techniques such as wire wrap or using veroboard or breadboard, that create an electrically correct circuit, but one that is not physically identical to the final product.



A simple electronic circuit prototype on a breadboard.

Open-source tools exist to document electronic prototypes (especially the breadboard-based ones) and move forward toward production such as Fritzing and Arduino.

A technician can build a prototype (and make additions and modifications) much more quickly with these techniques —however, it is much faster and usually cheaper to mass-produce custom printed circuit boards than these other kinds of prototype boards. This is for the same reasons that writing a poem is fastest by hand for one or two, but faster by printing press if you need several thousand copies.

The proliferation of quick-turn pcb fab companies and quick-turn pcb assembly houses has enabled the concepts of rapid prototyping to be applied to electronic circuit design. It is now possible, even with the smallest passive components and largest fine-pitch packages, to have boards fabbed and parts assembled in a matter of days.

Computer programming/computer science

In many programming languages, a *function prototype* is the declaration of a subroutine or function. (This term is rather C/C++-specific; other terms for this notion are *signature*, *type* and *interface*.) In prototype-based programming (a form of object-oriented programming), new objects are produced by cloning existing objects, which are called prototypes.[4]

The term may also refer to the Prototype Javascript Framework.

Additionally, the term may refer to the prototype design pattern.

Prototype software is often referred to as alpha grade, meaning it is the first version to run. Often only a few functions are implemented, the primary focus of the alpha is to have a functional base code on to which features may be added. Once alpha grade software has most of the required features integrated into it, it becomes beta software for testing of the entire software and to adjust the program to respond correctly during situations unforeseen during development.[5]

Often the end users may not be able to provide a complete set of application objectives, detailed input, processing, or output requirements in the initial stage. After the user evaluation, another prototype will be built based on feedback from users, and again the cycle returns to customer evaluation. The cycle starts by listening to the user, followed by building or revising a mock-up, and letting the user test the mock-up, then back. There is now a new generation of tools called Application Simulation Software which help quickly simulate application before their development.

Extreme programming uses iterative design to gradually add one feature at a time to the initial prototype.

Continuous learning approaches within organizations or businesses may also use the concept of business or process prototypes through software models.

Data prototyping

A *data prototype* is a form of *functional* or *working* prototype. The justification for its creation is usually a data migration, data integration or application implementation project and the raw materials used as input are an instance of all the relevant data which exists at the start of the project.
The objectives of *data prototyping* are to produce:

- A set of data cleansing and transformation rules which have been *seen* to produce data which is all fit for purpose.
- A dataset which is the result of those rules being applied to an instance of the relevant raw (source) data.

To achieve this, a data architect uses a graphical interface to interactively develop and execute transformation and cleansing rules using raw data. The resultant data is then evaluated and the rules refined. Beyond the obvious visual checking of the data *on-screen* by the data architect, the usual evaluation and validation approaches are to use Data profiling software and then to insert the resultant data into a test version of the target application and trial its use.

Scale modeling

In the field of scale modeling (which includes model railroading, vehicle modeling, airplane modeling, military modeling, etc.), a prototype is the real-world basis or source for a scale model—such as the real EMD GP38-2 locomotive—which is the prototype of Athearn's (among other manufacturers) locomotive model. Technically, any non-living object can serve as a prototype for a model, including structures, equipment, and appliances, and so on, but generally prototypes have come to mean full-size real-world vehicles including automobiles (the prototype 1957 Chevy has spawned many models), military equipment (such as M4 Shermans, a favorite among US Military modelers), railroad equipment, motor trucks, motorcycles, and space-ships (real-world such as

A scale model of an airplane in a wind tunnel for testing.

Apollo/Saturn Vs, or the ISS). As of 2014, basic rapid prototype machines (such as 3D printers) cost about $2,000, but larger and more precise machines can cost as much as $500,000.[6]

Metrology

In the science and practice of metrology, a **prototype** is a human-made object that is used as ***the*** standard of measurement of some physical quantity to base all measurement of that physical quantity against. Sometimes this standard object is called an **artifact**. In the International System of Units (**SI**), the only prototype remaining in current use is the International Prototype Kilogram, a solid platinum-iridium cylinder kept at the Bureau International des Poids et Mesures (International Bureau of Weights and Measures) in Sèvres France (a suburb of Paris) that by definition is the mass of exactly one kilogram. Copies of this prototype are fashioned and issued to many nations to represent the national standard of the kilogram and are periodically compared to the Paris prototype.

Until 1960, the meter was defined by a platinum-iridium prototype bar with two scratch marks on it (that were, by definition, spaced apart by one meter), the International Prototype Metre, and in 1983 the meter was redefined to be the distance in free space covered by light in 1/299,792,458 of a second (thus *defining* the speed of light to be 299,792,458 meters per second).

It is widely believed that the kilogram prototype standard will be replaced. There are two likely replacements. One is a definition of the kilogram that will define another physical constant (likely either Planck's constant or the elementary charge) to a defined numerical value, thus obviating the need for the prototype and removing the possibility of the prototype (and thus the standard and definition of the kilogram) changing very slightly over the years because of loss or gain of atoms. The other definition is using a system that finds the amount of force needed to counteract the pull of earth's gravity on a one kilogram artifact. [7]

Natural sciences

In many sciences, from pathology to taxonomy, prototype refers to a disease, species, etc. which sets a good example for the whole category. In Biology, prototype is the ancestral or primitive form of a species or other group; an archetype.[8] For example, the Senegal bichir is regarded as the prototypes of its genus, *Polypterus*.

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