How international report systems can help improve the quality and usability of everyday products

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Quality represents one of the basic concepts of human life. The term quality is used in two meanings with one of them meaning a high "quality", i.e. excellence. The other meaning is "fit for purpose". For the manufacturer of a product, quality criteria are objectively measurable features of that product while for the user the "user perceived quality" or "UPQ", yields a set of requirements the answer to which are certain product features. The translation between the quality concept of the user and that of the manufacturer is accomplished by the so called "Customer Data Table".

INTRODUCTION

Quality represents one of the basic concepts of human life. Despite the fact that many people think that quality is an objectively measurable feature of physical objects this concept is applicable to any entity, thus, also to services or organizations. In addition, quality is not an objective feature of that entity, it can be seen from different perspectives, e.g. from the manufacturer view or the user view. Thus, quality is not a feature inherent to an entity but the totality of characteristics of it that bear on its ability to satisfy stated and implied needs, i.e. the match between specified requirements and the features of that entity ("fit for purpose").

The view from the user perspective, the "user perceived quality" or "UPQ", yields a set of requirements the answer to which are certain product features. The relevance of attributes of a product for the quality assessment depends on the intended users and the intended use. E.g., the same program may have different "quality" for professional users than for home users. Generally speaking, it has!

For vendors who strive for acceptance of their products by the intended customer population, the so called "Customer Data Table" translates the relevant attributes into requirements or features of the product or service, resulting in the quality concept of the manufacturer, i.e. features inherent to the product or service which can be measured objectively or assessed. In general, these features cover more than the user perceived quality since the user is interested or involved in the product life period from purchase to dump while the manufacturer´s interests may cover all stages of the product life from planning to disassembling and reusing the remains of his goods. E.g., users of a piece of paper are interested in about half a dozen of properties like smoothness of the surface, colour or weight while the manufacturer may be interested in all product related aspects from the kind of tree to be used for the production to de-inking abilities of the final product in the recycling process.

Planning a product for maximum UPQ, the vendor has to know the requirements of the intended users, e.g. following the concept of usability (ISO). This concept requires to assess three different aspects: Efficiency, effectiveness and satisfaction. For a given product, e.g. a certain software, each aspect can be judged using different methods. The process of judgement, regardless of the method, is likely to fail to some extent leading to a gap between users´ requirements and product features considered sufficient to satisfy them. A further gap is likely to be caused by failing to fully translate the requirements into product features. Thus, the UPQ will be below the possible maximum even under best circumstances. In specific cases, a more severe problem may result from the changes of users´ perspective of the product: The requirements underlying the planning of the product are possibly no more valid when it enters the market. These three reasons force any vendor offering a product or service to learn from the market (cf. descriptions

of Deming Cycle for Continuous Improvement). One of the preconditions of learning is feedback and methods of deciphering that feedback.

The two faces of quality

The concept behind the term quality dates back to Aristotle and Democritus (Asam et al, 1986). The name "qualitas" was coined by Cicero who translated the Greek original. Philosophers like Plato, Aristotle, Kant, Hegel, but also modern authors have been involved in the development of our modern notion of quality. In fact, the current understanding of quality, i.e. evaluation of attributes or features of an entity on the basis of requirements, was part of quality related ideas of Democritus and Epicurus. Their so-called "secondary attributes", those based on agreement, in contrast to the primary attributes like shape or mass, have been transferred into our modern notion of quality.

For long time, ergonomists have not been aware of the fact that they have been expanding the term quality in consideration of features of systems or products characterized as "ergonomic". Engineers, product designers or architects who shape tools or living and working environments are still reluctant to recognize that "ergonomic" design elements constitute part of the quality of an entity. By establishing the usability concept (cf. ISO 9241-11) and its relationships with the overall quality of an entity the real nature of ergonomic features became apparent: Usability is part of quality, an integral part of it, and not the "icing on the cake" like many people think.

The conflict between conventional engineering wisdom and ergonomic way of thinking is easily resolved by appropriate acknowledgment of the goals to be considered by designers and ergonomists: In both cases, quality is compliance with specified criteria. However, the origin of "user centered" quality criteria is the use and the context of use, while the designer must consider all product related criteria from the birth of an idea of a product till disassembling and destroying it at the end of its life cycle (fig. 1).

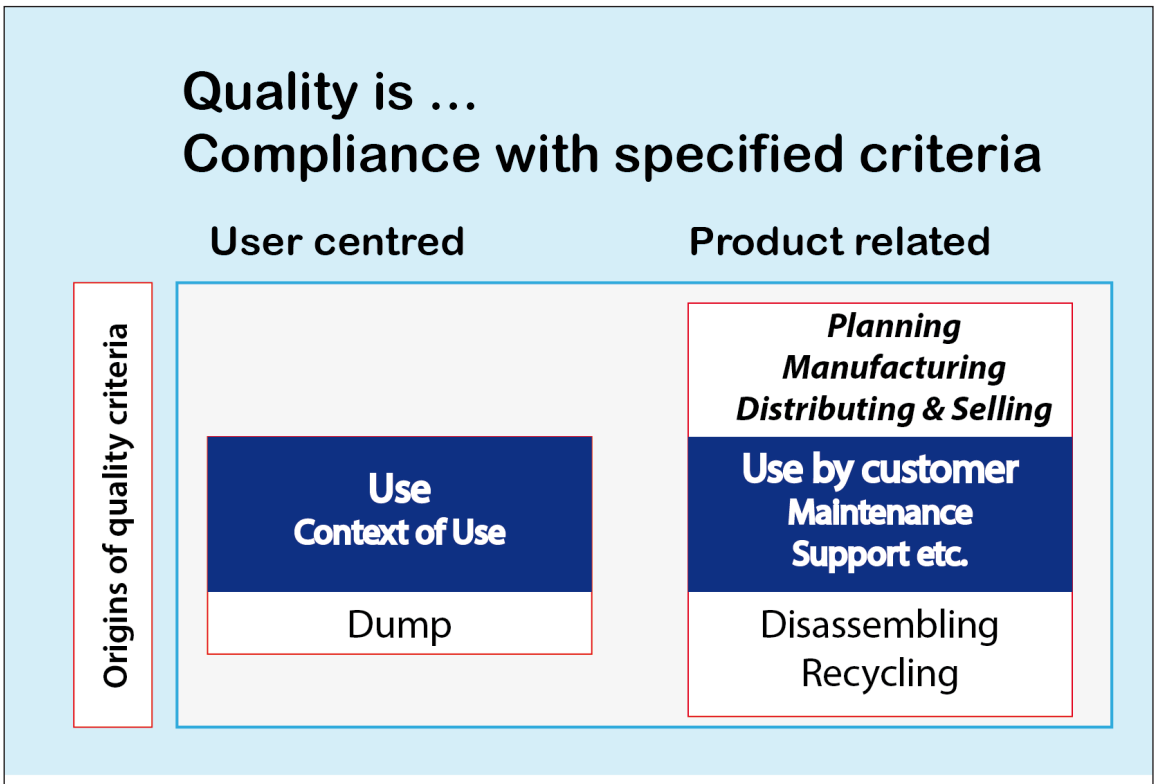
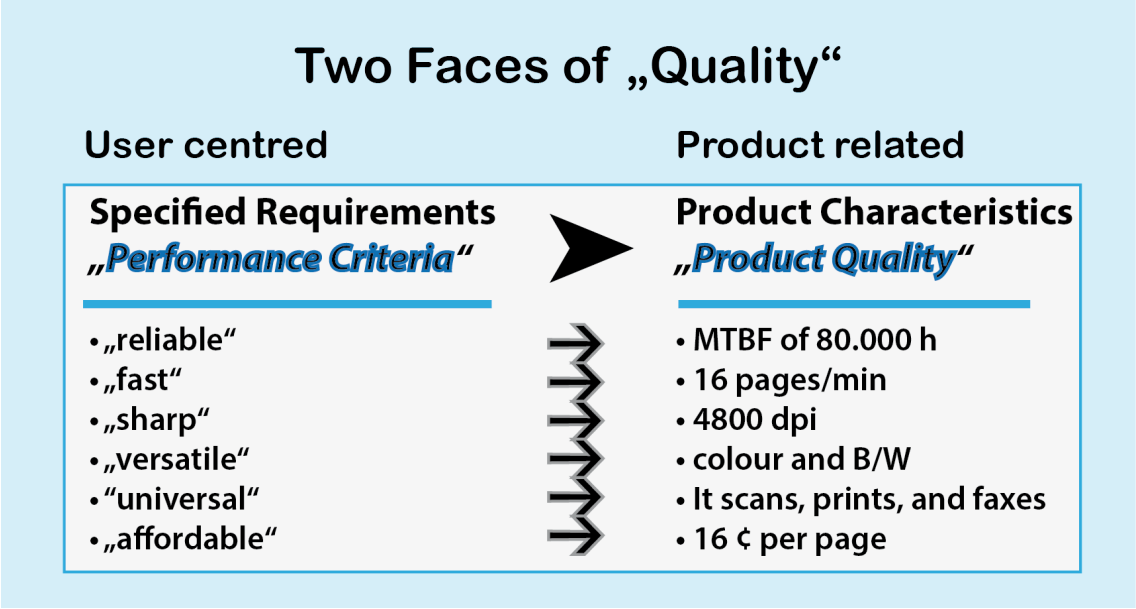


Fig. 1 Origins of quality criteria for product related and user centred considerations

Fig. 1 may be very helpful to understand the viewpoint of designers who are in conflict with ergonomists: A specific product feature one should strive for in consideration of usability may cause problems for manufacturing, recycling or elsewhere. An example for such a problem is given by the "amber" phosphor of visual displays which was considered to be superior to all others in optical quality (contrast, sharpness of the image, flicker) but was not acceptable from an environmentalist point of view. In some odd cases, manufacturing a "usable" product may cause more ergonomic problems for workers in the manufacturing area than the ergonomic features would prevent during use among the intended users. The conflict is resolved by considering user centered quality criteria as a subset of the total quality considerations.

The major source of conflicts between ergonomists and others, however, is not the different origins of quality criteria, but the simple problem of translating the concepts from a specific area to another. E.g., an industrial designer who is asked to develop a printer in consideration of user centered quality criteria may not understand or even misunderstand how users of her or his product comprehend the term "reliable". For a mechanic who owns a large set of tools within arm reach, this term may mean something different than what a white-collar worker in top management would think of. Depending on the specific task to be fulfilled, design and produce or use, one can justify two different viewpoints on the features of an entity. Thus, quality has two different faces, one relevant for those who use an entity and another for those who have to "materialize" what the users mean. The "Customer Data Table" or "Consumer Data Table" translates the user centered concepts into product related criteria (fig. 2) which are specified product features.

Fig. 2. User centred criteria translated into product related by the "Consumer Data Table"



The potential benefits of a report system need always to be considered within the limitations given by the scope of the accessible information: User centered concepts will always yield data limited to the use of an entity while product related concepts may cover a much wider scope. Under real world conditions, however, usability related issues may be of crucial importance even for "products" where technical criteria seem to play a dominant role. For example, a very simple violation of ergonomic rules was the reason why an insignificant failure of a technical device marked the beginning of the end of an era in world history: The "Age of Nuclear Power" has started its decline in the 70es when the NPP on Three Mile Island, USA had a rather simple incident. In the specific case, however, the staff was not able to recognize the problem because one of the lamps which should indicate the status of a certain valve did not function, and, the other lamp was obscured by a piece of paper like those one can find in many control rooms (cf. The Ac-

cident at Three Mile Island, "Kemeny Report", 1979). The direct damage caused by this simple failure was a two-digit number of billions of dollars while the indirect damage can be portrayed by the fact that since Three Mile Island no US-Company has ever planned an NPP and still does not consider to do so.

In some cases, the consideration of ergonomic criteria may change the entire product and lead to new product related criteria. An example for this is the introduction of viewfinder panels in video cameras which was suggested as a result of ergonomic studies. Some of the new designs do not even look like a camera and require some marketing efforts to convince buyers that the new product is much better even although it looks rather like a small cigar box with a lens attached to it. In other cases, ergonomic considerations in product design may cause very high costs and, in addition, marketing problems. An example for such an incidence is the segmented (split) keyboard the production of which may cause up to five-fold production costs compared to a normal keyboard. In addition, the vendor needs to persuade users of the benefits of the segmented keyboard.

In any case, the conflict between the interests of those dealing with product features and of others interested in usability-related features will remain a fundamental point of controversy. The role of the referee in this conflict can be successfully overtaken by the market if the vendors and designers learn to decipher its signals.

On INTERNATIONAL REPORT SYSTEMS - feedback from reality

Do we need feedback if we plan our products properly?

Any living being or system needs some kind of feedback from its environment and adequate response to the information from the environment to survive. The sudden collapse of one of the biggest empires of all times during our decade gives evidence that the need to respond to external factors is not limited to weak and powerless entities. One may think, however, that proper planning and production after carefully anticipating all circumstances can guarantee success, and no feedback was needed. In fact, there are few feedback channels manufacturers of everyday products have established in order to learn from their markets. Many world-class manufacturers even try quite the reverse, teaching the market what it should accept following a strategy which is reasonable to some extent but may prove wrong as a general behavior.

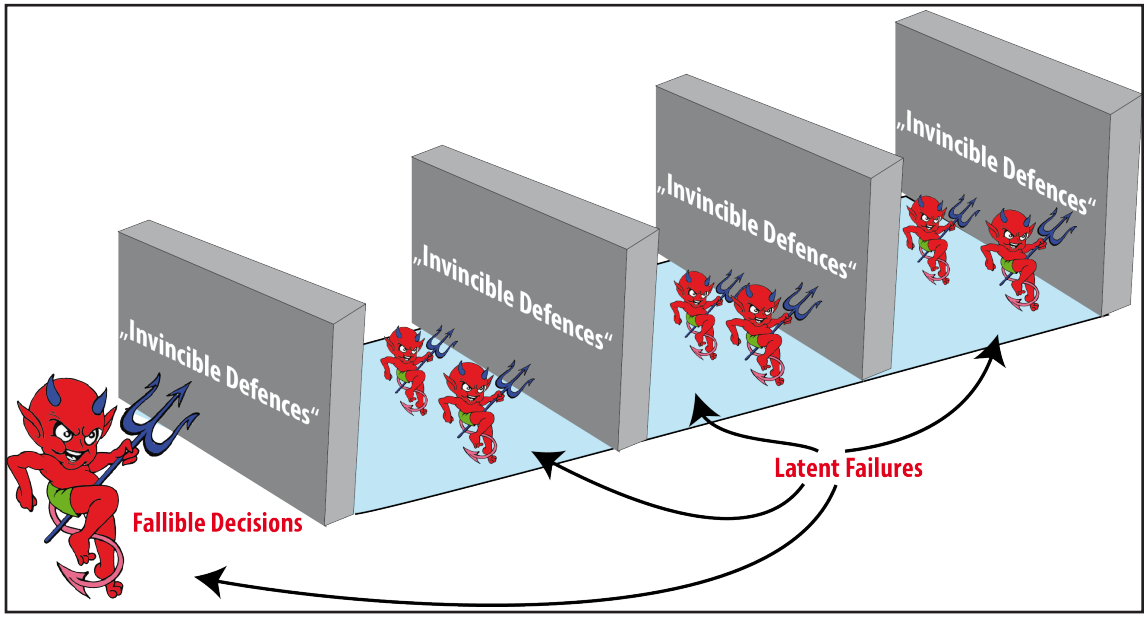
Where people have been aware of their need to learn, e.g. in low-risk high hazard areas, adequate systems have been installed with report systems being part of them. Such systems can be limited to a certain company, they may cover a business area (ASRS Aviation Safety Report System) within a country (e.g. INPO in the USA for nuclear power operations) or they can operate globally (WANO World Association of Nuclear Operators). The role of report systems is conveying "relevant" information from the source to others who are likely to be concerned ("to whom it concerns"). E.g., certain incidents in NPPs are reported throughout the world.

The existence of a report system in a specific area does not prove that hazards in this area are bigger than in others without such a system. For example, aviation as the safest transportation system has one the most powerful and efficient report systems ever while railway companies operating in many countries with a lower level of safety to not possess comparable means. The system that causes more deaths in single countries than aviation and rail transportation world-wide has no report system at all. In fact, road transportation causes in most countries of the world more deaths and injuries than wars did in the specific country. Whether or not people acknowledge the need for a report system is not based on objective data and facts but on subjective perception. For producers of everyday goods, it there is no obvious reason to adopt a system which may be warranted in nuclear energy sector or aviation. Thus, possible benefits of such a system must be convincingly substantiated.

Agents of the evil in healthy looking systems

The need for feedback even for well-planned products or systems can be demonstrated with the help of the "Resident Pathogen Metaphor" according to which incidents or accidents are mostly caused by fallible decisions from the planning phase of a system with the help of "latent failures"which remain undiscovered for long periods of time (fig. 3).

Fig. 3. Resident Pathogen Metaphor: Conventional wisdom suggests that proper planning and production either avoid fallible decisions or prevent their influence on later incidents by erecting "invincible" defences. Latent failures may exist, but cannot cause any problem since all relevant problems will be detected and eliminated before the system starts being used.



However, conventional engineering wisdom suggests that no fallible decision can affect later periods of the life cycle of a system because there will be barriers keeping them from penetrating the defences of the system. E.g., planning errors will be detected before building a prototype, errors of the prototype will become obvious when planning the production etc. Some analyses of important accidents, however, suggest that this notion does not match the truth. Reason (Reason, 1990) has created a model which shows the transmission path of fallible decisions through different phases of the life cycle until the accident occurs (fig. 4). The notion behind this model is that the "invincible defences" look rather like Swiss cheese offering loopholes for fallible decisions and latent failures which help them to survive even some periods of use and maintenance (fig. 5).

If the latter model is applied to the life cycle of a system or product, we obtain a model "Survival path of undocumented features" which links incidents from the use of the product to latent failures or fallible decisions from earlier phases (s. figure 6). While the original model explains the path of causes of accidents through various defense barriers, the "Survival path"-model for the so called "undocumented features", i.e. undesired or unplanned properties of a product, symbolizes the way of a cause from the birth of the idea over different stages of design and production to the environment of its use.The applicability of this model on real products is demonstrated by an analysis of errors in software (Balzert, 1996). This analysis shows, that 55% of constructive errors are introduced in the planning phase, but only 5% detected. A considerable proportion of errors survive all phases of planning and production: 35% of constructive errors are detected during final testing or use (fig. 7).

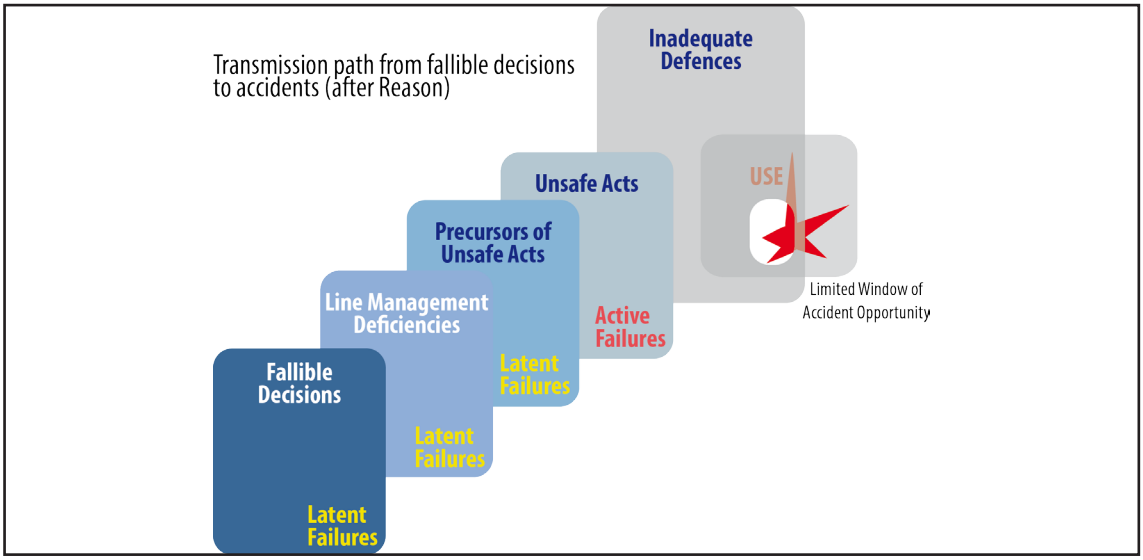


Fig. 4. The transmission of latent failures through the life cycle of a product or system

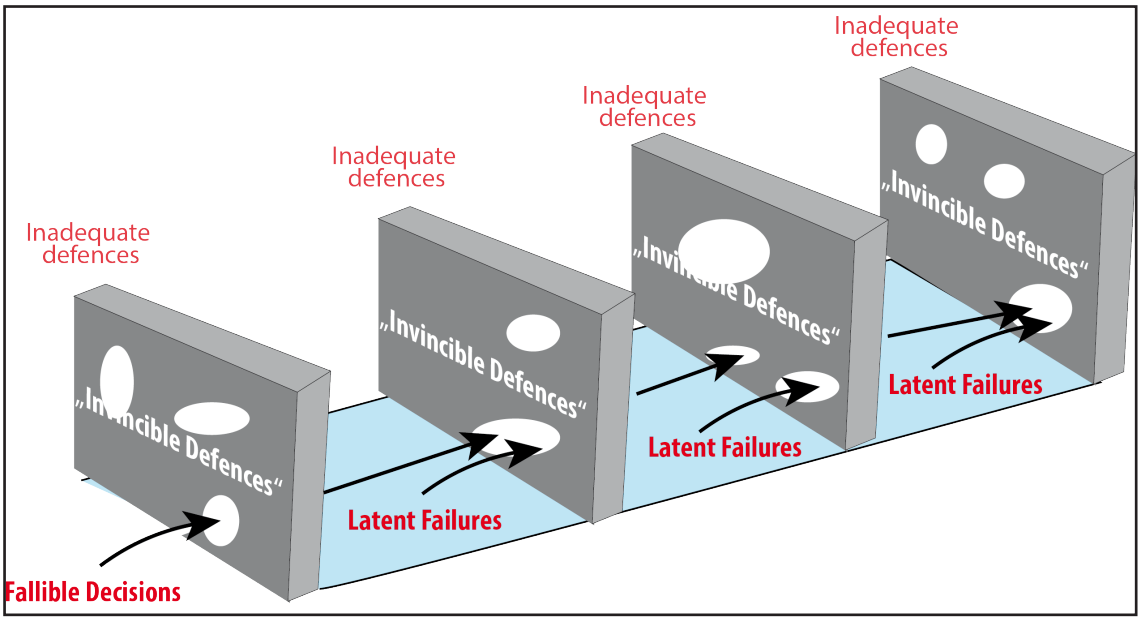


Fig. 5. Swiss cheese model of inadequate defences

The analysis of a recent accident in an industrial plant in Europe shows that even best engineering practices and safety precautions cannot prevent fallible decisions from penetrating well-organized defences and surviving many years of operation. What makes this case very interesting is that it demonstrates how in all phases of the life cycle of a system, including use, errors can be introduced and how they can survive as resident pathogens.

The construction that caused the accident has two units with the upper unit to be lifted by motors. This unit is held by three independent and redundant break systems. After finishing the task, the operator is asked to move the top unit into a "safe" position where two bolts fix it (fig. 8). The operation is finished by driving the unit into the appropriate position by hand. To accomplish this, the breaks have to be taken out of action. After finishing the job, the operator must bring the breaks back into their normal status. The accident happened because the first operator had

left the device in an unsafe condition (no breaks) and the next operator did not have the slightest chance to detect this condition. The later analysis did not only reveal that in each phase of the life cycle of the construction at least one ergonomic related error was introduced (latent failure) with training the personnel in unsafe operation of the unit being the worst (fig. 9) but also that the cause of the accident, the "safety related action", was completely unnecessary! None of the latent failures would have been powerful enough to cause the accident.

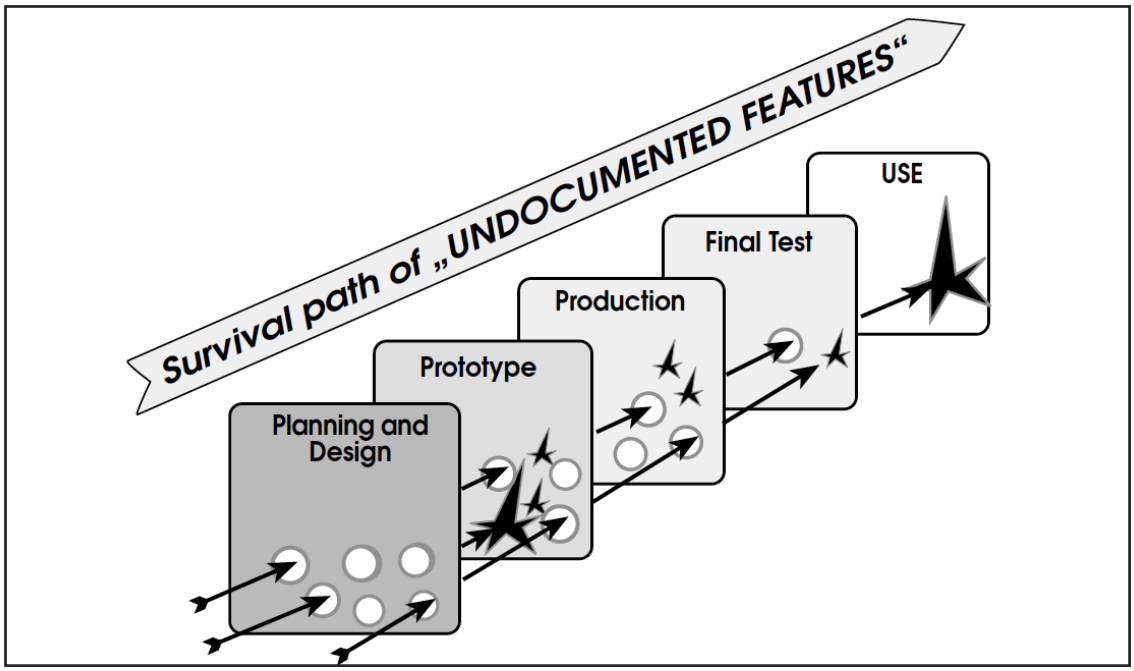


Fig. 6. Survival path of "undocumented features" through the life cycle of a product until it causes an incidence during use. Causes of failure may be able to penetrate some or all barriers setup to achieve the intended quality of the product and become effective during use. (Not displayed here: Causes induced during the stages of the product life cycle)

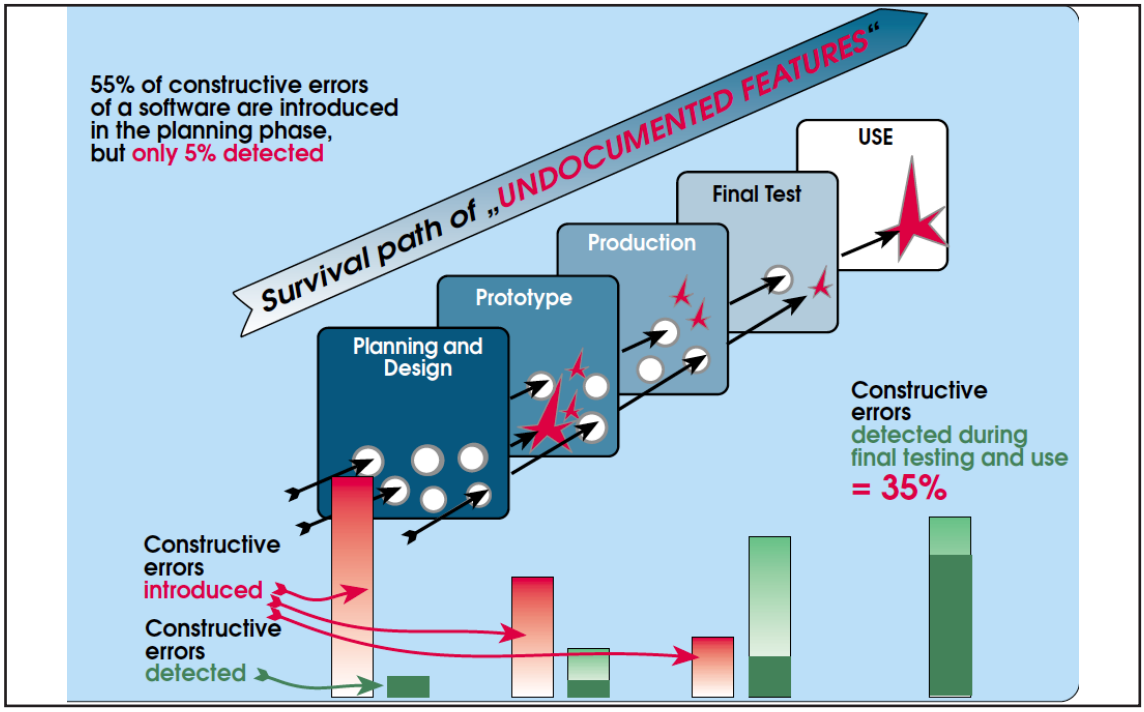


Fig. 7. Constructive errors introduced and detected in different phases of software life cycle

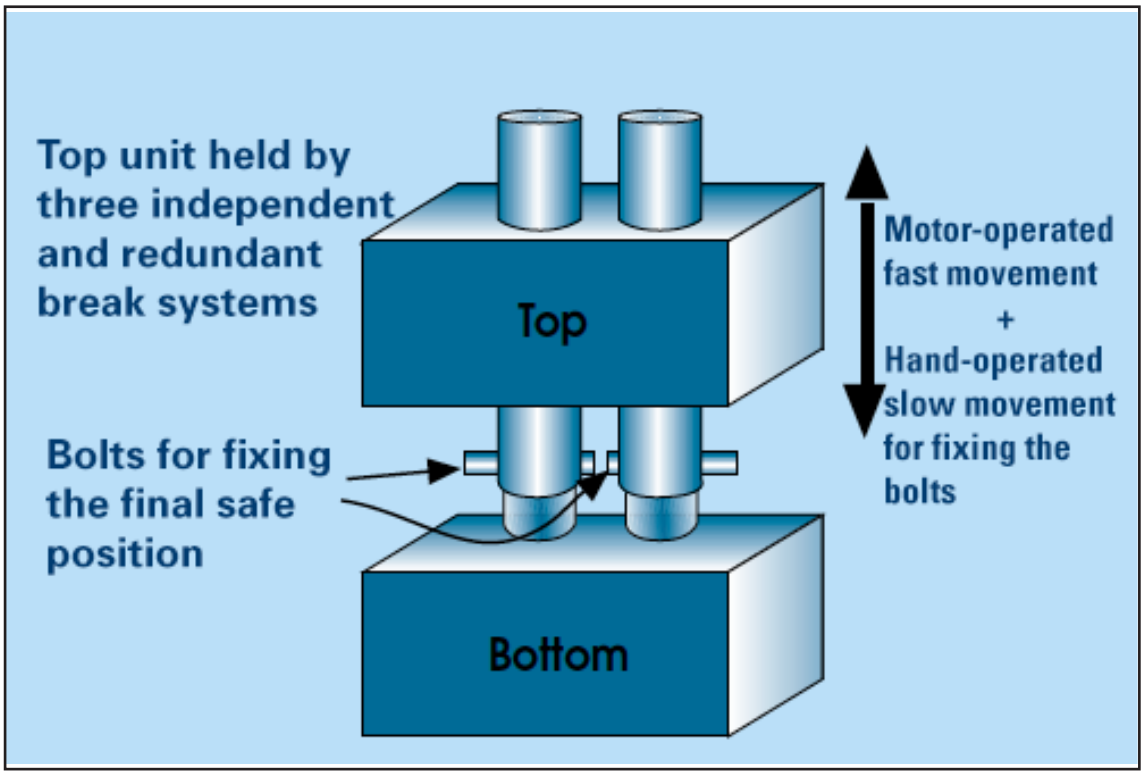


Fig. 8. Functional model of the unit which caused a major accident

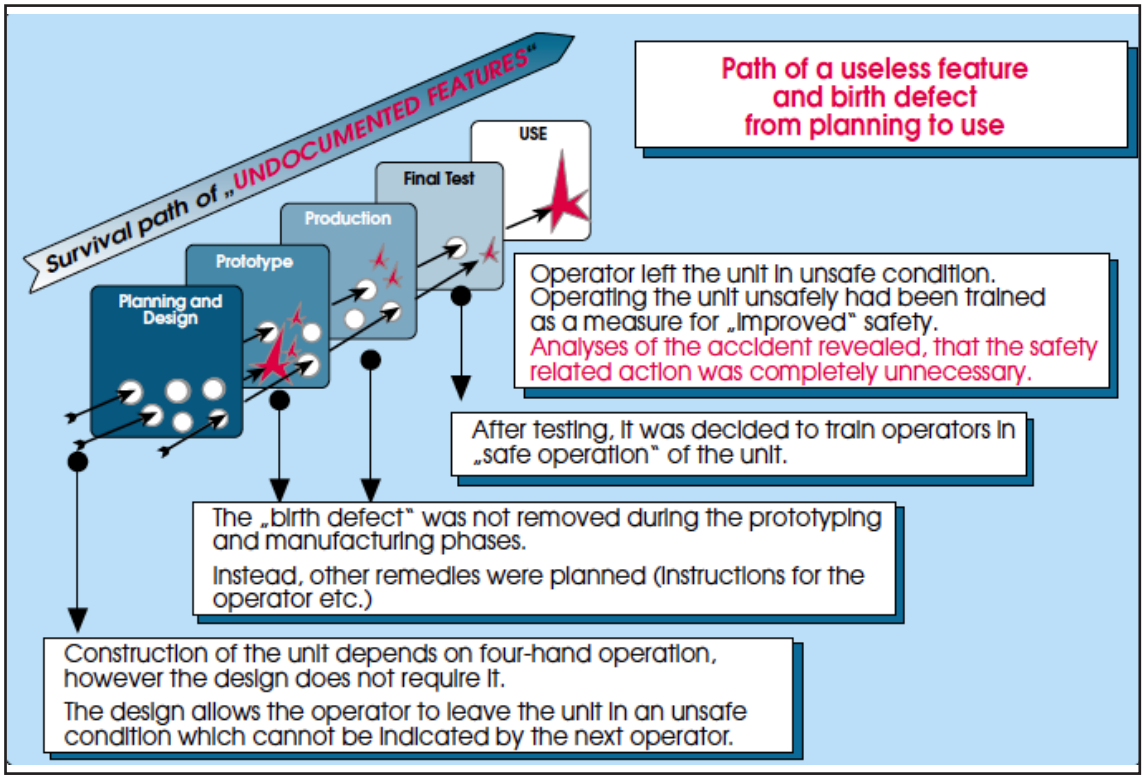


Fig. 9. The survival of a fallible decision in a well-planned and operated system from the first idea to a major accident: A useless safety procedure survives all phases of the development and operation of a system until the analyses of the root cause

Can everyday products benefit from report systems?

In general, most well-known report and feedback systems distribute "negative" information: They normally cover information on incidents or accidents. The recipients may or must use the information to check their operations or technical equipment. Under circumstances, they may even be forced to report back to an agency or political instance. Some systems collect the information on analyses of such incidents. The feedback to the persons or organizations concerned with the specific events completes the feedback loop from the root cause to those who may try to avoid comparable incidents.

It is questionable, however, whether report and analysis systems may be useful or successful for "normal" products such as software or TV-receivers. The main reason for scepticism is that the established systems do not convey "wholistic" information, i.e. the "good" and the "bad", but only information on occurrences of negative incidents. From such a system, one could not learn why customers buy and love a lousy peace of software or an ugly looking camera. However, the question is whether blind flying without instruments is a better choice: Most products we meet in our everyday life have been born in the minds of people who have never become acquainted with somebody like us and have been produced far away from our town. But: Where did the designers get their "Customer Data Table" from and how often do they update it? The experience of our institute shows that even important knowledge on well-known technologies have not been updated for decades. Some of them were successful, like a stray bullet that hits a or the target, while some others have gone forever. A quick look at the fate of some technologies may help understanding the role report systems can play for successful everyday products.

Products like stray bullets - hits by chance

Sources of our lessons

During the first two decades of its life, our institute was involved in the entire life cycle of some products and product groups as well as in the career of people who planned, sold or used them. With the user of the product in the focal point of our research, we have been able to study the success (or failure) of different approaches and to analyze the reasons. During this time period, some vendors, once very successful, have been scrapped from the order books. Worst of all, some industries, believed to become forerunners of an era, vanished after a short performance while ambitious mega-projects were silently put to rest (e.g. "Fifth Generation of Computers").

Others who looked like losers long ago, are still there and still going strong with the daily newspaper and the printed book being the best known. They were believed doomed at the end of the 70s because electronic media (e.g. videotext, computer generated text) were believed to replace them. Today, after an unbelievably fast and impressive progress in all crucial technologies, print media even go stronger than their would-be successors. Word processors, sure winners of the 70s, passed away while the corresponding product of a small company of those days has not only filled the gap but also created a much bigger market. From the fate of winners and losers, one can learn a lot about the importance of UPQ, feedback and learning.

Why some software companies flourish while others have ceased to exist?

In the middle of the 70s, computers grew smaller and small enough to fit into a room of a secretary. The era of "text systems" or "word processors" had begun. These were downsized computers, specialized to edit and print text. The main information their vendors perceived from the outside world was that these systems would prosper and outperform data processing computers by means of business by the end of that decade. Since the sources, well-known consultancy companies, were reliable, the vendors closed their eyes and ears in order not to see and hear the users´ problems. They believed that establishing a new technology needs some time where

you have to break the resistance of the conservative. The opinion of the market leader was very radical: "With … we have turned your arm to your back; with word processors, we will break your arm!" A market leader in another area, in the energy sector, made heavy investments to get his share of the future wealth. One of the biggest carmakers of the world invested heavily in a company specialized in office machinery to be prepared for the challenges of a new era. All believed in the "usefulness" of the technology and expected very bright prospects in near future. But they had less than a snowball's chance in hell.

Unfortunate for their vendors, the final days of the decade were not the heyday of that technology. Instead, no-name vendors entered the market under loud laughter of the established companies, and conquered it! These were producers of text processing software designed to be operated on a new kind of computers the name of which was still to be found (the name PC was coined at the beginning of the 80s). The reason for the laughter was that the products of the newcomers were somewhat inadequate with respect to the quality criteria believed to be decisive: Best in typing and editing text. The reason for the victory of the newcomers, at least from our point of view, is that they were fair to good in text editing but decisively better in communication: Until the end of the 80s, word processors had no adequate means for communication (stand-alone) while PC-vendors consequently strived for better communication. In addition, they have either known the needs of users or tried to learn from their market: 15 years ago, MS Word was a lousy text editing program like dozens of similar products. In the year 1998, all winners of the 70s and 80s are either gone or have become insignificant while MS Word has progressed to something like a world standard since it is believed to offer the best means for text interchange. Dedicated machines for word processing have gone long ago, so did their vendors regardless of the available financial means.

The advent of the year 2000 may display another view: If the reason of writing and editing text is communication, some other already existing systems are much better and cheaper. Thus, the hegemony of one product may change significantly within a very short time period: Most existing WORD-installations cannot publish text in the Internet directly without modifications, but the Internet is the ultimate stage for communication. In addition: Internet is believed to be something for world-wide-communication, but one can also improve the electronic communication from one room to the next by using it! These aspects may indicate a sudden decline of the importance of the product.

However, the newest versions of MS Word can be used to create WEB-pages directly. Although many people claim the vendor would not care about their needs there are indications that the opposite may be true in many respects. A comparison of the first version of MS Word with the plans for WORD 2000 may reveal that the vendor carefully studies software-ergonomic lessons as well as users´ attitudes.

Another vendor who had major influence on "information technology" of the past ("Copy and Paste"), Xerox, was less fortunate although this vendor has managed the "quantum leap" in information technology by introducing the graphical interface. Xerox could have become a monopolist in computer technology like the company was in its original business for 15 years. However, the relevant people in the company did not detect that users did not perceive the quality they offered. The case of Xerox was different from that of vendors who once had believed in word processors: The technology offered by this company was much better than people expected; possibly even better than what they needed at the beginning of the 80s.

Lessons learned: Billions of dollars of seed money have not been as effective as listening to the users and their quality criteria. User perceived quality should have been the magic focus of view. Those who dared another view in the past, mostly work in other businesses now. The same fate may await those who don´t know the causes of their success.

Computer Based Training and its predecessors

Computer based training or "CBT" represents the new name of an old dream: Replace the old-fashioned human teacher by a machine which is not only better, but much, much better! In 1965, the parliament in Berlin was convinced that ten years later about 90% of teaching in schools would be performed by machines! The first rise of the technology was in the 70s where people tried to put ideas from Skinner and Thursthone into machines which should replace human teachers and trainers. The failure towards the end of the decade was due to insufficient technology: To create an informative chart would take one or two days, and, to create a two-hour lesson would require about 60 charts, i.e. 120 days of work! Such problems are no more valid; if an author has adequate data, each chart can be created, printed and fit into a program within minutes. And within two days one can create very informative animations. What now?

Still, the question is whether you can replace a human trainer by "CBT". Without a feedback system which analyses the past, one would tend to say "No" because the reasons of failure are not perceived by the responsible instances. In addition, successful projects from the 70s are readily forgotten, if ever reported and perceived, since failures were more often. There is no objective analysis of the fate of CBT-projects of the 70s because all relevant vendors are gone and experts were and still are disappointed. Survivors resp. their successors are not interested in further analyses because this would unveil their former goals which did not really focus on learning methods but rather on selling the infrastructure (e.g. computers, projectors, CD-players) or the materials (tapes, films etc.).

Knowing about a failure is not sufficient for learning from it. If the feedback system does not differentiate adequately, one would tend to reject the whole approach, because in case of former failure the possibilities of success in the future tend to be underestimated. The opposite may happen in case of a success; the entire product is considered to be successful, negative features are readily overlooked. Sometimes, while planning the successor of a product designers even remove useful features and introduce costly and useless properties: Without knowing the real reason, the relevant features of the product or service, the next product may easily become a failure or even an expensive disaster. The year 1998 is still not the heyday of CBT! It is not analyzed why.

And the (in)famous TV-remote control

From the yellow press to scientific journals, a certain technical product, the remote control of TV-sets, managed to become the first-class example and proof for the plague nicknamed "modern technology", a new icon representing just the opposite of usability. Is the picture true?

If the answer is YES, we still do not know why, when and where! A thorough analysis will show a differentiating picture, e.g., some devices will fail everywhere while some fail in certain countries; not because of their own technical properties but because of their unusable manual. Other products may be accepted by some user populations but rejected by others, e.g. because the unit is labelled in English while the manual uses the language of the user. One can also find TV-remote controls which fail because of the software of the TV-set to which they belong to while the same device may be acceptable with another TV-set. Last not least, some manuals are not comprehensible because they serve explaining a technical device with some odd features.

How could a programmer of a TV-remote control learn which feature of her or his product was a hit and which one a failure without a proper analysis? How can a vendor decide what to do, a new device, an improved manual or better guidance of the user?

Lesson learned: Neither the success nor the failure of a product tells the whole story the designer of it or of its successors need to hear.

On products that hit the needs as planned

A success story and a mixed blessing

Without doubt, there are various products that hit the needs of their users, however, it is mostly unknown whether with the first shot. Thomas Alva Edison, famous as an inventor, gives us some examples on how to work to be successful: Long before he had invented the "phonograph", he had outlined in his notebook for which purpose his invention will be used. A close look at his way of working reveals that he was not the typical inventor but a very creative product planner, too. More than 100 years later, his invention is still used as intended: for communication between "boss and secretary". Attempts of others to utilize the device for mass communication between typists and the rest of the company, however, have widely failed in the long run regardless of the money the vendors spent for "market research". We have been able to find the main reasons (Çakir et al, 1983).

The intention of Edison was to facilitate the communication between two persons in a certain part of their cooperative work: Creating text. The "dictator" should be free from being paced by the typing speed of his secretary while speaking and the secretary should be enabled to type in a different pace than the boss speaks. In the intended environment, after more than a century, the technology does still work as planned. However, it is not applicable if the "dictators" are no bosses but simple employees who work in shared space and do not have own secretaries. The reason we found was that dictating machines offered an unbelievably bad acoustic quality which was opposite to what people expect from work tools in addition to the acoustic quality of work environment which does not allow proper recordings. In addition, "bosses" are often persons who are either talented or trained in verbal communication while most office employees do not need to be proficient in verbal communication in order to be successful in their jobs. The direct outcome for the typists is that they turn the device louder because a higher volume suggests better hearing. The opposite is true, spoken language becomes less intelligible beyond 80 dB(A) speech level. A better acoustic quality of the device would help to a great extent, but nobody seems to care since indicators for problems we detected at the end of the 70s can be found in the literature between 1900 and 1920!

Having an own secretary would also help to some extent because a person well-acquainted with the specific work is able to understand spoken words even under bad acoustical conditions. But organizations denied that there was a need for personal secretaries. In the contrary, they planned to utilize dictation machines as an aid for getting rid of personal secretaries.

Thus, organizations tried to separate the jobs of secretaries into "typing" and other activities, and typists were put into shared space where the noise of typewriters reached a level around 80 dB(A), a noise level under which verbal communication is barely possible. No health and safety expert has ever calculated the necessary speech level at the ear of a typist to hear properly under an environmental noise level of 80 dB(A). Ideally, a difference of about 30 dB(A) between signal and ambient sound level is needed for best intelligibility. This means, a typist working 8 hours with a dictation machine would be exposed to an approximate average level of 110 dB(A) if she chooses the ideal difference. Most machines we found on the market were able to exceed even this high level, with some of them reaching sound levels comparable to jet engines. The measurement of the preferred sound level in work environments showed that typists adjust their devices to levels up to 96 dB(A). Acousticians had never measured the sound levels of head-sets typists used. When some of them were presented the data, they claimed the measurements must have been wrong since it was impossible to achieve such high sound levels with office equipment. However, one could have calculated the approximate values for the levels using nothing more than the data from the manufacturer´s product specification and a ruler for measuring the size of the opening of the earphone.

Under sound levels beyond 80 dB(A), speech is less intelligible than needed for typing text correctly even using studio equipment. Typists who type text, however, are required to have less then one error per page, i.e. an error rate of less than 0.05%. How have they been able to match this? To answer such a question, one would need a report and analyzing system, established sometime at the beginning of our century. It would have helped finding problems and solutions. Since nobody was ever interested in spending time and money for this purpose, the technology failed before the advent of new technologies for text editing which cause much less ambient noise. Even if this system would not have helped saving classical dictation equipment from near-extinction modern voice input facilities for computers would have benefited.

The failure had many mothers and fathers, but Edison was not among them. His product is still successful under the organizational and environmental conditions he had assumed or anticipated. People who have tried to introduce it as the sole means for communication between the "creators of spoken word" - to avoid the term dictator - and the typists were less efficient.

Grandfather survives grandchild - Telex and Teletex

Telex, a communication medium from the beginning of the century, was planned to be a robust and reliable tool which should function even under unfavorable conditions. It still does, although considered outdated since the 80s. While much newer systems (e.g. Telefax) do not even guarantee to transport any part of a message (cf. business conditions of Telecom companies in different countries) Telex reliably conveys the message and even the correct address of the sender. A certain operational mode of Telex (8-bit reflected copy) guarantees the correct receipt of each single character sent. The user of Telex can send a recorded text or choose to call a person to the receiving station and conduct an interactive communication. The system has fulfilled all expectations and serves even purposes for which it has not been planned for, e.g., military versions of Telex can be deployed and used anywhere where paratroopers may be able to operate.

About half a century after the invention of Telex, Teletex was created. It should replace Telex not only in the areas where the predecessor was used, but should also conquer all offices. The Teletex system was hoped to represent the backbone of "Office Communication", an idea once believed to be much better than the "Office Automation". The transmission was 50 times faster than Telex and was able to transport a much bigger character set covering all languages using Latin alphabet.

Today, one still can send messages via Telegraphy, Telex is still there and operable, however, Teletex was abandoned in 1993. There are many reasons for the failure, but the most likely reason is that the banks have boycotted the system because it was claimed to fulfill all quality criteria for safe communication but the banks believed it did not. In difference to the Telex system where a central computer controlled the authenticity of the sender, the Teletex computer was considered vulnerably to fraud. In addition, it did not allow direct communication. Thus, two crucial features of a system have been deleted in favor of a new system which offered more speed and a bigger character set. Neither US nor European banks, however, have asked for a higher communication speed at the expense of security. Thus, the creators of the new system had introduced features considered useful by them but not perceived by the users as such (no "fit for purpose").

In the case of Teletex, the designers of the system did not even make an attempt to set up something like a "Customer Data Table". Upcoming criticism from user organizations was tried to drown under piles of PR-brochures. The outcome is that almost nobody has ever noticed that Teletex does no more exist. The vendors who had relied on Teletex, among them two German companies with a long tradition of building office machinery, have lost their existence long before the system was put to rest.

It can be claimed that Teletex would have never been introduced with its characteristic features if there was a system analyzing the reasons for the ongoing success of Telex in the intended use even after 50 years, and, in addition, the reasons for the lack of success in the rest of business world.

Whether or not a text based system would ever be able to compete with a "rich" communication a' la Internet is questionable and is worth discussing.

A success story for lending an ear to the customer

When in the early 60s the German carrier Lufthansa ordered a specific airliner the plane was something unusual but not an outstanding design as it is considered in our days. Unlike other US jet transports, the Boeing 737, originated with an order from a foreign customer (Varley, 1978) whose ideas did not really fit into the "American" way of thinking: It should serve short distance flights in Europe for which jets were not considered to be the right answer. To keep costs low, the design was adopted so that maximum use could be made of Boeing 727 tooling and components; a plane which reflected the real world of the makers. Now, 31 years after the introduction, the maker´s dream, 727, is outdated while the customer´s dream has advanced to an outstanding success of aviation industry: Boeing 737 has become by far the most important non-military jet airliner in aviation history the success of which has not even started to decline after three decades of existence.

In this case, there was not a classical report system which conveyed the relevant information from the use of a product to the manufacturer. Instead, its role was played by a certain network of interests between manufacturers and customers which is unique to aviation business. Some other businesses have even a more powerful communication network, e.g., suppliers for the tobacco industry never design a new machine without extensive discussions with the customers. In the same time, some other industries never lend an ear to the customer, e.g., TV-stations or studios as users of the most sophisticated and expensive video and audio equipment do not even dream of being able to persuade their major supplier to introduce small changes in the design of the equipment. Instead, they wait for someone else to hear their message, the computer industry.

A success story for a report system

The history of another product of which we have been able to analyze the first half and influence the second shows that the success story à la Edison is rather seldom. The product was a printing unit designed using the cumulated knowledge from the construction and practical use of its predecessor which was extremely successful. The vendor has recorded and evaluated all relevant indicators for quality from the first design step until the prototyping of the successor which was planned to become superior to anything comparable.

Even in such a fortunate case, the utilization of a report and analysis system had enabled the designers to improve the product drastically after its market introduction. However, this system processed only data concerning engineering issues with usability aspects treated as facets of minor importance. In the prototype stage of the second version of the product, we were able to simulate the input such a similar system would have induced on the usability or ergonomics if the manufacturer had installed it during the first half of the life cycle. The analysis lead to 35 major changes for an almost production ready prototype out of which the manufacturer accepted 33 and rejected only two for cost reasons. This means, even successful products may benefit from an analysis and report system, and even after this process ergonomic evaluation may add substantial benefits to the design. A close look at table 1 may disclose the extent of the changes introduced after the designers had believed that their product was "production-ready".

Table 1: Problems detected with the help of a simulated report and analysis system based on user centred quality criteria

Problem area	Problems and solutions
Dimensioning of unit and parts	Intended user population was not defined. The final product, dimensioned as the prototype would impair about 60% of users in the target markets. Relevant dimensions were changed to fit the intended user population.
	Space needed for proper operation was unnecessarily high. It was reduced by 50% from 16 m2 to 8 m2 without any loss in usability.
	Intended design required lifting weights in undue posture (possibly not permissible for females, strenuous for males). It was changed to accommodate the entire working population.
Controls and displays	Sufficient training of all users before starting the use could not be assured: Controls were reshaped and coded to facilitate learning.
	User had to remember the settings: Controls were reshaped to indicate actual settings.
	Displays were dimensioned and adjusted to fit a male person of Northern European origin: Displays were made adjustable to be visible by all hypothetical users
	User had to know which controls were not allowed to use: Controls for self-service were color-coded to distinguish from others.
User control	User had to know the actual status of each single device: Indicators were introduced for all relevant devices to easily recognize the actual state of the device.
	User did not get sufficient information to plan actions: Predictive displays were introduced for recognizing possible need for assistance.
	Maintenance personnel had too long response times: Helps for self-diagnosis were introduced.

The manufacturer of the product discussed here had utilized a powerful report and analysis system which had covered all of the phases of product development and production and feedback channels from the field of use. This system has helped avoiding various problems, however, it did not analyze whether the causes of problems and the reasons for not having problems were of ergonomic origin, i.e. usability related, hence the possibility of finding 35 important changes in a production-ready prototype. In some respect, their system did not even convey important information since nobody has ever asked for it: E.g., the designers believed that the users were male persons only but at least the half of the users were likely to be female. Without any reflection on the users in the intended market, they had dimensioned the product for a tall male person of Northern European origin whom they expected to be the likely user also in areas like California where a considerable proportion of possible users is of Mexican or Asian origin. Such

people had similar problems like users in Japan experienced. However, the information did not reach the designers.

What should a report system cover

Collecting and conveying information from different countries is very expensive and almost useless if the vendor does not know in advance why a certain type of information should be obtained. To determine which information should be collected, Ishikawa Diagrams are very useful although their main application area is manufacturing, a stage in the product life cycle where the desired product features are already known. However, the model can easily be applied to ergonomic questions. In our case, we used the following diagram (fig. 10). The "Quality Problem" was derived from the intention of the vendor to sell the product worldwide but to reduce the need for maintenance since the number of units sold in different countries was small making the shortest possible response time too long for a customer. The whole rest of the aspects mentioned in the diagram were treated as dependent variables for which the adequate features were determined as far as possible. This process followed the four-stage model of "systems ergonomics" where a given task, the mission of the system, is processed by a system of humans and machines. After determining the task, functions are assigned to humans, machines and to human-machine interaction. Tasks assigned to machines need to be accomplished without human interference while interactive tasks are the source of the requirements for the human-machine interface which consists of hard- and software.

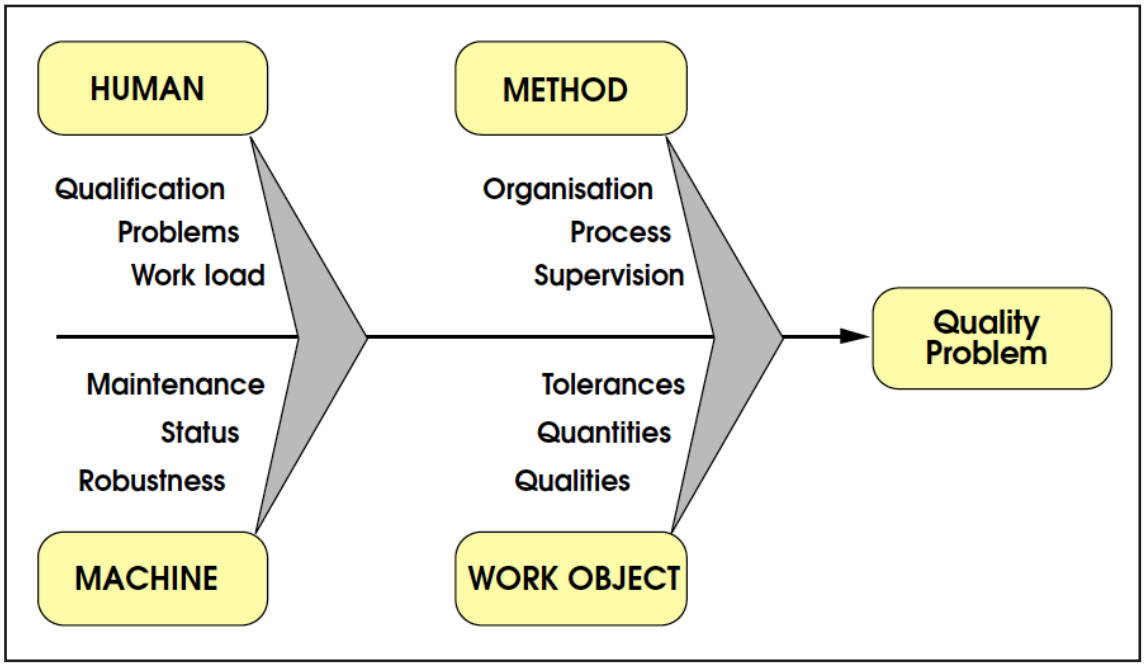


Fig. 10. Fish bone diagram for the evaluation of causes and effects on the overall quality of an entity. For a real world product, some parameters are treated as invariable (e.g. the qualification of an unknown user) while others are controlled to achieve the desired quality level (e.g. maintenance).

To learn whether the "Customer Data Table" for a product was sufficient and where it was successful or not, for the analyzed incidents at least the importance of hard- and software but also the context of use, e.g. environmental conditions and important characteristics of the users need to be known. In addition, one needs data which allow a reliable judgement on to which extent product features (objective quality) match user perceived quality (UPQ) in the specific area.

In case of insufficient match, the data obtained should allow a higher level analysis, e.g. whether the assignment of functions to persons and to technical equipment was adequate. In the worst case, an analysis of the whole mission may be necessary if the product fails. This is the case of a product with a birth defect (s. figure 9).

The adequacy of the obtained data does not guarantee the success of the system which depends on correct routing the information to the instance which can take efficient steps to improve the product. Thus, the report system must include information on how to route the obtained data.

The existing international report systems may help to establish own means for feedback systems as models covering a certain proportion of the problem area. The important difference of a system for everyday products to existing systems is that the latter convey "negative" information while feedback on everyday products should cover the "positive" information, too. Report systems do not necessarily convey cause analyses of the incidences reported. A useful system for everyday products must focus on analyzing data considering multiple causes for failure or success of a product. Report systems mostly report to the top level of organization or authority whereas a useful tool for "normal" products should deliver the information where it may have the biggest impact.

Why should we spend resources on report systems?

Our analyses of many technical systems from the "phonograph" to "Teletex" and "CBT", but also of specific products, e.g. certain brands of computer terminals, revealed that even spectacularly successful entities have not been properly analyzed for the causes of their acceptance. Nor did people sufficiently analyze the failure of systems with once brightest prospects, e.g., why the "grandfather" of Teletex, Telex, survived its grandchild. People who had invested in print media felt very uncomfortable during the advent of "new technologies" because they did not know the reason for the success of their old technology, and that paper-based media were not in danger of becoming extinct. Others, who did not believe in the mighty power of UPQ invested billions of dollars and all their hopes into technologies with birth defects, e.g. in Teletex. Report systems and additional means for adequate analyses of the data they obtain represent powerful tools conveying the message from the users to the makers. Regardless of its sign, the message may be decisive for survival and prosperity.

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