



## Aspects of the Engineering Design Process

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### Abstract

*When new mechanical engineers, but also engineers from other fields, are employed in department for development of some company, they have to satisfy certain requirements. Beside general and specialist knowledge (proved by diploma, working experience and achieved results), ability for team working and many other things, huge creativity is also required which is important for developing new products. Creativity rating can be done in several ways, so this paper offers a method of evaluating based on the assessment how much the candidates are able to perceive the space. It gives an example of problems to be solved in a way to draw as much as more possible different solutions of the body concerned its two given projections which can help the best appropriate engineer to employ as designer. The paper also describes aspects of design engineering process and the relation to development designer inside the company.*

**Key words:** *creativity rating, design process, development, engineer employing*

## 1. INTRODUCTION

Reception of every new worker represents a very joyful, but important, complex and extremely responsible task, especially if reception of new engineers is done in the development service. Engineers who work in development, usually designers, should have creative spirit, internal disturbance and dissatisfaction with existing technical solutions. Existing solution generates in them a desire for the creation of something new, requires the possession of talent, certain knowledge, experience, habits, skill, etc. [1]

## 2. CHARACTERISTICS THAT DEVELOPMENT ENGINEER MUST HAVE

**Knowledge** is a system of information that a person already possess. The scope and quality of knowledge that possess designer, depends to a large extent on his

qualification (faculty degree), his experience (work experience and complexity of work done so far) and general culture, and is divided into two groups:

- The general knowledge is the knowledge required for the design of each product. They include all polytechnical knowledge, for example draft geometry, technical drawing, mechanics, material resistance, machine elements, machine design, machine materials, using computers, etc.;
- Specialist knowledge is related to the specificity of particular designed product and the characteristics of operating conditions. It also includes all the knowledge related to the technological, structural and exploitation characteristics of the product concerned, as well as the knowledge from the restricted area for which this product is designed. [2]

Unfortunately, it should be noticed that the knowledge is very quickly outdated today. Knowledge acquired for the first professional occupation is not sufficient for the

whole lifetime as a designer. The engineer must continually improve his knowledge. Therefore, it should have in mind that investment in knowledge is the best way for investment. The habits and skills of designer are based on the knowledge that is formed in the process of continual practical work. Knowledge, understanding of the significance of their work and the correct method of its execution obtain the designer to acquire all of those personal qualities that lead him to perfection and success. [1]

The **habit** is the ability to perform certain activities automatically, without any particular thought or engagement, while the **skill** is capability of engineer to perform the given task with the appropriate quality and in acceptable time.

Professional skills represent a set of permanent, but under the influence of education also variable, individual psychological qualities of the personality of an engineer. The following professional skills are most important for the designers:

- **Technical view** is the ability to use the entire complex of polytechnical knowledge in order to understand the essence of technical systems and to quickly orientate in all technical issues;
- The **space observing** has a crucial significance in the work of the designer. Good ability of observing the space makes it easy to create and read drawings.

**Creativity** allows the designer to create new, original products. The possession of creative abilities is not only related to the amount of acquired knowledge and experience, but rather, it depends on the character and affinity of the designer personality. Tendency for creativity should be developed during all stages of education and bringing up of each person. Designers with creative competence are especially appreciated when developing a technical task, as well as in the initial stages of design, and in all cases when the given task requires new – atypical solutions. Innovation is one aspect of creativity and represents the ability to create completely new, useful, technical solutions. Since this type of ability is particularly required of designers, it is usually said that designer possess a talent for construction.

**Brainstorm courage** gives the opportunity to apply a new, original, completely unusual and at first glance incredible solution when solving certain tasks. This reveals the way to finding high quality design solutions. This brainstorm of designer should not be limited by anything, in order to give the maximum effect.

**The ability to accept new and unusual solution** (flexibility) presents the skills of analyzing, selecting and using new solutions without the fear of abandoning old and common technical solutions.

**The feeling for a nice** is very important characteristic of the designer, which today is extremely appreciated. It allows him to make high-quality solution, so therefore design also represents an artistic creation. [2]

**The speed of the thought process** ensures the productivity of the thinking activity.

**Observing skill** is the ability to perceive what is essential for achieving the set goal. Recognizing the main and essential on the object of the research, as well as the assessment of their usefulness, provide the possibility

of creating a completely new technical solution on the same basis.

**The methods of carrying out engineering analysis** mean the designer's skills to split the structure into components, and processes into operations and steps, for their further study. Engineering analysis enables simple and easy comparison and evaluation of existing variants, as well as easy choice of the right solution.

**Using the solution** is the ability to use the results of an engineering analysis in order to select a design with optimal features.

**Possession of own aspect** is also very important characteristic of the designer which makes it possible to obtain the correct conclusions. Building an own viewpoint must be done on an objective basis.

**Correct and clear expression skill** in written or oral form is a very important characteristic of designer. It is related to the ability of logical generalization, to perform the necessary conclusions, to take an active part in professional discussions, submitting reports of the results of their work, etc.

**Communication skill** is, in most cases, very important for designers. It enables easy and quick contact with associates, easy collection of information needed for successful work, and easy presentation of achieved results.

**Speaking of foreign languages** is a very important for designers. Today there is a need that designers and all faculty educated people speak at least one or more world languages, usually English and German. This makes it easier to follow world literature and generally communicate with colleagues abroad.

**Self-confidence** is very important for designer, not only for communication, where it can help the designer not to feel inferior, so that it is not possible to "impose" one's own attitude, but also during all other activities. Self-confidence and optimism can have positive influence to associates, since they usually encourage them to engage more. Self-confidence can be obtained by more knowledge, but although it is certainly a feature of education and personality.

**The designer's initiative** is the ability of self-compulsion, as well as the encouragement of others to greater engagement, and even the choice of harder ways to solve tasks, if it contributes to improving the quality of design solution.

**The broad horizon of the designer** signifies that he possesses principled knowledge not only of his own specialty, but also of other related fields that are related to it. Usually, a wide horizon is provided with a wide range of interests. This means that the designer must constantly improve and acquire new knowledge from practically all areas.

**Discipline** is characterized by the accuracy of executing the task, diligence and love for work. Managers and associates always value this kind of personality.

**Readiness for hard work** (diligence) tells about the ability of the constructor to sacrifice additional time to solve a particular task. Readiness for work turns into a tendency for work and enthusiasm. This kind of designer can solve all tasks. Every job can be done, if designer is prepared and interested in the occurred problem.

**Readiness to have a risk** is an important characteristic of the designer, depending on whether he will design something significantly new or not. Certain risk is taken into account by designer in each design solution. The risk is the core of innovation. However, the percentage of the risk should be always known. It is unreasonable to start calculation and design, if there is small chance for success.

**Persistence** is a readiness to remain in the process of work and it is very important and good characteristic of the designer, of course up to a certain limit, beyond which it passes into stubbornness. If someone is persistent, it does not necessarily mean that he is also hard-working and vice versa.

**Patience** is a very important designer's characteristic. The process of making design documentation is most often a very painstaking and long-lasting process, as well as the production and testing of products according to this documentation. Consequently, great resistance and patience are expected from the designers.

**Restraint** is a very good characteristic of the designer and it implies the ability of the designer to control his behavior even in unpleasant situations that sometimes occur in design bureaus.

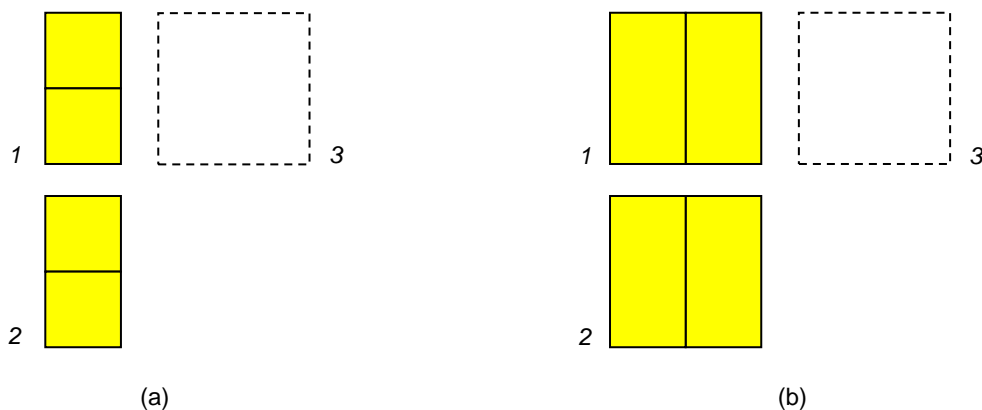
**Team working**, i.e. the readiness to accept criticism and to recognize the mistake is an important characteristic of the designer and especially the executives. It depends on the character of the personality and the general level of culture.

**Concern about the people** is an extremely important factor for achieving success. Therefore, the designers,

and especially the executives, are required to pay great attention to this element, i.e. to respect and appreciate their associates, to give them maximum support and to allow them the freedom to develop their own approach of work and, in particular, that they can do the job in their own way. Additionally, when issuing the assignments, managers need to take into account the ability and instant mood of each designer individually, in order to make them more rational, as well as to properly organize and share work among older, more experienced, and younger, insufficiently provable, designers.

Beside all the above mentioned characteristics, the designers must be intelligent, positive, reliable, loyal, honest, objective, responsible, cautious and serious personalities who will be able to comply with everything that is agreed. Of course, they must also take into account the culture of dress, speech, behavior, etc. Only thanks to these qualities they will be entrusted with serious, responsible and well-paid jobs. It should be noticed that many designer's skills and therefore the quality of the design solution, depend to a large extent on the time available for the designing and the intended stimulation.

Also, designers have to possess the outstanding imagination that needs to be verified when recruiting new employees. For the evaluation of the imagination of engineers, but not only mechanical engineers, a simple test can be applied. It consists in drawing a third projection based on two given – Fig. 1.



**Figure 1.** Based on the two projections of bodies (a) and (b) – see projections 1 and 2, draw as many different solutions as possible of the third projection – see projection 3

Engineers with better technical view and space observing have better imagination and will offer more results. On the basis of estimated imagination and all other positive qualities, it follows the reception of new designers.

### 3. RESEARCHING IS GOING BEFORE DESIGN

Various stages of the design process (and even earlier) can involve a significant amount of time spent on locating information and research. Every designer has to research. Consideration should be given to the existing applicable literature, problems and successes associated with existing solutions, costs, and marketplace needs. The source of information should be relevant, including

existing solutions. Other sources of information include the Internet, local libraries, available government documents, personal organizations, trade journals, vendor catalogs and individual experts available. [3]

Since designers are individualists, they research the problem by their way, which is certainly good. Individualism is necessary for creative research work. The researcher should have enough "honored hands" and great autonomy, but also timely integration into teamwork. The research team is worth as the researchers in it. The right choice of researchers is very important, because success depends on the composition of the research team. For example, the more experienced researchers (1, 2, 3, 4) have very high knowledge in the

areas of their specialization, and relatively low in other scientific fields (Fig. 2). On the other hand, the researcher-beginner (6) in all relevant fields has an equal, modest knowledge. As a difference from them, the research team leader (5) possesses relatively high knowledge in

all areas relevant to research and development (A, J, K, M). The total knowledge base of the research team is presented with the curve line, which represents the highest value of researchers' knowledge in certain areas. [4]

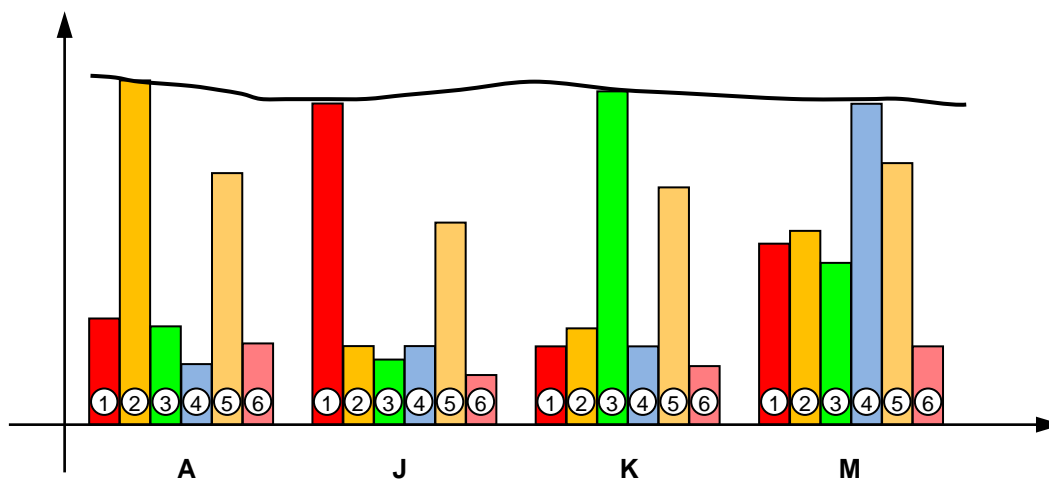


Figure 2. Depending the intensity of knowledge from the field of research [4]

It is necessary to periodically hold meetings of all participants working on the realization of a particular research or development project, in order to exchange views on the observed or expected problems. It is very important to cultivate the spirit of team work. Responsibilities must be clearly defined. Researchers of bad character and those who do not cooperate should be avoided, unless they are geniuses. [4]

Communication between participants in research and development is a very specific problem. Differences in approach to problems, in understanding other ideas and directions of development can completely break the team and personalize individuals in the team. A circle of possible ideas can be quickly closed by individual thinking. The self-satisfaction achieved by the first result usually leads to the interruption of further efforts in the same direction. Successful team work is also based on the intense communication of team members, the exchange of ideas and the stimulation of thinking leading to a defined goal. [4]

Different methods have been developed in order to solve the problem of communication between individuals within the team, exchange of mutual information and encouraging thinking and generating new ideas. Corrections of other team members remove individuality in thinking. [4]

The research team leader is required to be a distinguished scientific worker, an active expert at the top of a certain field, to have wide and reliable knowledge, organizational skills, high moral qualities, to know and apply psychology, to know that motivate people, to cheer, listen and criticize. Only skilled research team leaders can listen to the opinions of others. One's own opinion can be corrected by listening to the opinions of associates, and new arguments can be found by argued rejection of the presented proposals, which strengthen their own attitudes. If leader can listen it corresponds with his education, respecting the opinion and personality of other team members, supporting the freedom of expressing person-

al attitudes, developing responsibility with the collaborator, etc. [4]

#### 4. COMPARISON WITH THE SCIENTIFIC METHOD

The engineering design process has some similarity to the scientific method. Both processes begin with existing knowledge, and gradually become more specific in the search for knowledge (in the case of "pure" or basic science) or a solution (in the case of "applied" science, such as engineering). The key difference between the engineering process and the scientific process is that the engineering process focuses on design, creativity and innovation while the scientific process emphasizes discovery – observation. [5]

While scientists study how nature works, engineers create new things, such as products, websites, environments, and experiences. Because engineers and scientists have different objectives, they follow different processes in their work. Scientists perform experiments using the scientific method; whereas, engineers follow the creativity-based engineering design process. Both processes can be broken down into a series of steps, as seen in the diagram – Fig. 3. Both scientists and engineers contribute to the world of human knowledge, but in different ways. Scientists use the scientific method to make testable explanations and predictions about the world. A scientist asks a question and develops an experiment, or set of experiments, to answer that question. Engineers use the engineering design process to create solutions to problems. An engineer identifies a specific need: Who need(s) what because why? And then, he or she creates a solution that meets the need. [6]

In real life, the distinction between science and engineering is not always clear. Scientists often do some engineering work, and engineers frequently apply scientific principles, including the scientific method. Much of what is often called "computer science" is actually engi-

neering-programmers creating new products. Many projects, even if related to engineering, can and should use the scientific method. However, if the objective of some

project is to invent a new product, computer program, experience, or environment, then it makes sense to follow the engineering design process. [6, 7]

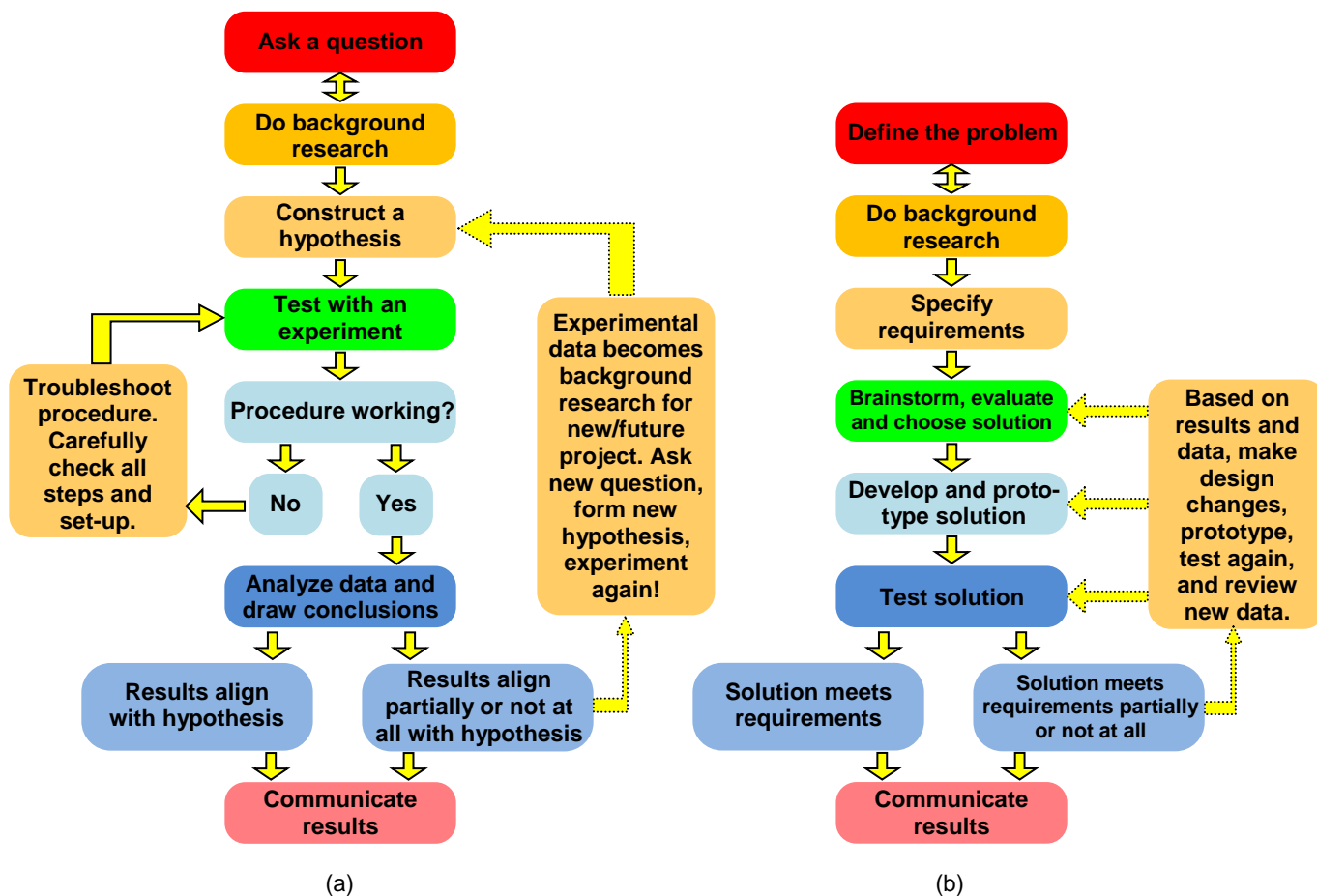


Figure 3. Comparison of the scientific method (a) and the engineering design process (b) [6]

## 5. THE RECEPTION OF DESIGNER

The arrival of every new designer in the design bureau, especially if it is his first job, is a great event, first and foremost for him and then for the company. Therefore, special attention must be paid to the reception. The reception from the colleagues, but also from the management, should be friendly and welcome. It must be collegial and everybody has to be pleased for reception of new employee. New designer must prove and demonstrates his skills and try to contribute the successful work of the bureau. The help of older colleagues will be very useful, but from new employees it is expected some result when they got certain task. Knowing that new designer can not know enough about the problems that are solved in that bureau, they are given the so-called "mentors" who "guide" them during their work and get to know them in detail with the problem, gradually increasing the complexity of tasks that they later need to solve independently. Only after this approach significant results can be expected. It is usually considered that it takes three to five years for that designer "grows up" into an independent designer, and at least ten to fifteen years of serious work to be the leading designer or manager. Acquiring knowledge is a long-lasting and hard process, so the acquired knowledge is

a great capital, not only for the individual, but for the company as a whole, and it must be highly appreciated. It is usually practiced that each designer has a separate records about his results, especially the successes, on the basis of which he is progressing, stagnating or, possibly, falling back. [2]

## 6. THE BEHAVIOR OF DESIGNER

Designers are required to dress appropriately, look, observe and behave in order to preserve the reputation of the profession. Their appearance and behavior creates significant impression about designers, about the company where are employed, and hence about their attitude for the obtained task. Relationship between colleagues is especially important. All notified mistakes and failures should be commented personally (between manager and designer), but if it does not help then with present all colleagues. At the same time, all prizes should be publicly announced, as they usually have a major impact on even greater engagement of designers and all employees in general. It should be known that designers are, in most cases, very conceited and difficult to accept the opinion and of the others, which is certainly a bad characteristic. Therefore, when presenting different opinion or proposal, it should be very tactful. The correct attitude among col-

leagues creates and preserves good work atmosphere in the company, which certainly enables the quality execution of all tasks in time.

Older designers have to provide a positive example to the younger and to be a role model by their behavior and attitude towards work and obligations. They have to develop and keep up the so-called "cult of work", i.e. obligation to do something during the work and something to achieve, something new and important to obtain. By such a serious and responsible approach to work, older designers influence the proper attitude towards the work of all employees in the bureau, as well as on their personal respect and appreciation, not only by younger designers, but also by all employees in the company. [2]

## 7. THE WITHDRAWAL OF DESIGNER

The departure of experienced designers from the design bureau must be prevented in every case, since this represents an irrecoverable loss for the entire company. Knowledge and acquired experience must be transferred from generation to generation of designers, creating a certain tradition, and this practice must not be interrupted, if company should succeed. Designers, after certain time, become designer manager or developing manager, or become associates, advisers and even directors. In the case they are saturated of design, they usually go to commercial (purchase or sale, import or export) or marketing service, because they recognize very well the products and everything related to them, so that they can make a big contribution to the company at these jobs.

Since designers are often advanced, or abandon their current job of the designer, or simply retired, some attention must be given to these moments also. Usually, the manager should briefly review the work of the designer, point out his results, and express the gratitude for his work so far and the overall contribution to the design bureau and the company as a whole. These small forms of attention enable that good contact maintains with the people who leave and who will, of course, be able to help their former colleagues, the design bureau or the company in which they worked.

Designers who are leaving or promoted also need to leave the company in certain way, i.e. they must not "slam the door behind". They should leave as friends and colleagues, since it often happens that the designers need to return to their former (old) workplaces. If they did not maintain good business and friendly relations with their colleagues, especially with the management, this could be an invincible problem in their re-employment.

## 8. CONCLUSION

This paper describes characteristics which designer should have, offers the way how to select engineer to become a good designer and explains the importance for the company to have experienced designer and how to educate, develop and keep him, since leading designer and his acquired knowledge is a great capital for the company.

Design is described as the application of practical and scientific knowledge to the solving of a problem through the use of a methodical process. The engineering design process is a series of steps that designers follow when they are trying to solve a problem and design a solution for something; it is a methodical approach to problem solving. This is similar to the scientific method, but there is no single universally accepted design process. It seems as though most designers have their own twist for how the process works. The process generally starts with a problem and ends with a solution, but the middle steps can vary.

The new technological advancements are forcing to work on the new design methodologies from a different perspective. The use of computers as a part of our daily life forces engineers to develop new approaches to the investigation of design process.

Nobody can refuse the past theories and methods as they have their own truths and the knowledge of the developers. If there are so many theories and sciences related to this area of design methodologies, it means there are concern problems and there is a lot to be done in the area of design theories and methods. There are big gaps between the research and practice of design, but most of the theories and methods fit to the problems of the professional practice.

The design process in its simplest terms can be seen as a 3-step loop between the generated idea, its implementation and the evaluating and testing the product. Typically, during this testing and evaluation, additional ideas are generated, and the process starts over again. This cycle and repetition is why it can be said that design is an iterative process. Iteration is the act of repeating something over and over again in order to improve the process and eventually achieve a desired goal. Obviously this process could go on forever (or until the design group stops thinking of new ideas and stops finding problems with the design). There is a saying sometimes used by veteran engineers: "At some point in every design process someone needs to get rid of the engineer and just build the thing!" [8]

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