

# A COMMUNICATION AUDIT FOR ENGINEERING DESIGN

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## 1 Introduction

This paper contends that many problems in engineering design are the result of poor communication and that at the same time poor communication can be an indication of other problems. This statement stems from an extensive literature search and is grounded in empirical evidence. The authors argue that a careful assessment is needed to separate out whether communication is the cause of a problem, the problem itself or symptomatic of a problem in the engineering design process.

In order to distinguish between symptoms, problems and their root causes, a communication audit is necessary. At its most basic, an audit is an evaluation of a designated process [Hargie & Tourish, 2000a]. The practice of auditing is most commonly associated with assessing an organisation's financial health. Its use has since been applied for example to business, human resources, organisational communication and education [Odiorne, 1954; Goldhaber, 1983; Emanuel, 1985; Booth, 1986; Hargie & Tourish, 2000b]. An audit is a means to analyse, measure and assess communication practices. The audit tool under development is essentially a set of methods, a toolbox, with which design managers can systematically analyse the state of communication in their company.

Before the appropriate methods are chosen, a conceptual framework has to be created with which factors influencing communication and their interrelationships can be understood. This paper focuses on the key aspects which have to be considered in constructing a conceptual framework for a communication audit. Based on this framework, an audit tool will be constructed. By developing a communication audit for design the researcher aims to improve the effectiveness of engineering design communication by deepening the understanding of the complex processes underlying communication. Effectiveness is defined as the mutual fit of communication requirements and capabilities.

The remainder of this paper is structured into five parts. Section two outlines the problem situation. Section three justifies why a communication audit for engineering design is necessary. Section four sketches the envisaged end product/service. Finally, section five discusses key aspects which need to be considered in constructing an audit.

## 2 Problem situation

Communication is defined as the social and cognitive process by which messages are exchanged between interacting partners and meaning is created. It applies to almost every communication environment and circumstance, from the most basic two-person verbal exchange to the most complex network involving hundreds or thousands of people. Communication has different directions such as top-down from manager to design engineer, bottom-up or in-between. It can be formal or informal. It can happen at the same time - synchronously - or at different times - asynchronously. Transmitted information can take many different forms, for example verbal, written or pictorial - and designers often communicate with reference to objects [Eckert & Boujut, 2003].

With a multi-faceted phenomenon like communication it is often impossible to fully understand what bears on it [Eckert et al., 2004]. The theoretical framework behind the author's understanding of communication is systemic. Communication is influenced by many factors which we group under the headings: environmental, organisational, team, and personal (Figure 1). Environmental factors are considered to be outside the organisational system. Organisational factors are beyond the direct control of a project manager but are within the control of the organisation.

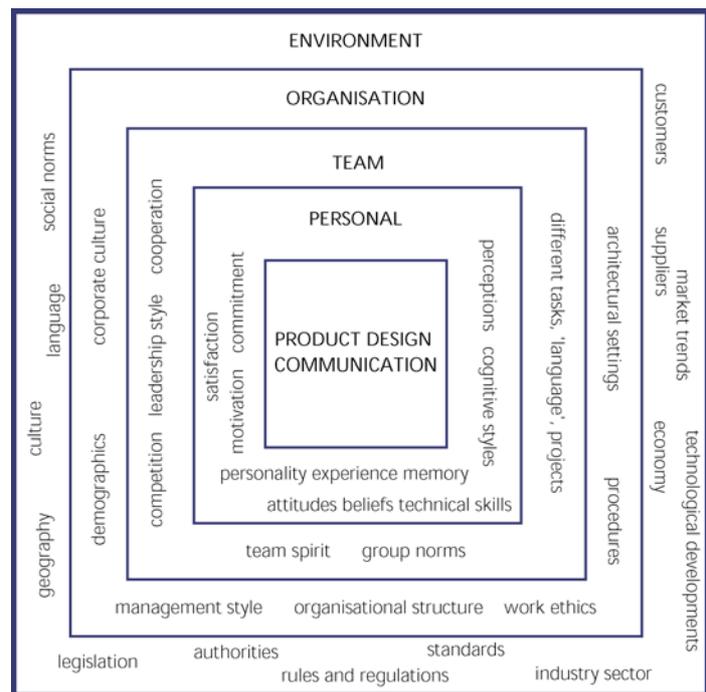


Figure 1:  
Factors influencing product design communication, adapted from Whyte (1968) and Moray (2000).

The graphic model suggests that factors within the various layers directly or indirectly influence communication patterns. How these factors interact is not easy to understand. There are many possible different communication situations. The complexity of possible situations confronting the manager is apparent. It is easily to be imagined that managers might have difficulty coping with understanding and the management of communication throughout the product development process.

Do problems emerge from the synergistic impact of the broad layers of influence on one another? In other words, do problems arise from one factor or from two or more simultaneously? Communication problems stem probably from a network of causes and effects. As a result, it is difficult for engineering design researchers to propose specific strategies and to advise designers and design managers what decisions to make and what to do. However, theoretical frameworks and tools can be constructed to help in understanding, analysing and assessing the dynamics of communication processes. One has to bear in mind that one situation is not like any other and one solution does not fit to all occurring problems.

### 3 Need for a communication audit in engineering design

#### 3.1 Industrial demand for a systematic analysis of communication processes

An exploratory study at an aerospace system and component supplier in the UK highlighted the need for a systematic analysis and assessment of specific and generic communication patterns throughout the product development process. The company is particularly interested in communication at interfaces, such as between engineering and manufacturing, mechanical and electrical development teams, and between the firm and its suppliers and customers.

#### 3.2 Communication as critical success factor in design

In a concurrent product development environment where product- and process engineering runs in parallel, adequate information flows and efficient communication is necessary. For example, parts having to be reworked and changes of design processes can be avoided which often offset potential gains from concurrent engineering [Clark & Fujimoto, 1991].

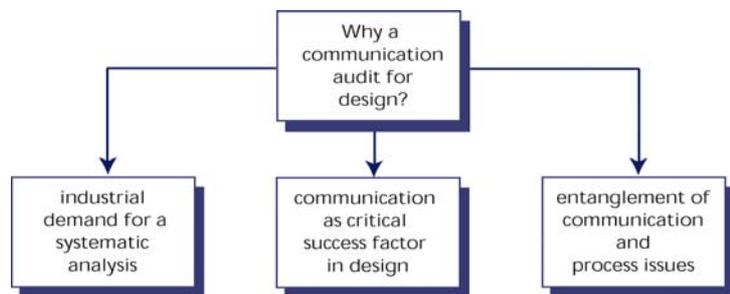


Figure 2: Why a communication audit for design?

Efficient communication is important because it provides context, raises awareness, elicits needs of individual stakeholders involved, and binds all activities and design tasks together. In other words, communication is needed to create a ‘*Sinnzusammenhang*’ [Luhmann, 1987], i.e. to make sense of how the individual entities of the whole product development process form a whole.

Pioneering work on the role of effective communication in product development processes has been done by Allen since the early 1970s [Allen, 1977]. Research findings clearly indicate that improved communication brings significant organisational benefits, such as higher performance and motivation of staff, improved productivity, higher quality of services and products, increased innovation and reduced costs [Clampitt & Downs, 1993].

Communication has been identified as a major determinant for project success or failure. Hales (2000), concerned with error-proofing and failure analysis, identified communication as one of ten success factors in engineering design. Similarly, Chao and Ishii (2003) performing a Failure Mode and Effect Analysis (FMEA) throughout the product development process concluded that communication is one of the categories for failure - and is the biggest concern.

#### 3.3 Entanglement of communication and design process issues

If hundreds of individuals are concurrently working on a complex product - sometimes only ‘virtually collaborating’ from geographically dispersed locations – mistakes are likely to occur. Some of these mistakes will be attributed to the human factor [Sanders & McCormick, 1992], under which communication is subsumed. Yet, it is most likely that many errors and mistakes have multiple causes and it is the impression of the authors that communication is sometimes used as an umbrella term for non-tangible and non-identifiable causes. It is often

not immediately clear whether communication is symptomatic of a problem or whether communication is the problem or even the cause of a problem.

Communication has the ability to make problems visible and audible as well as stop problems from occurring. It can function as a 'safety net'. This does, however, not necessarily mean that something happened due to the lack of or the overflow of information and poor communication. Hence, the intention of a communication audit for design is to carefully separate out what problems or issues are due to poor communication and what is for example rather an attribute of deficient planning [Eckert & Clarkson, 2004] or personal factors than a communication problem itself.

A number of communication audits for organisational communication exist (for an overview see Sampson, 2004). Most notably the communication audit by the International Communication Association (ICA) [Goldhaber, 1979 and 1983]. The intention was to report on the status of communication within the company. It is, however, not designed to differentiate between a symptom, a problem, and potential causes. Furthermore, it is not tailored specifically to engineering design firms. Hence, specific engineering design problems are not taken into consideration. The research presented here aims to address these limitations.

## 4 The envisaged communication audit for engineering design ...

### 4.1 ... is functional for ...applicable to... usable by...

... is functional for analysing and assessing current communication patterns in an organisation. The aim of the proposed communication audit is to produce a clearer understanding of how well and efficient communication works, why it works the way it does and how it can be improved. The communication audit helps in identifying communication symptoms of discontent which can turn into communication problems [Hargie & Tourish, 2000a] and furthermore, it is a means to find the root causes of communication problems. The audit is not meant to assess individual performance. It has a wider target audience.

... is applicable to engineering design firms across different industry sectors. The difficulty lies in striking the balance between universal applicability and customisation to the needs of the individual company.

... is usable by design managers, team leaders and individual designers. A communication audit, as a set of methods, suitable for industrial application should be easy to use. Easy in this sense refers not only to the straightforward construction of topics and methods but also to the resources (money, people-time) it would potentially demand. It should take into account that daily routine business will most likely have priority.

### 4.2 ... consists of 'building blocks' with topics, levels and methods.

Communication needs and preferences, communication networks, channels and tools of information transmission, and representations are possible topics on which this research will focus. The rationale behind the choice of these potential focus areas is as follows:

As Eckert et al. (2004) have shown, typical communication scenarios in design are 'handover', 'joint-designing', and 'interface negotiation'. During the execution of these activities, the most frequent communication breakdowns happen because of a lack of overview, because

information about the information provision is missing, information is distorted, and misinterpreted or misunderstood [see also Eckert et al. 2001]. Taking the communication situations and the causes for breakdowns into consideration, it is firstly important that communication needs and preferences are clear and elicited, i.e. that all communicators know what, when, how and why information has to be transmitted. Secondly, it is essential that communication networks are functioning according to the required information flow of the respective design task and project. Thirdly, it has to be ensured that channels of communication and tools for information transmission are used appropriately. Lastly, it is necessary to understand why and how certain types of representations are used. The influencing factors shown in Figure 1 act as drivers. How they interact and what 'causal loops' they form will be the subject of further work.

Some aspects of communication can be addressed and analysed directly. For example, it is beneficial to explicitly enquire who is communicating with whom about what, when, how often and why in order to draw a picture about the communication networks and to find out who functions as a 'hub' or is an 'isolate' etc. Likewise, looking at the channels of communication and the usage of communication tools leads to concrete results. However, issues, such as communication needs and preferences, and the usage and understanding of representations are possible focus areas which need to be addressed indirectly in order to gain insight and draw conclusions.

The levels of analysis envisaged for this research are: intra-team, inter-teams, inter-departments and possibly inter-firms. The first two levels are believed to be the most important to examine. Once individual designers and teams have understood the dynamics of communication, it might sharpen their awareness on a higher level.

Methods by which facts are gathered will be a selection or combination of in-depth interviews, focus groups, observations and surveys. There is not solely just one 'right' method for auditing communication. Each method has its strengths and limitations, and each organisation has its own unique needs and problems. Which methods will be applied for what topics and levels has to be confirmed in future work.

The communication audit is envisaged as 'modular system'. Individual blocks can be selected according to the wishes of the company. For example, the subject communication networks can be analysed on the inter-departmental level, or understanding and use of representations on the intra-team level. It is envisaged that people in decision-making positions in a company could select 'building blocks' based upon which the detailed steps of an audit can be planned. What needs to be finalised are the different focus areas, the level structure and the methods to be used. This will eventually be visualised in a kind of grid or matrix system.

After an audit has been conducted and facts analysed, recommendations and guidelines on how to improve communication will be

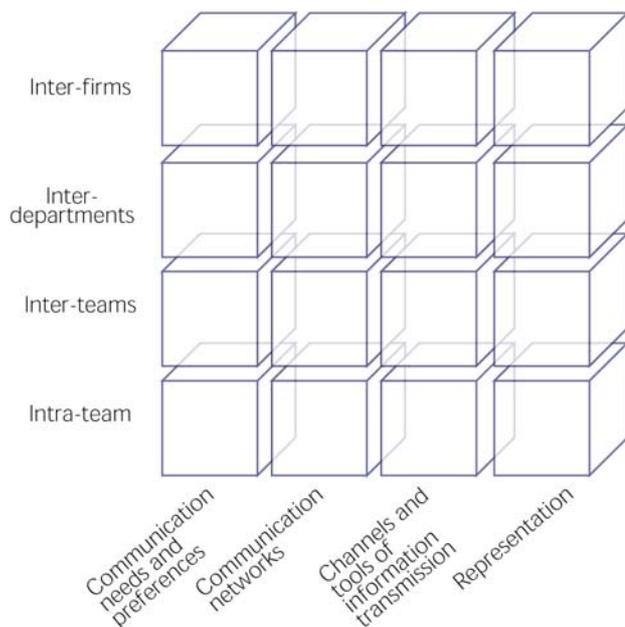


Figure 3:  
'Building blocks' of a communication audit

suggested. Recommendations, if implemented, can result in structural changes in the organisation. A communication audit can result in quick fixes for minor changes, however, communication patterns do not change over night. It is most likely that ‘true’ benefits can only be seen from a long-term perspective.

## 5 Key aspects to consider in constructing a communication audit for engineering design

### 5.1 The research process

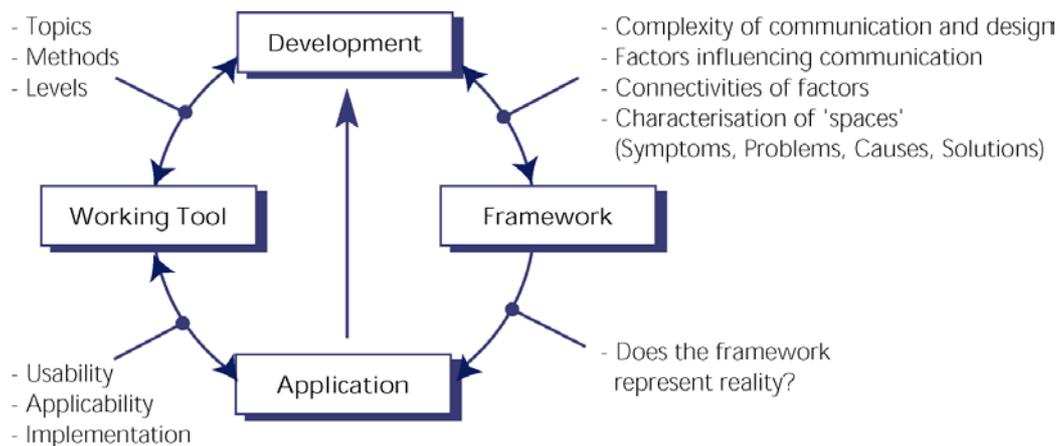


Figure 4: The process of constructing an audit

In order to construct a communication audit for engineering design there are a lot of aspects which have to be considered before the actual end-product – the audit tool – can be realised. The construction process will iteratively proceed from development of the theoretical framework, over applying the framework to developing the working tool and to development of the working tool to application in industrial settings. Between each step there are pertinent issues which have to be addressed (see Figure 4). This section concentrates on the development of the conceptual framework. For the envisaged audit tool, please refer to the previous section.

### 5.2 The theoretical framework

In order to tailor a communication audit to engineering design, one has to understand the nature of designing, the complexity of the design process and the potential problem areas. The complexity arises out of the interactions between the product, the process, the designer and the user [Earl et al., 2004].

As already outlined in section two, communication is influenced by many factors. Relationships between these factors can be dynamic, i.e. change over time. This can lead to predictable as well as unpredictable patterns. To identify patterns, possible linkages and behaviour of the elements in connection have to be identified. In case of communication practices, it would be helpful to understand which influencing factors react in what way under changing circumstances and which factors are the 'control factors'. This might lead to the detection of the root cause(s) of a problem.

The detection of interactions of parts within a system is, however, merely a first step. The main issue is to see what we can learn from interactions, i.e. what do they tell us about the function of the product and the process and in this context, about the arising and emerging communication patterns.

To separate out whether communication is the cause of a problem, the problem itself or symptomatic of a problem in the engineering design process the different 'spaces' - the 'problem space', 'symptoms space', 'cause space' and 'solution space'- have to be characterised. Key recurring problems will be selected based on the estimated severity of impact and frequency of occurrence. Estimation by experienced designers will be taken as guiding principles. Furthermore, potential root causes and solutions need to be listed.

## 6 Conclusion

This paper has argued that a systematic analysis and assessment of communication patterns throughout the engineering design process, in the form of a communication audit, supports and leads to the improvement of the design process. What is meant by conducting a communication audit and what has to be taken into consideration in order to develop a communication audit for engineering design has been outlined. In the near future, emphasis will be put on constructing the theoretical framework which lies underneath the toolbox.

It should be noted that communication problems can be detected, managed but not fully eliminated. They are pertinent to human activities, such as communication and design. The point being that problems need solving but one needs to go beyond fixing them to establish a communication environment which avoids recurrence of problems and builds upon existing strengths.

The idealistic but meritable aim of this research is to increase awareness and understanding of communication for engineering design so that eventually communication will be treated with the same diligence as financial issues before a project starts. Thus, as Jones (2002) puts it: *"...a communication audit would not be a snapshot in time but an ongoing reflexive learning process within the company."*

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