STABU LexiCon

Diffusion and adaptation of a new information standard

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"Life is a lesson; you learn it when you're through." Limp Bizkit

Preface

This report is the final result my activities the last several months. After spending a period from March until August at the STABU foundation office in Ede, I finished my graduation thesis at home. I had a good time in Ede and wish to thank everybody who made that possible, especially Mr van Hezik for giving me the opportunity, Mr. Teitsma and Mr. van Rees for their support and guidance and off course Mr. Udink for providing lunch.

Next I need to say thanks to Mr. Wassenaar and Mr. Tijhuis for guiding me and helping me with new ideas and different insights. For input thanks go to all who have taken the time to meet and speak to me. And a special thanks to Mr. Looijenga, Mr. Bonsma, Mr. Woestenenk and Mr. Veenbaas who in addition to Mr van Hezik, Mr. Teitsma and Mr. van Rees attended the expert panel meeting.

Very special thanks must go to my girlfriend Dieudonné, for supporting me through most of my student life and nudging me (with different amounts of strength) in the right direction. Last but not least thanks go to all those who supported me and/or believed in me.

Jasper Feenstra

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Abstract

The digitalisation of our society has taken big leaps forward in the last decades, the growth of online shopping, discussion platforms is enormous and much more examples can be given. In the building and construction industry (B&C industry) this growth seems to be less enthusiastic. Slow adoption of innovation and separate development of innovations for use in different stages of the building process, have created islands of automation. To create a bridge between these islands, STABU has developed the LexiCon. This is an information standard to create uniform object libraries that can be applied throughout the B&C industry.

The next challenge is to put the LexiCon to use, in other words to diffuse the innovation and get industry wide adoption. The problem definition of this research is:
In what way can STABU foundation stimulate the diffusion and adoption of the LexiCon?
In order to answer this problem the terms diffusion and adoption are unravelled through literature and internet research. It appears that innovations have several aspects that influence the diffusion and adoption process, they can be categorised into; relative advantage, compatibility, complexity, trailabilty and observability. Aspects of organisations potentially adopting innovations are concerned with organisation size, culture and industry type. Since diffusion is a process of communication, networks of communication are of importance as well as opinion leaders and critical mass. A threshold is a point where a person observes his personal network as having reached critical mass

A closer study of the B&C industry revealed a huge network of research institutes, knowledge platforms and sector organisations. The LexiCon is supposed to be of use for all sectors in the B&C industry, which means all potential users will have to agree upon the definitions set. This agreement is most useful amongst software developers, because they create the applications organisations will work with. It appears organisations in the B&C industry have no specific demands for an information standard other than that their standard practice does not have to be changed. Their search is for better more compatible software.

This research shows that in order to get the B&C industry to adopt new innovations, either a clear advantage will have to be visible or the use must be mandated. Creating applications with a clear enough advantage requires a lot of work, because the intended benefit of the LexiCon, being an industry wide standard, requires applications for different stages of the building process to be simultaneously LexiCon compatible. Mandating the use can be done by law, or by demanding it in the commissioning stage of the building project.

Closing this research are some recommendations regarding the next step in the developing of the LexiCon and a number of ideas for future research.

Samenvatting

De digitalisering van onze samenleving is de laatste decennia met grote sprongen gegaan, de groei van on-line shoppen en discussiegroepen is enorm en er zijn nog veel meer voorbeelden te bedenken. In de bouw wereld lijkt deze groei minder enthousiast te zijn. Terughoudendheid in de adoptie van innovaties en het feit dat voor elke fase van het bouwproces door andere partijen onderzoek wordt gedaan heeft geleid tot eiland automatisering. Om een brug te slaan tussen deze eilanden heeft STABU het LexiCon ontwikkeld. Deze informatie standaard kan gebruikt worden om objectenbibliotheken te maken die door de gehele bouw gebruikt kunnen worden.

De volgende uitdaging is om het LexiCon te implementeren, met andere woorden, het diffusie proces van de innovatie en het verkrijgen van bouwbrede toepassing (adoptie). De probleemdefinitie is:
Op welke manier kan STABU het diffusie- en adoptieproces van het LexiCon stimuleren.
Om dit probleem op te lossen worden eerst de termen diffusie adoptie en innovatie toegelicht middels literatuur en internet onderzoek. Het blijkt dat innovaties diverse aspecten hebben die de diffusie en adoptie ervan beïnvloeden. Deze kunnen ingedeeld worden in: relatief voordeel, compatibiliteit, complexiteit, probeerbaarheid en observeerbaarheid. Aspecten van organisaties die de diffusie van de innovatie en de adoptie van de organisaties beïnvloeden blijken verband te houden met de grootte van de organisatie, de industrie waarin hij opereert en diverse aspecten van de organisatiecultuur. Daar het diffusieproces een proces van communicatie is, zijn de communicatie netwerken van belang, want samen met de individuele adoptiedrempels kan de kritieke massa worden bereikt waarna diffusie meer vanzelf lijkt te gaan.

Nadere studie van de bouw onderzoekswereld heeft uitgewezen dat er een groot netwerk van onderzoeksinstituten, onderzoek programmerende instellingen en branchverenigingen is dat betrokken is bij de invoering van een standaard. Het LexiCon is bedoeld om in alle fasen van het bouwproces, van ontwerp tot sloop, inzetbaar te zijn. Dit houdt in dat alle betrokkenen het eens moeten zijn over de te gebruiken definities. Met name bij de software ontwerpers is dit belangrijk, daar zij de toepassingen maken waarmee de bouw gaat werken. Het blijkt dat de bouw geen specifieke eisen stelt aan een informatiestandaard, behalve dat deze toepasbaar moet zijn in de huidige omstandigheden. Gezocht wordt naar betere meer compatible software.

Dit onderzoek toont aan dat de bouw alleen innovaties implementeert als het voordeel meteen overduidelijk is, of als het van hogerhand wordt opgelegd. Om applicaties te ontwikkelen die een duidelijk zichtbaar voordeel opleveren, is integratie van diverse applicaties uit verschillende fasen van het bouwprocesnodig. Dit is een grote hoeveelheid werk. Anderzijds kan zoels gezegd het gebruik van het LexiCon opgelegd worden, hetzij bij wet hetzij als eis bij de aanbesteding dat er voor dit project met een bepaalde informatiestandaard gewerkt moet worden.

Tot besluit van dit onderzoek worden enkele aanbevelingen ten aanzien van de volgende stap in het ontwikkelen van het LexiCon.

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List of Abbreviations

(Abbreviations in Dutch are complemented by a translation in italic between brackets)

ACL   Algemene vereniging voor Centrale verwarming en Luchtbehandelingsindustrie (general association of central heating and air treatment industry)

ArtB   AdviesRaad voor Technologie in de bouw (council of advice for technology in the B&C industry)

AVBB   Algemeen verbond BouwBedrijf (general association of building industry)

AVOL   Algemene Vereniging van Ondernemers in het Loodgieters-, sanitair- en gasverwarmingsinstallatiebedrijf (general association of plumbing-, sanitary fitting-, and gas heating entrepreneurs)

BAM   Bataafsche Aannemings Maatschappij (large Dutch construction company

BAS   Bouw Afspraken Stelsel (building agreements system)

BIM   Bouw Informatie Model (building information model)

BNA   koninklijke maatschappij tot bevordering der bouwkunst Bond van Nederlandse Architecten (confederacy of Dutch architects)

CAD   Computer aided design

CCP   Communicatie Civiele Projecten (communication civil projects)

CROW   Centrum voor Regelgeving en Onderzoek in de Grond-, Water- en Wegenbouw en de Verkeerstechniek (centrum for policy making and research in earth, water and roadbuilding and traffic technology)

CUR   Civieltechnisch Centrum Uitvoering Research en Regelgeving (civil centre for the execution of research and policy)

EPIC   European Product Information Cooperation

HBG   Holland Beton Groep (former large Dutch construction company)

IAI   International Alliance for Interoperability

ICIS   International Construction Information Society

ICCI   Interministeriële Commissie voor Communicatie en Infrastructuur (interministerial committee for communication and infrastructure)

IFC   Industry Foundation Class

MVRO   Ministerie Volkshuisvesting en Ruimtelijke Ordening (ministry of public housing and environmental planning)

ONRI   Orde van Nederlandse Raadgevende Ingenieurs (order of Dutch consulting engineers)

PDF   Portable Document Format

RAW   Rationalisatie van Automatisering Grond-, weg- en waterbouw (rationalization and automation of ground, road and waterways)

SBR   Stichting BouwResearch (foundation of building research)

STABU   STAndaardbestek voor Burger- en Utiliteitsbouw (standard specification system for civilian commercial and industrial building)

UGCB   vereniging voor Uniforme Grondslagen en Coordinatie van informatievoorziening in het Bouwwezen (Uniform foundations and coordination of information in the building industry)

UNETO   UNie van ElecroTechnische Ondernemers (union of electro technical entrepreneurs)

1 Introduction and Research Design

1.1 Introduction

STABU foundation was founded mainly because the government saw the need for a uniform way of creating building specifications. There was a general provision regarding the building specifications, but it needed replacement. Furthermore there was a gap between the standard reference specifications for building and construction and the standard reference specifications for maintenance and home improvement, which needed filling. Moreover the coexistence of the two standards was deemed undesirable. Therefore it was decided to merge them into one specification system, the STABU specification system. This specification system was soon renewed into a system based on a relational database, which provided more efficient management of the specifications and made it possible to group specification in different ways (STABU2). Currently most building and construction specifications are made using the STABU2 specification format. [STABU 2001]

When STABU2 failed to provide intended benefits like aiding in CAD-application (creating specifications based on CAD drawings) and calculating building cost based on specifications, the development of the STABU LexiCon was started. The LexiCon is an object library in which concepts of all building and construction related objects are stored. It can be viewed as a possible information standard for digital communication. The LexiCon is based on ISO 12006-3, currently an ISO DIS (draft international standard). This ISO 12006-3 is a collaborative effort of international organisations in the building and construction industry and close to being accepted as a norm.

The LexiCon is intended to be a standard to be used by all parties involved in the building and construction industry (B&C industry). Amongst others, architects, construction engineers, various (sub-) contractors, project developers and suppliers. Currently, the information that has to be interchanged between these companies often cannot be transferred digitally. In most cases information is effectively exchanged in paper format and needs to be re-entered in the third parties' software applications (although some information is sometimes exchanged electronically, in order to 'use' it, it has to be re-entered into other software). This is not only time consuming but also less accurate, after all a mistake is easily made. If the information could be exchanged digitally a lot of time could be won and mistakes could be avoided.

1.2 Research motivation and objective

As the STABU LexiCon was being developed, it was clear there were numerous advantages; one of the most obvious being that software based on this database could be multi-lingual without loss of information or changes in meaning. Digital communications between, for example, an architect and a construction company can be quicker as well as more accurate. However, these advantages only apply when all parties involved use the same information standard. This means the advantages for an organisation using the LexiCon are non-existent, or even become disadvantages, if they are the only one to have adopted this system. This poses a barrier for the adoption of the LexiCon.

The objective of this research is to provide STABU foundation with information on the process of adoption and diffusion of an innovation. (The terms diffusion and adoption are explained in detail in the next chapter). And more specific on how the adoption and diffusion of the LexiCon can be stimulated. The most appropriate way of presenting this information will be a step-by-step plan to ensure maximum diffusion and adoption. Due to the amount of variables involved in diffusion and adoption of innovations (see also next chapter) it is not possible to present a best practice. Therefore a number of options will be presented in combination with the possible consequences of the options.

The research objective can be summarised as follows:

The objective is to provide STABU foundation with a number of options to stimulate the diffusion and adoption of the STABU LexiCon and the consequences of these options.

1.3 Problem definition

In order to achieve the research objective a number of problems need solving. First the issue of diffusion and adoption of innovations needs to be cleared up, what exactly is diffusion and adoption? Next we try to figure out what aspects of an innovation impact the diffusion and rate of adoption of this innovation and what characteristics of an organisation affect the adoption of new technologies? When these aspects are known, this knowledge is applied on the LexiCon and its potential adopters.

How to rate the LexiCon on the, previously found, aspects impacting diffusion and adoption and what are the characteristics of the potential users of the LexiCon that could affect their rate of adoption? Finally, how can STABU foundation affect or take advantage of the characteristics of potentially adopting organisations to ensure maximum diffusion and adoption?

These problems can be combined into the following problem definition:

In what way can STABU foundation stimulate the diffusion and adoption of the LexiCon?

1.4 Research questions

In order to solve the problem defined above, a number of questions have to be answered. These questions are based on the problem definition and the research objective. The first two questions are purely theoretical; this means that the answers can be found in literature alone. The following two questions are more practical but still based on theory. The last two questions are purely practical.

First and foremost it is important for this research to understand the principle of diffusion and adoption. Hence the first research question is:

1   What is diffusion and adoption of innovations and what aspects of innovations affect diffusion and adoption of this innovation?

Of course, affecting the diffusion and adoption of the LexiCon are also the (potential) users. In order to be able to say something relevant about the adoption of the LexiCon by its potential users, stocktaking of the aspects of organisations affecting the adoption of new technologies is in order. Question number two is:

2   What aspects of organisations affect the adoption of new technologies?

When the aspects of an innovation affecting its diffusion and adoption are known, a closer look at the LexiCon based on these aspects is possible. This brings us to the third research question:

3   What aspects of the LexiCon stimulate adoption and diffusion and what aspects do the opposite?

Having found the aspects of organisations affecting the adoption of new technologies, analysis of the potential users of the LexiCon is possible. Because the LexiCon is supposed to be adopted by various parties in the B&C industry and in the software and research community related to the industry, the environment needs to be taken into account. This leads to the fourth research question.

4   What are the characteristics of organisations potentially adopting the LexiCon and how do organisations in its environment fit in?

In addition to the aspects of organisations that affect diffusion and adoption it is also necessary to determine the relationships between the different user groups (architects engineers etc.) and how they affect each other in adoption decisions. The fifth question is:

5   How do different (potential) user groups relate to each other and how do they affect each other in adoption decisions?

Combining all of the answers to the first five research questions, it should be possible to get an insight into the adoption behaviour of the different user groups, as well as the influence they have

on each other. For instance, which parties in the B&C industry and its environment play a leading role in the adoption of new technologies? Question number six:

6 In what way can the user groups, their needs and demands and their interrelationships, be utilised in order to improve diffusion and adoption of the LexiCon.

From this part of the research several options to diffuse the LexiCon will emerge, as far as possible, consequences of these options will be estimated, thus meeting the goal of this research. And the research questions will be answered.

1.5 Research approach

The first stage in the research process will comprise of a study to enhance the understanding of the concepts of diffusion and adoption as well as the aspects of innovations affecting diffusion and adoption. Next, the characteristics of organisations affecting the adoption of new technologies by these organisations will be studied as well. This will be done through literature as well as Internet research. This will result in an answer to research questions one and two[1].

In the following stage the LexiCon and the organisations that will potentially work with the LexiCon will be analysed using the previously found characteristics affecting adoption as a guideline. This will be done through interviews with developers of the LexiCon and potential users of the LexiCon combined with interviews with experts. Research questions three and four will thus be answered.[2]

In combination with an analysis of the characteristics of the organisations potentially adopting the LexiCon, the relations between these groups of organisations will be subject of study. In an expert panel discussion about various theses based upon the information gathered so far, my assumptions will be tested and methods to stimulate the diffusion and adoption of innovations in general and the LexiCon in particular will be discussed. This will answer research question number five and six.[3]

1.6 Research structure (what to expect)

In this chapter a short introduction to STABU foundation and the LexiCon was given, furthermore the research design has been outlined. In the next chapter various aspects of diffusion and adoption will be presented. The emphasis will be on the aspects of innovations affecting diffusion and adoption and the characteristics of organisations that impact the adoption off new technologies by these organisations. In the third chapter the LexiCon will be investigated using the aspects affecting diffusion and adoption, found in chapter two. In the fourth chapter the potential users of the LexiCon will be studied according to the characteristics also found in chapter two. The evolution and current role of ICT in the B&C industry is also presented in this chapter, as are the interrelations between the potential users of the LexiCon. In the next chapter the results of chapter three and four will lead to a number of theses that are presented to an expert panel. A summarised account of the discussion and conclusions based hereupon will also be presented in chapter five. Finally in chapter six overall conclusions and recommendations for STABU, about steps to be taken to maximise diffusion and adoption of the LexiCon, and with regard to future research, will be given.

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[1] See paragraph 1.4, question 1 and 2
[2] See paragraph 1.4, question 3 and 4
[3] See paragraph 1.4, question 5 and 6

A schematised reproduction of the research structure is presented in figure 1.

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                    ┌─────────────────────────────┐
                    │  Context and problem definition │
                    │         (chapter 1)          │
                    └─────────────────────────────┘
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                    │    Theoretical background    │
                    │         (chapter 2)          │
                    └─────────────────────────────┘

        ┌──────────────────────────┐        ┌──────────────┐
        │  Analysis of the LexiCon │───────▶│ Conclusions  │
        │       (Chapter 3)        │        └──────────────┘
        └──────────────────────────┘
        ┌──────────────────────────┐        ┌──────────────┐
        │ Analysis of the B&C-industry │───▶│ Conclusions  │
        │       (Chapter 4)        │        └──────────────┘
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        ┌──────────────────────────┐        ┌──────────────┐
        │   Discussion of thesis   │───────▶│ Conclusions  │
        │       (Chapter 5)        │        └──────────────┘
        │ (thesis based on conclusions of │
        │      chapter 3 & 4)      │
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                    │ Overall conclusions and recommendations │
                    │            (Chapter 6)              │
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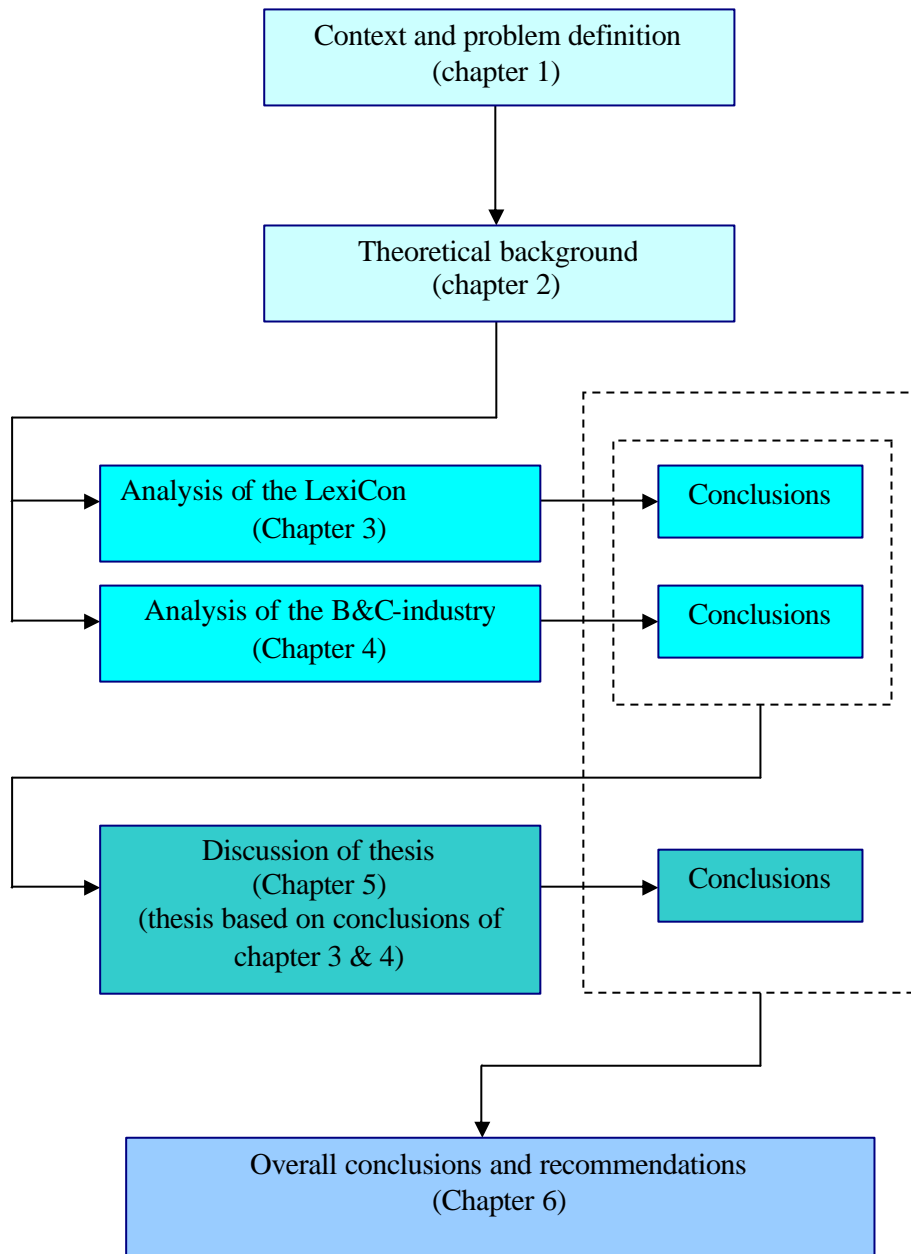
Figure 1: Graphical representation of research structure

2 Theoretical Background

2.1 Introduction

In this chapter earlier research into diffusion and adoption of innovations is presented. In paragraph 2.2 the term innovation is clarified and in paragraph 2.3 adoption and diffusion are explained. With these terms clear we can move on to the factors that impact the diffusion and adoption process, the rate of adoption and the aspects of innovations and potential adopters that affect this rate are subject of paragraph 2.4. In paragraph 2.5 the effect of communication networks on diffusion and adoption can be found. Finally the coherence between all discussed aspects and this research will be made clear in the final paragraph of this chapter.

2.2 Historic overview of relevant research

In 1903 a French judge by the name of Gabriel Tarde, who had kept an analytical eye on trends in his society as presented by the legal cases before his court, observed certain generalisations about the diffusion of innovations, which he presented in his book called "the laws of imitation". Clearly being ahead of his time he observed, though using different names, the S-shaped curve the process of innovation adoption usually follows (see later in this chapter) and he identified the presence of opinion leaders who, by their adoption, boost the adoption of the innovation.

Much of the present day studies into diffusion and adoption of innovations have their roots in sociology, psychology and anthropology. These studies complement each other despite the fact that there was no communication between the fields. Rogers noted that and, in 1963, wrote a book about diffusion because he felt that the knowledge about diffusion should be diffused more. Since then diffusion research adopted a more multidisciplinary viewpoint.

2.3 Innovation

In this paragraph the concept of innovation is further explained. Beginning with the definition (one according to Tidd, Bessant and Pavitt and another according to Rogers) after that the innovation development process is explained and finally the innovation decision process gets a closer look.

2.3.1 Definition

Tidd, Bessant and Pavitt
Tidd Bessant and Pavitt define innovation as change. In their opinion this has two dimensions.
First there is the "what" of the change. In a technological environment this means either a new "thing" (product or service) the organisation offers or a new way of producing the current product or service. Other terms for these types of changes are product and process innovation.
The second dimension is the degree of change. This is a relative scale, because it is subject to the perceived newness of an innovation. One can imagine that a mobile phone with camera and flashlight is a small change for the person who already has a phone with a camera whereas it is a huge change for the person who still uses his mobile phone (type: brick) from 1996.

Rogers
Another definition of an innovation is:
An innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption. [Rogers 2003, p12]
In this definition the perception of the individual or unit of adoption is a key value. As long as it is perceived to be new it is an innovation no matter how long it has existed.
In both definitions the LexiCon is an innovation. It most certainly is a change, because the way information is exchanged nowadays is usually non-digital and if it is, the format requires re-entering of information due to incompatibility of the diverse software used for, for instance, drawing and calculating the cost. Furthermore the LexiCon is not known by most individuals in the B&C industry and will therefore be perceived as new by these people.

2.3.2 The innovation development process

Before its first user adopts an innovation and thus the diffusion process begins, numerous steps and decisions have been taken. The recognition of a problem or need, decisions considering funding of the research, the actual invention of the innovation, its development and commercialisation, a decision whether or not the innovation should be diffused and/or transferred to a diffusion agency and its communication to an audience of potential adopters. After all these decisions have been made will the first adoption occur and will the diffusion process begin. These steps are important because they influence the way an innovation is accepted and adopted (and therefore its diffusion). The next figure shows six stages in the innovation development process. It suggests a linear sequence of these stages, however, usually, this is not the case. Some stages may not occur while others occur parallel instead of linear.
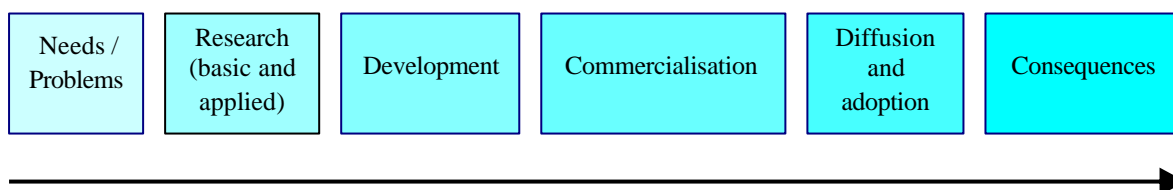
Needs / Problems	Research (basic and applied)	Development	Commercialisation	Diffusion and adoption	Consequences

Figure 2: The six stages in innovation development [Rogers 2003 p138]

The next section will briefly describe the stages.

Recognition of a problem or need

The innovation development process usually begins with the recognition of a problem or a need. This recognition triggers the further innovation development process.

In certain cases scientists may foresee a problem in the future and launch research beforehand. It is also possible that research has been completed but it is not utilised until the need is recognised by the public. [Rogers 2003, p137-139]

Basic and applied research

Basic research can be described as original investigation for the advancement of science and applied research can be described as scientific investigations that are intended to solve practical problems. Applied research utilises basic research for a practical purpose. Together they form the research stage of the innovation development process.

Development

Development of an innovation is the process of putting a new idea in a form that is expected to meet the needs of an audience of potential adopters. [Rogers2003 p146] Development is always closely related to research. Hardly any organisation has separate departments for research and development. This is because research and development are closely related. The R&D acronym also implies that research precedes development; this is true because the development stage cannot start without some form of research. However, at some point both may be undertaken at the same time.

In the development process uncertainty plays a big role. Not only does the developer have to anticipate problems of the ultimate adopters of the innovation, he will also have to deal with uncertainty in his own R&D organisation, other R&D organisations and government regulations. This is why information exchange about technology (technology transfer) is of crucial importance in the success of the innovation.

Commercialisation

Whether the innovation comes from research activities or from practice (where practitioners seek new solutions for their own problems or needs), before it can be sold in the marketplace the innovations needs to be packaged in a form ready to be adopted by users. This packaging process is called commercialisation and it comprises of the production, manufacturing, packaging, marketing and distribution of a product that embodies the innovation.

Diffusion and adoption

When to start the diffusion process is one of the most crucial decisions concerning marketing an innovation. On the one hand there might be pressure to approve the innovation for diffusion as early as possible. Especially if the social problem or need the innovation is to solve has a high priority. On the other hand the credibility and reputation of the change agent depends on him only recommending innovations that will have sufficient beneficial consequences for its adopters. Also starting the diffusion of an innovation before it is at its best may hinder the acceptance of future versions.

Different fields require different diffusion methods. In the agricultural field one usually relies on agricultural experts to diffuse an innovation. In the medical field quality assurance is used as a primary means of diffusing innovations, considering the consequences of lacking quality in this field, this makes perfect sense.

Consequences

The final stage is the analysis of the consequences of an innovation. The consequences of an innovation are defined as the changes that occur to an individual or social system as a result of the adoption or rejection of an innovation. The process of studying the consequences of innovations is not often done as it is a time consuming process and the innovation has been implemented anyway. Moreover the consequences are difficult to measure.

The consequences can be classified as; 1) desirable versus undesirable, 2) direct versus indirect and 3) anticipated versus unanticipated. Usually the desirable, direct and anticipated consequences go hand in hand as do the undesirable, indirect and unanticipated consequences. Although unintended and desirable consequences may occur.

Position of the LexiCon

The need was recognised, as the previous improvement of the STABU system (STABU2) did not fulfil the need it was intended to fill (coupling of building specifications software with drawing and calculation applications). After this the basic and applied research were conducted simultaneously. The basis research in the form of the development of ISO 12006-3[4] and the applied research, in the form of the development of the LexiCon structure itself.

The LexiCon is currently in the development stage. STABU foundation is now also entering the commercialisation stage by trying to find ways in which to utilise the LexiCon. This research is supposed to aid in this process as well as trying to predict the consequences of different diffusion tactics.

2.3.3   Type of innovation decision

Optional innovation decision

The optional innovation decision is a choice to adopt or reject an innovation made by one individual (or unit of adoption). This choice is independent of the choices made by others in the social system however the choice of others in the social system may influence the decision.

Collective innovation decision

The collective innovation decision is made by an entire social system based on a consensus among the members of this system. Usually all the members of the social system must conform.

Authority innovation decision

Authority decisions are made by relatively few individuals in a social system, who possess power, status or expertise. The rest of the system has limited or no influence on the decision, they simply have to adopt.

What about the LexiCon?

The LexiCon is not an optional innovation decision, because the consequences of the decision to adopt are not independent of the choices made by others in the social system (the B&C industry). Whether it is a collective or an authority decision depends on the course of action STABU foundation takes.

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[4] iso 12006-3 is becoming an international accepted standard.

If it is to be presented as a collective decision, all parties involved in the B&C industry will have to be brought together to create a consensus regarding the structure and content of the LexiCon. With over 70.000 organisations in the Dutch B&C industry [WWW4] this looks like a Herculean effort. To extend this internationally seems impossible.

However, if it supposed to be an authority decision, who has the authority to make this decision? As we will see in chapter four, the B&C industry in the Netherlands is very fragmented. Moreover there are numerous research institutes, research programming institutes and knowledge platforms that operate in the B&C sector none of which has the power to single-handedly change the B&C industry. The number of research institutes that need to reach a consensus about the content and structure of the LexiCon is much smaller than the 70.000 organisations in the B&C industry, needed for a collective innovation decision.

2.3.4 The process of innovation decision

The innovation decision process is the process through which an individual, or decision making unit, passes from first knowledge of an innovation to a decision to adopt or reject the innovation and in the case of adoption it includes implementation and conformation of the decision. [Rogers 2003 p169] In figure 3 a model of these five stages is given, below the stages are explained further.
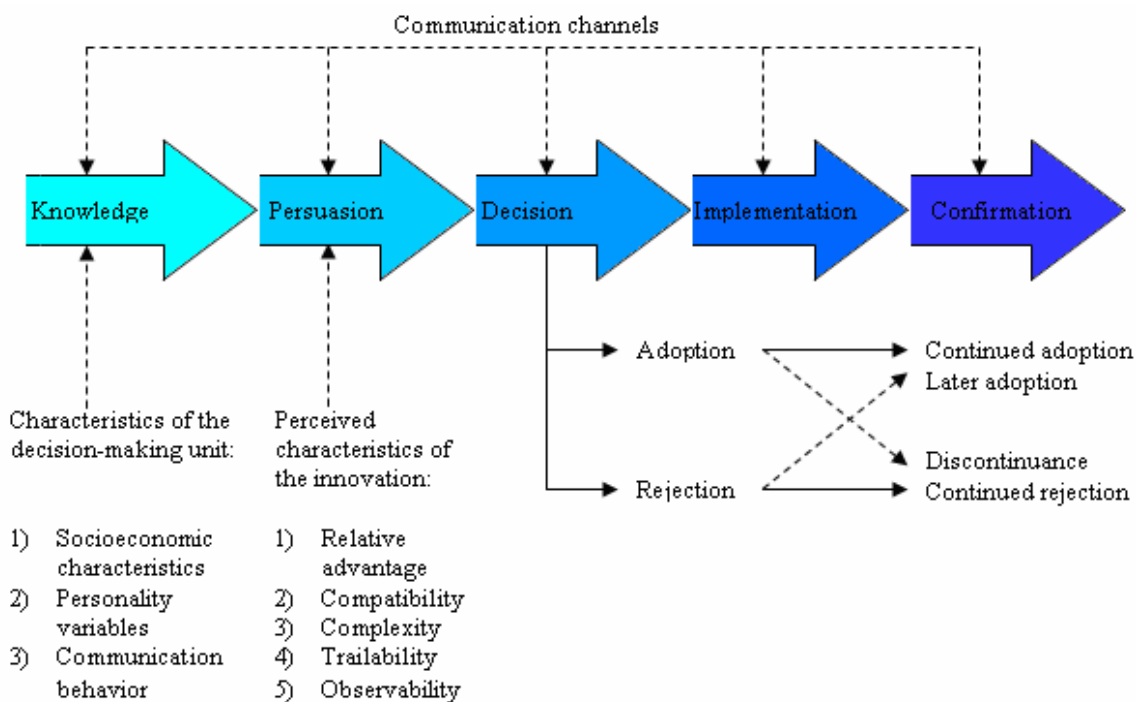

Figure 3: Five stages in the innovation-decision process [Rogers 2003 p170]

The knowledge stage is the stage in which the individual is exposed to an innovation and gains a basic understanding of its functionality. Three categories of knowledge exist: awareness knowledge (what is the innovation), how-to knowledge (how does it work) and principles knowledge (why does it work). The Persuasion stage occurs when an individual forms an attitude (favourable or not) about the innovation and the decision stage takes place when an individual engages in activities that lead to a choice concerning the adoption or rejection of the innovation. The implementation stage comprises of all activities undertaken to put the innovation to use. If, in the decision stage, the innovation is rejected, this stage is skipped, but can occur later if in the next stage the previous decision is reversed. Finally in the conformation stage an individual seeks reinforcement of an innovation decision already made. The previous decision can be reversed in this stage if information about the innovation contradiction previous conceptions is received.

2.4   Diffusion and adoption

2.4.1   Diffusion

According to Rogers [Rogers 2003, p5] diffusion is: *"The process by which an innovation is communicated through certain channels over time among members of a social system."*
This definition only deals with the communication of the innovation; the adoption of the innovation is not part of the diffusion process. However, the rate of adoption is closely related to the efficiency of the diffusion process.

2.4.2   Adoption

Adoption is a decision to make full use of an innovation as the best course of action. (Rogers 1983 p172) adoption also implies that the innovation comes from an external source. In case of an internal source of the innovation we speak of generation.
The opposite of adoption is rejection, which in contrast to adoption can be active as well as passive. When an innovation is actively rejected this means that the innovation has been considered, it may even have been tried, but the decision maker decided not to adopt. In case of passive rejection, also called non-adoption, the innovation is never really considered.
Kwasi Boahene states that the adoption process is a multidisciplinary process; it deals with aspects of economics (cost, profitability of the innovation), sociology (the nature of communication channels and differences in social relations and positions), geography (information flow and spatial differences) and anthropology (compatibility with societal norms and values). [Boahene 1995]

2.4.3   Innovativeness and adopter categories

The potential adopters of an innovation can be categorised according to the moment of their adoption. This categorisation is linked to the innovativeness of the adopters. Although innovativeness is a continuous scale it has been divided into five ideal types. It is like dividing the continuum of social status into upper, middle and lower class. It is a simplification that aids understanding, but loses data. The ideal types are innovators, early adopters, early majority, late majority and the laggards. This categorisation divides adopters to their relative time of adoption. See figure 4.
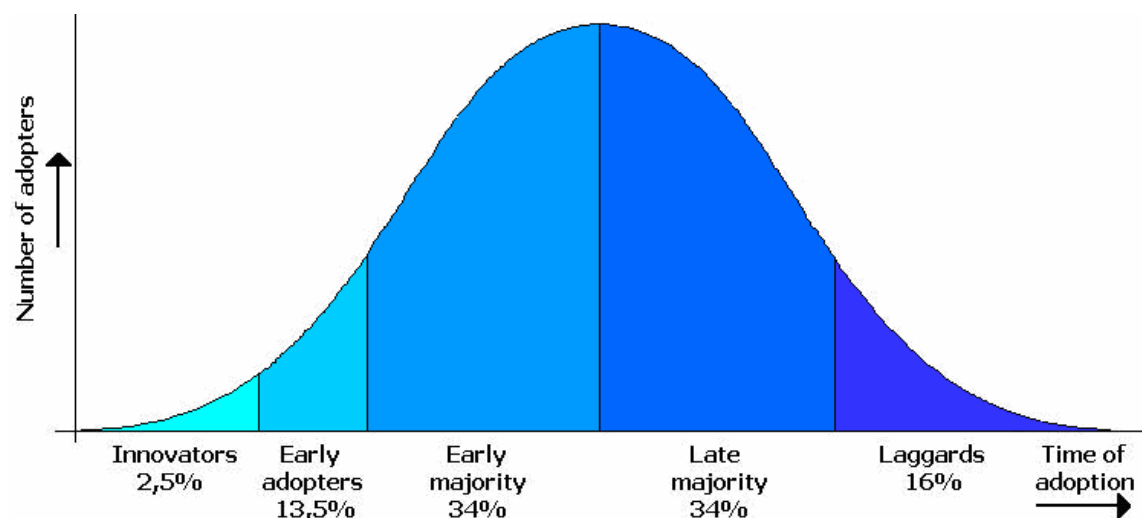

Figure 4: Graphical representation of adopter categories [Rogers 2003 p281]

The innovators

The innovators adopt first, they are venturesome and are very eager to adopt innovations. This leads them out of a local circle of peer networks and into more cosmopolite social relationships. Communication patterns among innovators are common even though they may be geographically widespread. There are some prerequisites to being an innovator. These include control over

substantial financial resources to absorb possible losses due to an unprofitable innovation, the ability to understand and apply complex technological knowledge and the ability to cope with a high degree of uncertainty about the innovation at the time of adoption.

Early adopters
Next the early adopters make use of the innovation. The early adopters are a more integrated part of the local social system. They are localities as opposed to the cosmopolitanisms of the innovators. The opinion leadership of this category is the greatest of all categories. They are not too far ahead of the average individual in innovativeness; they serve as a role model to many other members of the social system. For this reason early adopters are generally sought by change agents to be a local missionary for speeding the diffusion process.

Early majority
Thirdly the early majority adopts just before the average member of a social system. The early majority frequently interacts with their peers, but seldom holds positions of opinion leadership. They may deliberate for some time before they adopt. Due to the size of this group it can be regarded as an important link between early adopters and the late majority and laggards, the second half of the potential adopters.

Late Majority
After that the late majority adopts, usually because of economic necessity or increasing network pressure. The late majority are sceptic towards innovations and will not adopt until the innovation has proven itself. Although they can be persuaded to utilise the innovation, the pressure of peers is necessary to motivate adoption.

Laggards
And finally the laggards adopt. The laggards are traditional in the sense that they keep looking back at how it used to be done and keep doing it that way. They are usually near isolates in the social network. They posses almost no opinion leadership and interact mostly with others who share their traditional values. The process from awareness of the innovation to the adoption stage is usually a lengthy one.

2.5 Rate of adoption

The rate of adoption is the relative speed with which members of a social system adopt an innovation. The rate of adoption can be seen as the slope of the S-curve shown in the figure below. The rate of adoption is determined using the innovation as the unit of analysis rather then an individual or unit that adopts. See figure 5.
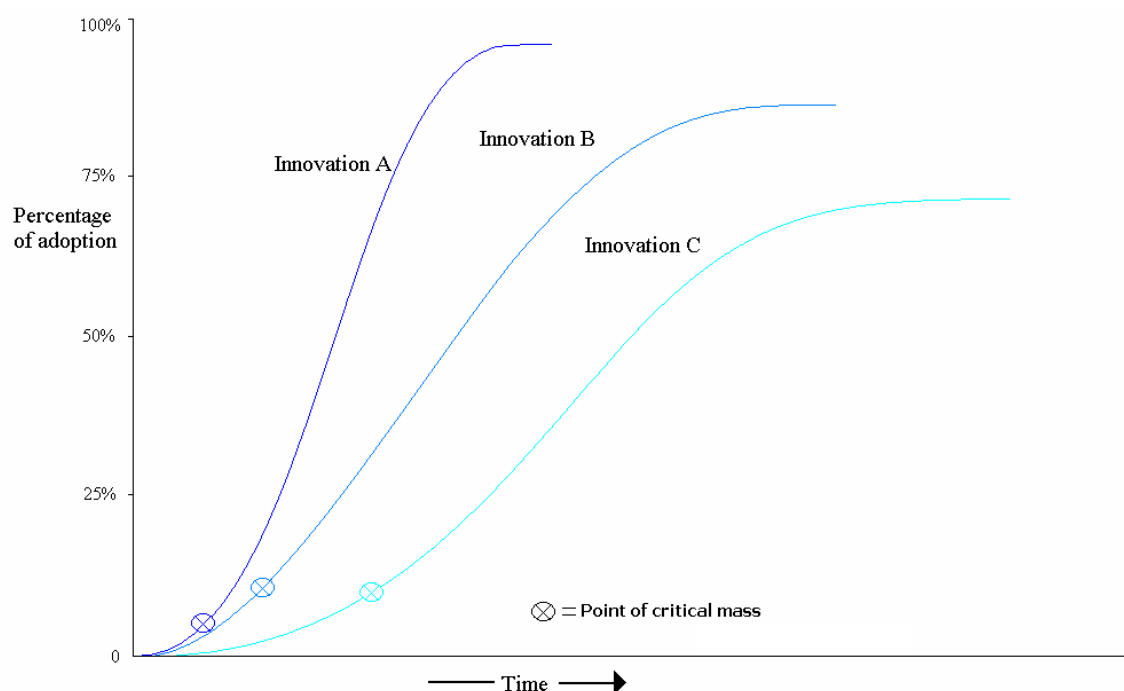
Figure 5: S-shaped curve of diffusion process [Rogers 2003 p11]

In the beginning there is a slow pick-up of the innovation, followed by a period of rapid growth of the adoption and in the end the last adopters follow slowly. Innovation A is a rapidly diffused innovation that reaches almost 100% adoption, whereas innovation B & C are a little or more slowly diffused and reach less and less adoption. At the point where the curve is bending upwards, the point of critical mass is reached. Depending on the shape of the curve, critical mass can be reached at different percentages of adoption and at different times.

The diffusion and adoption of innovations depends on a number of factors. These factors can be organised into four main categories; the innovation itself, its potential adopters, the environment (of the potential adopters) and the opinion leaders and change agents. About this last category, opinion leaders and change agents, one can argue it is part of the environment of the potential adopters or, in case of internal change agent, part of the potential adopter itself. Because of this ambiguity and the fact that this group of people is important to such an extent it deserves its own category.

2.5.1   Characteristics of innovations

According to Rogers there are five aspects of innovations that determine the ease of the diffusion process. These are: relative advantage, compatibility, complexity, trialability and observability Each of these aspects is somewhat interrelated with the other four, but they are conceptually distinct. As with the innovation itself, the perceived values of these aspects count, not the aspects as classified 'objectively' by experts or change agents. It appears to be a limited number of aspects, but other aspects that could be mentioned can be categorised in one of the aforementioned categories. Below a short explanation of all categories is given. [Rogers 2003 p229-259]

Relative advantage
Relative advantage is the degree of perceived advantage of new technology over the old technology, in terms of economic factors (cost, payback time) and non-economic factors (convenience, prestige).

Compatibility
Compatibility is the degree to which an innovation is consistent with the existing skills, equipment, procedures and performance criteria as well as the compatibility with current values and norms and needs of the potential adopter.

Complexity

Complexity is the degree to which an innovation is perceived to be difficult to use or understand.

Trialability

Trialability deals with the possibility to experiment with the innovation on a limited basis, for instance on a single project base, or even on one single aspect of a project. This is harder for innovations that have a broader scope or innovations that demand changes in work methods.

Observability

And finally, observability is the degree to which others can observe the consequences of an innovation. This can be done through demonstrations or pilot project, preferably large public project with media attention.

2.5.2 Characteristics of potential adopters

In the beginning of diffusion research only individuals were subject of study. Only in the 1960s diffusion studies treated organisations as subject of study, however these studies were oversimplified in the sense that data was usually gathered from one individual within the organisation, thus reducing the organisation to the equivalent of an individual. In the 1970 studies began to look inside the organisation at the aspects of organisations that determine the innovativeness of the organisation. The following aspects appear to have an impact on the innovativeness of organisations.

Company size and industry type

The bigger the company the more innovative the organisation is and the more technologically advanced the industry type, the higher the innovativeness of the organisation.

Organisational slack

This is the degree to which uncommitted resources are available to an organisation. More organisational slack tends to lead to more innovative organisations.

Centralisation and formalisation

These have a negative impact on the innovativeness of organisations, but once the decision to adopt is made they have a positive impact on the implementation of an innovation.

Interconnectedness

Interconnectedness is the degree to which units in a social system are linked by interpersonal networks. A higher degree of interconnectedness is associated with a more innovative organisation.

System openness

System openness is like the interconnectedness; however this deals with linkage with external individuals.

Complexity

Complexity in an organisation is the degree to which members of an organisation possess a high level of knowledge and expertise. A higher degree of complexity encourages members to grasp the value of innovations, however it may make it more difficult to reach consensus about implementing them. [Rogers 2003 p407-417]

2.5.3 Environment of potential adopters

Social structure

Structure is defined as the patterned arrangement of units in a system; therefore social structure is the patterned arrangement of units in a social system. This has a formal and an informal aspect. The formal social structure can be seen as a hierarchy where those on higher hierarchical levels can give orders to those on lower levels. This gives regularity and stability to the social system, which leads to better predictable behaviour.

The informal social structure gives some insight into who communicates with whom in a social system. These communication channels are not based on hierarchy, but on social linkage with other individuals[5].

System norms

Norms are the established behavioural patterns for the members of a social system. These norms define a range of tolerable behaviour. [Rogers 2003 p23-26]

Communication channels

A communication channel is the means by which messages get from one individual to another [Rogers 2003 p18]. These can be divided into mass-media channels and interpersonal channels. Mass media is most effective in reaching great numbers of potential adopters, however interpersonal contact is much more efficient in persuading someone to adopt. Compare your own willingness to try a new washing detergent when you have seen a commercial on TV to your willingness to try it if a good friend recommends it. Somewhere between these two channels the internet exists. It combines the great numbers reached through mass media with the interpersonal contact because the internet is interactive and online discussions as well as one-on-one persuasion are possible.

2.5.4 Opinion leaders and change agents

Change agent

A change agent is an individual who influences clients' innovation decisions in a way deemed desirable by the change agency. Usually a change agent tries to persuade clients to adopt an innovation, but he can also slow down the diffusion of innovations deemed undesirable. Change agents use opinion leaders in a social system to enhance the efficiency of the diffusion activities.

Opinion leader

Opinion leadership is the degree to which an individual is able to influence the attitudes or behaviour of other individuals in an informal way. If an individual is frequently capable of doing this, we speak of an opinion leader.

Opinion leaders have a high level of external communication (with external we mean outside the organisation the opinion leader works in). They have a higher socio-economic status and greater social participation than their followers. They tend to be more innovative than their followers unless system norms do not favour change.

2.5.5 Mandates and incentives

Mandates

If an innovations, or the consequences thereof are deemed desirable by the government, but not (or not at first) for the individuals that have to adopt, adoption of an innovation can be mandated. This means that negative consequences will follow failure to adopt. This creates a negative atmosphere considering the innovation and is therefore best avoided and if possible, the diffusion and adoption process should be stimulated through providing incentives.

Incentives

In order to stimulate the adoption of innovations, incentives can be awarded. The main function of incentives is to increase the degree of relative advantage. Incentives can come in a variety of forms.

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[5] See paragraph 2.6.1

For different categories of adopters

For the adopter or the diffuser: incentives can be given to the adopter himself, or to the individual who persuaded someone else to adopt.

For the individual or the (social) system: incentives can be given to one person (organisation) or to the social system he is part of. (For example the Indonesian government paid a community incentive to villages with a high rate of adoption of family planning, instead of the individuals who adopted contraceptives)

In different forms

Monetary or non-monetary incentives: not all incentives have to be monetary; they can also take the form of other desirable commodities or objects.

Immediate or delayed incentives: Incentives are usually awarded at the time of adoption, in some cases incentives are awarded at a later date. This helps ensuring long-term use of the innovation.

Positive or negative incentives: usually incentives are awarded for adopting an innovation, however if the adoption of an innovation is not (yet) desired, penalties can be given for adoption. This is called a negative incentive or a mandate.

2.6 Network models and critical mass

2.6.1 Networks

A communications network consists of interconnected individuals (or units of adoption) who are linked by patterned flows of information. The degree to which units in a social system are linked by interpersonal networks is the interconnectedness. The higher this interconnectedness, the more innovative the unit probably is. Communication links can either have an outward direction, in the sense that it is more likely that the individual persuades others to adopt, or an inward direction, meaning the individual is being persuaded to adopt. The individuals with high numbers of outward communication links are called opinion leaders[6]

2.6.2 Critical mass

Critical mass occurs at the point, at which enough individual units of adoption have adopted, that the innovation's further rate of adoption becomes self-sustaining. It is shown in figure 5 at the beginning of the steep incline of adoption. This critical mass point is particularly important in the diffusion of interactive innovations (with interactive innovations we mean innovations where a new adoption of the innovation provides additional benefit for all future and previous adopters).

According to Rogers there are four ways to gain critical mass faster; get highly respected organisations, opinion leaders, to adopt first, introduce the innovation into a subgroup that is likely to be more innovative, give incentives for early adoption and shape individual perceptions by implying critical mass has been, or will soon be reached.

2.6.3 Threshold

A threshold is the number of others that have adopted and are satisfied with an innovation, in an individual's network needed, before the individual decides to adopt. Critical mass is the point where most people have their threshold. However critical mass operates at system level whereas a threshold is purely individual.

2.7 Conclusion and coherence

Solving the research' problem definition, starts with answering the first three research questions in this chapter. Definitions of diffusion and adoption, as well as aspects of organisation and innovations that affect the diffusion and adoption process of these innovations, have been presented.

The various aspects that have been proven of importance for the diffusion of innovations, relative advantage, compatibility, complexity, trialability and observability, will be utilised to analyse the

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[6] see paragraph 2.5.4

LexiCon. This analysis will be based on a description of the LexiCon [WWW1], which is summarised before the analysis.

Next the aspects of organisations, potentially adopting the LexiCon, appears to be size, industry type, organisational slack, degree of formalisation and centralisation, interconnectedness, system openness and complexity. However, since the innovation decision is not an optional one[7], network effects play a large role in the diffusion and adoption of the LexiCon. Opinion leaders and change agents can speed up or delay the diffusion and adoption process. Identifying these opinion leaders and change agents and determining the communication networks in the B&C industry will lead to the answer of research question number 4 and 5.

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[7] see paragraph 2.3.3

3 The LexiCon

3.1 Introduction

The LexiCon is a computer-based tool for the management of construction terms, which describe Built Objects and their associations. The construction terms identify the products resulting from construction activities, such as buildings, roads and parts of these, as well as products to be incorporated in these constructions or to be used as construction aids. The LexiCon is an object-oriented approach to the classification and description of buildings and parts of them. A building is a Built Object and so are the physical components and the spaces contained by it. In this chapter more about the history and structure is presented in paragraph 3.2 and 3.3. More about the current and intended use is presented in paragraph 3.4 and after looking at the lexicon through the eyes of Rogers in paragraph 3.5, conclusions about the aspects of the LexiCon that affect the diffusion and adoption process positive or negative are drawn in paragraph 3.6.

3.2 Development of the LexiCon

3.2.1 In the beginning…

The idea for the LexiCon was based on the shortcomings of the newly developed STABU2 system. When this version was released it turned out that intended benefits, like aiding in CAD applications and calculating cost based directly on building specifications, were not going to be achieved. This was due to the fact that the STABU2 system, the calculation libraries and the CAD applications in use at the time did not share a common dataset. Moreover, the larger software developers all had their own standards, usually based on the SfB method[8], that were not compatible with STABU2. This intention to bridge the gap between the "islands of information", created by the diversity of the available applications for CAD, costs and specifications, resulted in the founding of BAS (vereniging bouw afspraken stelsel) which ha a substantial contribution in formulating criteria for the LexiCon.

3.2.2 ISO standard

In 1989 STABU foundation organised a congress in the Netherlands, where organisations similar to STABU from other countries met to exchange experiences. This ultimately led to the founding of the international construction information society (ICIS). Based on contacts made within ICIS, one of the main developers of the STABU specification system, Mr. Kees Woestenenk, became involved in international classification activities; initially in ISO TC59/SC13/WG2, which led to involvement in ISO TC184/SC4 (STEP), the EPIC and several international conferences and contacts with the IAI.

During the development of the LexiCon, the developer was also involved in an ISO project concerning the structure of an information system that could be used in the building and construction industry. The primary idea was to create a standard structure for classification system by building a framework. From here on, this project developed in two ways, ISO 12006-2, which appears to be closest to the original intent of the ISO12006, and ISO 12006-3, that would lead to an object oriented classification system on which different views were possible. This is somewhat similar to the ISO STEP project (Standard for the Exchange of Product model data) and could be incorporated in it.

Furthermore the LexiCon is inspired by other object libraries under construction like EPISTLE and POSC-CEASAR Class library (respectively based on ISO 10303 and ISO 13584) as well as the industry foundation classes (IFC's) developed by the IAI.

3.2.3 Financing

BAS intended to commission STABU foundation to develop the LexiCon. However BAS was unable to provide adequate funding for the project and it was decided that STABU foundation

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[8] more information on SfB in appendix A

should develop the LexiCon internally and BAS would act as a committee of control with regard to the guidelines for object libraries established earlier.

Until now, part of the financing came from organisations participating with STABU, another part has been financed by participating in the European concur project. Since the LexiCon is yet to be finished additional funding is required. STABU foundation is trying to get government support and funding for the LexiCon.

3.3 Structure of the LexiCon

As mentioned before the LexiCon is based on ISO 12006-3, which can be described as the grammar for the LexiCon where the LexiCon itself is the dictionary. This dictionary consists of a set of concepts. The hierarchical structure in which these concepts are ordered is called taxonomy. In this taxonomy the most generic concepts are at the top becoming more and more specialised towards the bottom of the hierarchy.

3.3.1 Concept

A concept is an abstraction, a construct of our minds, allowing us to recognise things around us. For example the concept of a chair allows us to recognise one when we see it, regardless of the specific shape of the chair. Concepts are indicated by labels either a name, a picture, a sound or other representations. Each concept can have as many labels as we would like, for instance the concepts name in different languages, and these allow us to communicate about the concepts. Next to labels each concept has a unique identification.

3.3.2 Object

The term object, used for the concept at the top level of the hierarchy is taken from ISO 12006-3. Considering object as the root, the most generic concepts are: subject, predicate, measure and unit. These relate as shown in Figure 6: Relations of the most generic concepts in the LexiCon.
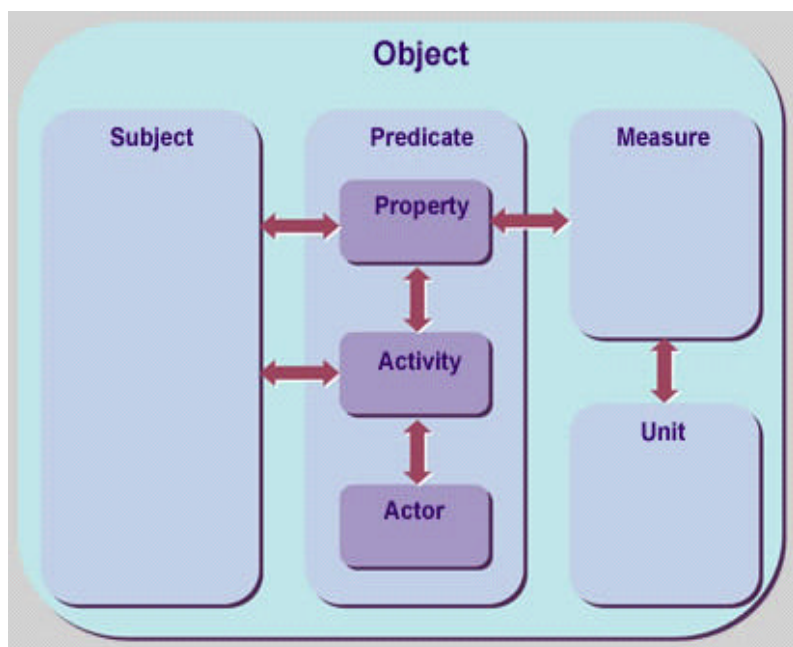

Figure 6: Relations of the most generic concepts in the LexiCon

All other concepts are specialisations of these generic concepts. As such these specialised concepts have an "is-a" relation with their parent and inherit their characteristics. Below the four subtypes of object are described further.

Subject

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Subject is a generalisation of all 'substantial' concepts. In other words subjects are the things that make up our physical or virtual world of construction. On levels derived from subject all types of construction objects, like spaces, products and materials, can be found. Specialisation of subjects on each level is based on the distinction between an intrinsic and an extrinsic point of view. In the extrinsic viewpoint, the task the subject fulfils is the basis. The intrinsic viewpoint is based on the quality of the subject. For clarity an example:

The subject "Fixed wall" is specialised into load bearing wall, non-load bearing wall and retaining wall from the extrinsic point of view. From the intrinsic point of view the same fixed wall is specialised into multiple leaf wall, single leaf wall and single leaf wall with covering layer.

Predicates

Predicates are concepts providing the definition content. These predicates are divided into three concepts: property, activity and actor.

Properties are predicates that can be used to define characteristics of subjects and activities. Most properties used for definitions are classifying properties, dividing subjects or activities into classes, each class being one of the possible values in the value domain. These classes usually have a definition of their own; however, they cannot be instantiated on their own, but only when assigned to a subject or activity. Values for properties are contained in measures, to which a scaling factor is added by means of a unit. A property can also contain a description (in this case a measure without a unit is used). It is defined as a concept by a description and by its associated value domain; a property (seen as a concept) does not have any properties assigned.

Activities are predicates that can be used to associate events altering a subject. Generally they are not used to define subject, but need to be defined as concepts in order to be used in specifications.

Actors are used in conjunction with activities. They hold the definition of roles that have to be played and not so much the person or organisation playing the role.

Measure

A measure, although a category of concepts on its own, can only be instantiated in association with properties. A measure contains a value that quantifies a quantity or quality of a property. It can provide identifying classes, like the class tangibility that is assigned to subjects, or provide other property values, like distance or weight. The measure is combined with a unit.

Unit

A value only has meaning when it is combined with a unit. A unit is a scaling factor for a value. The unit for classifying properties is class; most other units come from the SI system. The values of properties may use several measures, as long as the units belong to the same family. The property distance for example might be measured in meters or inches, both units using a length quantity.

3.3.3 Definitions

LexiCon definitions consist of a number of items:

ID's: a never changing identification. They are defined on a local as well as a global level. (The globally unique ID is used for harmonisation with different libraries.

Names: a language dependent term used as a lexical indicator of a concept. A concept can have any number of names and names are not unique for a single concept. Synonyms and homonyms are allowed. Names have their own ID's.

Descriptions: A series of language depend sentences explaining in a lexical way what is meant with a concept. They are optional, not restricted in number and start with a reference to the supertype, thus avoiding the repetition of inherited characteristics. These too have own ID's.

Comments: optional addition of text that is not part of the definition.

Graphical representation: like descriptions, graphical representations are optional and not restricted in number, have their own ID's and can be used to indicate shape properties, such as sizes.

Predicates: a concept assigned to another concept. It makes a statement about the concept it is assigned to. Predicates form the formal definition of a concept. Derived concepts inherit all predicates assigned to its super type. Each predicate has its own ID's.

References: A link from a concept to an external document.

Administrative data: consists of a date, a version number, the status and the owner of the definition (the person or organisation responsible for maintaining the definition).

3.3.4 Specifications

The LexiCon specifications provide templates to describe instantiated concepts, as defined by the LexiCon definitions. The specifications extend the definition with variable characteristics. Using the terms functional unit and technical solution, provided by Gielingh in GARM, the difference between definition and specification could best be made clear. A functional unit (a definition) can be 'solved' by a technical solution (a specification). There can be more technical solutions for one functional unit.

For example the concept 'closed cable tray system' (functional unit) can be instantiated by closed steel cable tray system, closed plastic cable tray system, closed stainless steel cable tray system or closed aluminium cable tray system (technical solutions).

3.4 Use of the LexiCon

3.4.1 Currently

Since there are no applications based on the LexiCon it cannot yet be used in the B&C industry itself. However since the object definitions are already publicly available, software developers could start with the development of applications based on the LexiCon.

Due to the considerable investments involved in developing software applications, these will not start until the LexiCon is accepted as the best possible information standard.

3.4.2 Future

When the LexiCon is fully adopted throughout the B&C industry, it will be used in all stages of the building process and will be able to deal with general definitions and descriptions of specific products. An object library of building objects like the LexiCon is never completely finished. New products emerge and in order to be able to use the LexiCon for calculating and ordering of supplies up-to-date pricelist of building products is available. These are two of the reasons why maintaining the LexiCon is so important. But who does the job?

Maintenance of the STABU2 system is in the hands of STABU foundation and is financed through license fees. The fact that STABU maintains their system is mostly because they are the authority on the subject. The LexiCon is much broader; this means that it is not as logic for STABU foundation to be responsible for the maintenance of the LexiCon as it was for the STABU2 system. However considering the subtitle of STABU foundation "Building-industry wide information system" it does fit into the area of STABU foundation.

Information from suppliers about their products is currently added to the STABU2 system by means of additional CD-ROMs with every new issue of STABU2 (twice a year). This means that changes in supplier product can take up to six months to become known by the buyers. The availability of broadband internet connections provides the opportunities needed to supply this information on-line. The responsibility of updating this list could very well be appointed to the manufacturers of the supplies. It is as necessary for them to be listed correctly as it is for the individual trying to order products, though for different reasons. The supplier wants to be listed in a system that is being used in many organizations; the buyer wants to find a choice of products to compare.

3.5 The LexiCon through the eyes of Rogers

3.5.1 Relative advantage

It is difficult to determine relative advantage, because it is more or less one of a kind. So, advantage relative to what? Compared to the NL/SfB there is the advantage of the virtual unlimited extension of the LexiCon in contrast to the limited options for classification NL/SfB provides. Moreover it includes the definitions of specifications related to the objects defined. By including all specifications related to the objects described, the use of the LexiCon provides a much broader basis than any other standard currently in use. Due to the fact that all terms used in the specifications are themselves defined in the LexiCon definition part, all information is unambiguously defined and thus computer interpretable.

The benefits of using the LexiCon differ per building stage.

Over the entire project profits in time and money will be gained because all information will only be inserted once, however the information entered into the system needs to be correct, because a mistake in this "input" stage carries on into all other stages.

Most information needed in a building project (concerning the building object) is entered in the design stage. The higher need for correct information can mean extra work in this stage. In the design stage most communication about the building object is internal, or with long term partners that specialise in sub-stages of the design stage. The need for standardisation of this information exchange is often already met. By changing the standard exchange format of the information into a nation wide standard, the outsourcing of sub-stages of the design process can more easily be achieved, which could result in price competition amongst suppliers and create a financial benefit in the design stage.

3.5.2 Complexity

The LexiCon is highly complex. Although the level of abstraction of the definitions, especially of those on higher levels in the taxonomy, has been reduced greatly, some categorisation of objects is not self-explanatory. Moreover the structure of the taxonomy is, at certain points, subject to heated debate. For instance a radiator from a central heating system can be categorised as part of the heating system, or as part of the furniture.

On the other hand, if applications based on the LexiCon can hide the taxonomy of the LexiCon and provide a clear user interface (possibly like the user interface used in current applications that are not LexiCon based) the complexity of the LexiCon does not need to hinder the diffusion and adoption of the LexiCon, this hurdle is one to negotiate in cooperation with software developers.

3.5.3 Compatibility

The LexiCon is developed to enhance compatibility of different software applications used in the B&C industry. However due to the radically different way of structuring information and the fact that all information about different building elements can be combined it inherently means changes in current practices in the B&C industry. For example where currently the calculator and the building planner both extract the information needed from the building specifications and enter them separately into their own applications, in the situation where the LexiCon is used, this information can be extracted from the same file by computer. This means a change in working methods, but should make the building process more flexible (the effect of a change in the design will be instantly known in other stages) and less error prone because information is only entered once and not re-entered by everyone who needs the information.

Radical changes in working methods are usually not greeted with much enthusiasm so a migration path with a number of smaller changes can help in overcoming the resistance to change. STABU foundation is currently incorporating the NL/SfB in the STABU system (STABU-element), providing a step-up for he use of the LexiCon[9].

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[9] See Appendix B

3.5.4 Trialability

By lack of applications, the LexiCon cannot be tried yet. This is, however, vital to the success of the LexiCon, as STABU would not be the first to promise interoperability and fail to deliver it. Being able to give a demonstration of smooth interoperability and the possibility for potential user to try it themselves, can take away the scepticism currently felt towards the subject of interoperability.

3.5.5 Observability

Since it cannot be tried, it is not possible to observe as yet. But as is the case with trialability, successful use of the LexiCon in a trail project will smooth the path for the LexiCon.

3.6 Conclusion

The LexiCon is a complex data structure that has the potential of becoming the standard for communication in the B&C industry. A lot of effort has been put in making the LexiCon a complete library with a taxonomy that is based on an ISO norm[10]. Considering the broad basis of the LexiCon, covering all aspects of the building process, it can be an advantage for many different organisations in the B&C industry. This is also the difficulty in diffusion and adoption of the LexiCon, because for it to come to its full potential a large number of organisations from different stages of the building process will have to adopt.

Aspects of the LexiCon that have a positive impact on the diffusion speed
A broad scope with a large number possible area's of application
Supported by research community[11]

Aspects of the LexiCon that have a negative impact on the diffusion speed.
Large number of adopters necessary for full benefit to be gained
It does not operate according to current working methods
It is a complex structure
Lack of applications

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[10] ISO 12206-3 is going through the steps to become an ISO-standard
[11] See paragraph 4.4.2

4 The B&C Industry

4.1 Introduction

In this chapter the central focus is on the B&C industry. All stages in the building process are considered as well as the role ICT can play in these stages. Information was gathered through internet research as well as interviews with several experts[12]. First the building and construction industry is mapped separately from its environment and its cultural aspects described (respectively paragraph 4.2 and 4.3). Second, the environment, in the form of government, software developers and research institutes, is observed in paragraph 4.4. A few things can be said about critical mass in paragraph 4.5 after which in paragraph 4.6 conclusions are presented.

4.2 Networks

A simplified model of the communications in a building process is presented in figure 7
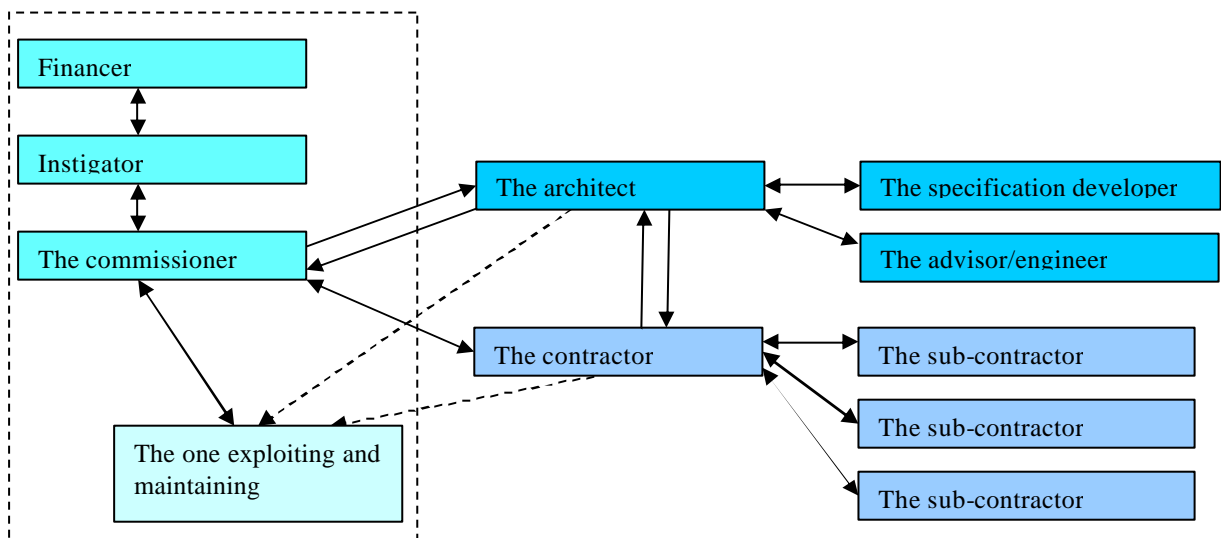
Figure 7: Simplified representation of communication in a building project

In this figure only the basic lines of contact are given, in reality sub-contractors could possibly need to communicate with a commissioner or architect or both. The three main stages of the building life cycle, design, building and maintenance, are preceded by the initiative stage. In this stage the need for the building arises and legal and financial consequences are estimated. Constraints for the exploitation and maintenance needs can be set by in this stage. Some or all parties, separately represented in the dashed rectangle in this figure (financier, instigator, commissioner and the one exploiting and maintaining), can be the same organisation. The contacts between these different parties are most often on a single project base. Together they set design wishes, demands and constraints for the design stage.

4.2.1 Design stage

In the design stage, the architect develops an idea that is presented to the commissioner for approval. In the design stage continues contact with the commissioner is needed for approval of all design stages. Architects contract other organisations for calculations, specification development and engineering advice. Contacts with these organisations are usually long term. At the end of the design stage building specifications, drawings and calculations are presented to the commissioner.

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[12] Interview questions can be found in appendix E

Organisations in this stage would have to invest time and money into a new system like the lexicon. Costs arise from purchasing the system, educating users to use it and maintaining it. The gain is mostly in a satisfied customer and possibly easier communication advisors and engineers. Although in combination with IFC's[13]

4.2.2   Building stage

Then the building can be built, the commissioner now finds a building contractor that offers the best combination of price and service. The contractors use various sub-contractors. These contacts can be long term, but often the choice of sub-contractors is based on geographical aspects or because of specific demands.

It is possible that changes in working methods will occur after adopting a new system like the LexiCon, some employees will have to be educated in using the system. In this stage a smaller percentage of the employees will have to work with the system, while the benefits should be larger than in the design stage.

4.2.3   Exploiting/maintaining

The one exploiting and maintaining the building usually has contact with the commissioner of the project regarding the maintenance demands and possible with the architect regarding the impact certain design choices have on these demands. During the building stage contact between the maintaining organisation and the contactor ideally exists regarding changes in the design, necessary during the building stage, due to time or budget constraints.

Since most large exploiting companies have either their own maintenance department or use only a few other organisations for their maintenance, improvement in this stage not in better communications between exploiting and maintaining. Most gain can be found in the better documentation of the object to be exploited or maintained although better comparison of maintenance offers, due to clear descriptions of object to be maintained, can deliver a financial benefit for the exploiter. The maintenance organisations can estimate maintenance requirements easier, but have to compete with more companies.

4.3   Cultural aspects

Combining the fact that there are over 70.000 organisations in the Dutch B&C industry with the knowledge that organisational culture differs per organisation, it is impossible to state specific details. A number of generalisations can and have been made. They will be presented according to aspects Rogers defined[14].

Company size and industry type
The industry as a whole has the image of being a slow adopter. With less than one percent of the organisations larger than 100 employees and almost 90% with less then ten employees, the company size is generally small.

Organisational slack
The margins in the B&C industry are small, there is much competition and price is the major point of competition. Therefore most organisations have a small amount or no organisational slack.

System openness
The B&C industry exists for its cooperation; therefore system openness tends to be high in this industry. However, some organisation work mostly with the same partners, these organisations are less open, although they can have many external contacts.

Complexity
In most stages, a high level of skill and expertise is present in the employees. Mostly this expertise is focussed on specific skills, which lowers the level of complexity in the general B&C organisation.

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[13] See paragraph
[14] See paragraph 2.5.2

Centralisation/formalisation and interconnectedness

Larger organisations tend to be more centralised and formalised; however, more generalisations cannot be given for the B&C industry. The degree of interconnectedness is also different per organisation and impossible to generalise.

4.4   Opinion leadership

Considering all contacts presented in the previous paragraph opinion leaders for the different stages could be sought. Considering the intended use of the LexiCon for supporting communication and cooperation through the use of IT, some important groups have been overlooked.

The software developers work with the research community to innovate. The research community consists of a huge number of organisations of which STABU is one. The government is funding the research on top of which contributions from the application users can be gained by developing something they can use directly, like NBD-online [WWW11] in turn the research community can use the application users as subjects for research. The software developers must do the same to create applications that are useful. The government can demand the use of an innovation, in the case of the LexiCon, demand an organisation in the B&C industry to use a specific information standard. This is usually not recommended, but can be necessary at some stage. See figure 8
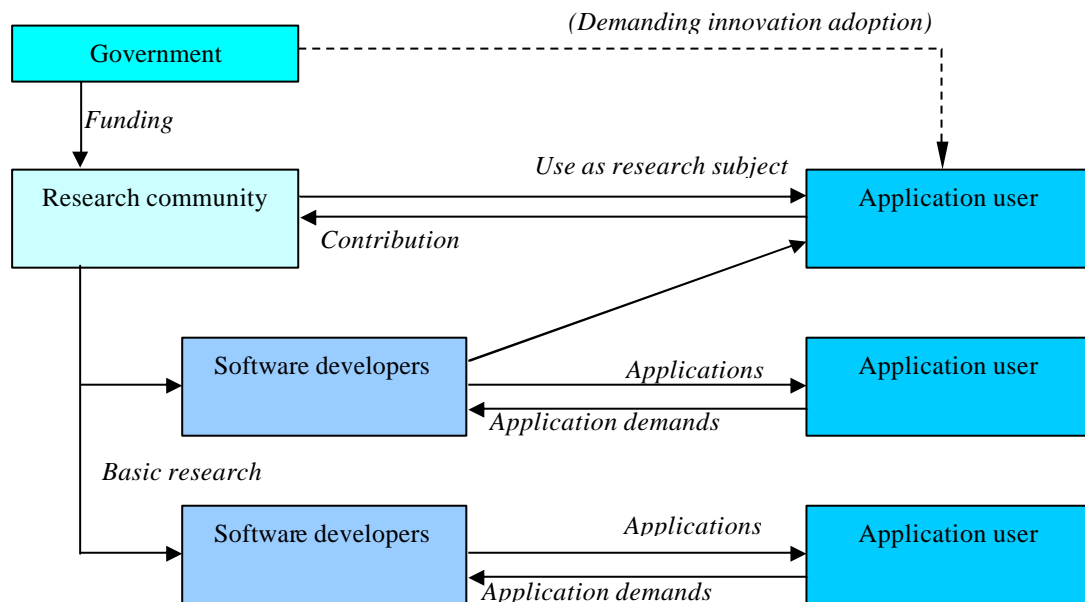

Figure 8:   Relations between government, the research community, software developers and application users

Below these categories are explained in more detail. Since it is impossible to list all organisations active in these categories[15], an explanation for its importance or an example is mentioned. Moreover there appeared to be hardly any consensus towards an opinion leader in these areas.

4.4.1   Government

The government has more than a double role in the diffusion of innovations. It funds the research community in developing innovations. In the form of a study commissioned by the ArtB and executed by ir. D Spekkink into the ICT-development in the B&C industry. This resulted in the 'Quick-scan ICT in de bouw'. Based on this report six initiatives, concerning the structuring of information and information flows, were considered to be complementary rather than exclusive. Therefore, representatives of these initiatives were brought together to co-operate and harmonise

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[15] Although ir. T. v Leeuwen will be giving an exstensive overview of the research community in a study to be published in 2005

all structures. PAIS is the platform in which these six initiatives are cooperating. The LexiCon is one of these initiatives. [WWW6] PAIS has already drawn the conclusion that a new industry wide information standard will only be used when the B&C industry is forced to do so by its customers. The Dutch government, as commissioner of large building projects, should, according to PAIS, play a large part in this by demanding the use of a new standard in the project.

4.4.2   Research community

The research community for the Dutch B&C industry consists amongst others of TNO, STABU and various universities. Software developers can also perform research, however, in light of the competition this usually stays within the organisation. Complementary to the research institutes, collective research programming institutes oversee the general direction of all research. PSIB, SBR and ISSO are some of these institutes. PSIB has a budget from governmental funding that is granted to organisations that meet specific criteria. PSIB was founded by the government and accepts the conclusions of PAIS.

4.4.3   Software developers

A large number of software developers are active in the B&C industry. Quite often they focus on software for one particular stage in the building process or one particular product range. The combination of support for communications between different stages with functioning applications has not yet been successful. A number of software developers are cooperating in *"Forum systeem huizen bouw"*. This association of software developers cover all aspects of building information. In an interview with the president of the association, it became clear that the association recognises the outcome of the *"Quick scan ICT in de bouw"*. The association agrees that effort should be put in the development of applications based on the data structuring initiatives that have evolved as opposed to developing new data structures.

4.5   Critical mass

Critical mass, the point where diffusion of the innovation becomes self-sustaining[16], can be reached on different levels, within the research community, amongst software developers and within the B&C industry. The association of software developers mentioned above, are willing to adopt the LexiCon and to create applications based on it, when it is clear this initiative is supported by the research community and the B&C industry. As we have seen before, the B&C industry will adopt applications based on a new information standard, but not a new information standard as such. A chicken and egg problem in the making. Finally the research community recognise the potential of the LexiCon, however considering previous attempts at developing industry wide information standards they will support it fully if the intended benefits can be demonstrated. Moreover, the research community is always in motion and the fact that the development of the LexiCon has already taken a long time decreases it attractiveness.

The chicken and egg problem is now complete, since the research community and the B&C industry will start adopting if the benefits of the LexiCon have been made clear by functioning applications and the software developers will only start developing applications if the research community and the B&C industry have chosen to adopt.

4.6   Conclusions

Considering the cultural aspects of the B&C industry, a quick diffusion and adoption process of the LexiCon is not to be expected. The area where the new standard is to be implemented is wide and to choose a most opportune starting point is difficult. Most organisations in the industry tend to only adopt when significant gain can be foreseen on short notice. Another way to ensure diffusion and adoption of an information standard can be to enforce the use of the standard at any building stage (architectural, building or maintaining) on the commissioning of a large project.

At whatever stage of the building process the use of the information standard is demanded, applications will be needed to actually make it possible. For support reasons relationships with

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[16] See paragraph 2.6.2

knowledge platforms and software developers should be kept close. Through telephonic questioning of a number of building contractors it became clear that the search was not for an information standard in particular. A new software application that "could do everything the old one could, just better" was wanted. Current division and methods of work were preferably maintained. The price appears to be of importance, but more in terms of return on investment and the cost of maintenance than in terms of actual purchasing price

Aspects of organisation and environment that positively affect the diffusion and adoption
Potential recognised by research community software developers and government
Close fit with predicted future developments[17]
Wide range of opportunities

Aspects of organisation and environment that negatively affect the diffusion and adoption
Most generalisations of organisational culture predict a slow diffusion and adoption process
No clear opinion leaders
Investments to be made and benefits to be gained are different per building stage

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[17] See chapter 3 and appendix C

5   Expert panel Discussion

5.1   Introduction

In order to generate conclusions from the aforementioned information an expert panel discussion was deemed necessary. To start the discussion I created seven thesis considering the wishes or demands from the B&C industry concerning innovations. In this chapter these theses are presented to the reader and the results of the discussion is presented afterwards. After the summary of the discussion is presented, conclusions will be drawn. The conclusion will be presented per focus point. These conclusions will provide the basis for the overall conclusions and the recommendations in the following chapter.

5.2   Theses

My theses focus on three main points for diffusion of the LexiCon. I decided upon these focus points after my interviews with several experts and telephonic questioning of organisations in the B&C industry. They appear to stroke with the theory.
The first three theses about the compatibility with current working methods are meant to find out whether the standard should be adapted to the working methods or vice versa, whether it should focus on specific parts and in what way cooperation with software developers should be sought.
The next two argue that the LexiCon should be mandated in order to start adoption and question who should mandate the use of the LexiCon, the customer or the government.
The last two theses try to find out whether STABU foundation's image interferes with the possibility of developing and selling software and on which organisations it marketing should be targeted. Between these two theorems, a member if the expert panel posed the theorem that the developer of the LexiCon, in this case STABU, should provide open source software to access and work with the LexiCon. It was considered to be a logical follow up of the previous discussion and thus discussed. (It is inserted as six alpha)

Thesis	Deals with
One	Compatibility with current working methods
Two	On what information should be focussed
Three	Who should be developing the applications
Four	Should the use of the LexiCon be mandated
Five	In what way can the use of the LexiCon best be mandated
Six	What is the role of the STABU image in developing STABU software
Six alpha	Should STABU provide open source software to work with the LexiCon
Seven	Who should be targeted by a marketing campaign

Table:1 subject of theses

5.2.1   Compatibility with current working methods

In order to get adoption within the B&C industry it appears to be necessary to implement the LexiCon within the current working methods. This can be done in different ways and through the first thesis we try to determine whether to adapt the standard to the working methods or the working methods to the standard. The scope of the standard and the type of applications are subject of the next two theses.

Thesis one
Despite the fact that compatibility with current working methods is considered important, an ideal data standard should be developed separate from these working methods, if necessary these working methods should be adapted to the data standard.

Thesis two
In developing the LexiCon, one should not focus on all information needed in all stages of the building process; instead they should concentrate on a data set that is shared by most stages in the building process.

Thesis three
In developing the LexiCon, software developers currently active in the B&C industry should be asked, to create applications that are similar to the current applications, but are based on the LexiCon. This means organisations can work with applications that appear the same, but have better interoperability.

5.2.2   Mandate the use of the LexiCon

The benefits in the design stage of a building process for the LexiCon are in far worse proportions to the gains than is the case in either the building or maintenance stage. To get the organisations from the design stage to adopt the LexiCon to get a large advantage in the building stage, a mandate, by the government or the commissioner of a building project (in thesis five, customer and policy maker can be the government, they play different roles and on a different scale; one company versus all companies). Whether or not to mandate and if so, in what way to mandate the use of the LexiCon is covered by these theses.

Thesis four
Organisations in the B&C industry only adopt innovations (of this magnitude) if it is mandatory by governmental rule or circumstances, no matter what theoretical advantages it offers.

Thesis five
Mandating the use of the LexiCon can only be done as a customer, not as a policy maker.

5.2.3   Marketing and Image

Since it appears that the B&C industry will wait for successful applications before considering adoption. This lack of applications creates a dead lock situation where the B&C industry waits for applications and the application developers wait for the demand for applications. How to force a break in this situation could be revealed through these theses.

Thesis six
The current image of STABU foundation (a dusty governmental foundation) prohibits the successful introduction of STABU software; hence, STABU foundation can only market the LexiCon in cooperation with software developers.

Thesis six alpha
STABU needs to provide open source software to work with the LexiCon.

Thesis seven
Organisations in the B&C industry are not actively seeking innovations, software developers do, and hence STABU foundation should aim their initial marketing campaign on software developers.

5.3   Discussion

5.3.1   Compatibility

Thesis one
After finding out that an innovation like the LexiCon most likely will have influence on the working methods, it is discussed that applications that work with the LexiCon can be build in a way that it goes unnoticed. It only works in the communication layer. Working methods will change as a result of the improved communications. So to improve diffusion, the applications will first have to be based on the LexiCon to improve communications. The changes in working methods as a result of the improved communications must also be supported by the LexiCon. As far as these changes can be foreseen, applications can be prepared and the migration paths can be prepared.

Thesis two
By focusing on a specific set a lot of information is missed, therefore it will only be applied in a few sectors. A standard way of describing information, based on set definitions, an object library to put the information in and a format to exchange it with, are starting points for wide diffusion and adaptation of the LexiCon. A possibility to add specifications to objects, described by definitions, is necessary. For different applications a different set of specifications is necessary, they all come from the same master file of the object.
The fact that the definitions should be set and maintained by an organization other than STABU is without a doubt for STABU.

Thesis three
Software developers can play different roles with respect to the LexiCon. They can create libraries (although this is considered to by a highly specialized job), or applications to access libraries and can facilitate in the possibility to communicate about building objects by means of an exchange format. For all these actions a standard to base them on is necessary, but this is excluded from governmental funding due to the fact that STABU is a foundation and that the LexiCon is not an application. Software developers only invest in a standard if they feel confident it is supported, since a standard will only gain support automatically if it can be demonstrated with applications, a deadlock situation occurs. Creating a common idea, with software developers, that the LexiCon is the key to the integration of applications might open the situation up.

5.3.2   Mandates

Thesis four
Innovations that can prove their effectiveness immediately and show their future potential clearly, are soon to be adopted (consider faxes and mobile phones); it is about the theoretical advantages that skepticism exists. Therefore in these situations mandating the use of the LexiCon can be the way to create the pilot project necessary to prove the functionality to reach critical mass. Financial benefits have not seemed to help in the diffusion of a digital ordering application. Before organizations will work with information that they have not entered themselves, a certain amount of trust is necessary. Software developers who have already developed their own standard are not likely to adopt easily even if under mandate. IFC however proves to be working anywhere but in the Netherlands.
Moreover the panel stresses the need for filled object libraries to start the development of applications. The fact that these object libraries need to be correct and trusted is deemed inevitable considering the wide range of possible errors that could result from one error in the object library.

Thesis five

A number of standards are already based on governmental mandate, so therefore the thesis is already untrue for this part. But it is true as far as the mandate from the customer is concerned. In situations where the commissioner and the future maintainer are the same, the advantages of information in a LexiCon format can be shown with a maintenance support application based on the LexiCon. This way large customers can enforce the use of LexiCon based applications, but again only if applications are available or conversion is possible.

Furthermore the contradiction is not seen as such; instead the roles of policy maker and customer are compared, as being the same if not the policy maker would mandate it for all projects and the customer for one. Governmental mandate provides widespread use, because organizations from different stages can be targeted. Finally we come back to the deadlock situation from thesis three where there is no funding for the development of the standard that can only be mandated after completion of it and the libraries based on it.

5.3.3   Marketing

Thesis six

Whether or not STABU foundation should develop software depends on several factors. First there is the control of the LexiCon standard; this cannot be combined with the development of applications based on it. The LexiCon is meant to be controlled and maintained by an organization other then STABU.

Furthermore there is such a wide variety of possible applications that STABU foundation could not possibly provide them all. Moreover why develop a CAD application when are already based on a working standard, IFC with which the LexiCon is being coupled. Last point against making software would be that the LexiCon could be possibly specially fitted for STABU application while connection with other application becomes less possible. This is should be solved by the fact that control of the LexiCon is placed external to STABU foundation.

Thesis six alpha

Open source software creates the risk of changing the basics of the LexiCon, free software does not provides a source code, but a can provide a handle to use the LexiCon. On top of the better security of the basics of the LexiCon, freeware can provide the opportunity to maintain a record of applications and their developers and control the quality by providing approval certification. Possible coupling with other standards currently in use (like IFC) should be considered.

Thesis seven

Software developers are ready to create applications based on LexiCon object libraries. But as yet there is no complete LexiCon yet and there appears to be no demand for LexiCon based applications. This demand needs to be created. Therefore applications for demonstration need to be developed. Software developers will only work with complete object libraries… I have seen this before. Next to needing complete object libraries for the start of application development, an exchange format is vital in providing the benefits intended by the LexiCon. As a positive side effect, an exchange format also sets the access formats of the object libraries. This way they can be geographically distributed and accessible from one computer with internet capability. Considering the size of the libraries and the effort needed to maintain them, a high level of quality can be demanded through assigning this task to separate organizations. However, financing these organizations probably involves financial consequences for the use of the libraries.

5.4 Conclusions

From the discussion we can conclude that first of all applications need to be developed.

To force a breakthrough in the deadlock situation, where the industry needs applications and the software developers will not start developing applications before the standard has proven itself, mandating the use can be a solution. This does provide a need and thus a demand in the B&C industry. However, this does not diminish the fact that applications are needed. Whether the use of the LexiCon should be mandated per project or nation wide (by law) is a matter of scale. One organisation or all organisations; however mandating the use by law will probably create more resistance.

Since the range of applications that can possibly be based on the LexiCon is so big, this can hardly be left to one organisation. In order to get as many organisations developing applications based on the LexiCon, good tools and documentation are necessary and preferably available at low cost. Free registration software for this purpose keeps STABU in the position to control the quality of the LexiCon based applic ations.

6 Conclusions and Recommendations

6.1 Introduction

In this final chapter the conclusions of the theses discussion are presented. These are combined with the results of chapter three and four. The conclusions will lead to recommendations for steps STABU foundation can undertake and the conclusions that cannot be drawn become clear in the recommendations for future research.

6.2 Conclusion

In short the conclusions from the expert panel meeting are listed per thesis focus point.

6.2.1 Compatibility

With regard to the compatibility to working methods it is best to disregard the current working methods and build a clean standard of definitions with an expandable set of specifications. Combined with an exchange format, the organizations in the B&C industry will get interested as well as software developers for the B&C industry whom are necessary for the diffusion process since organizations in the B&C industry can adopt applications, not a standard. Next to the availability of the standard and the exchange format, the software developers need complete and correct object libraries. These object libraries hold the keys to create LexiCon based applications, and thus demonstrate the use of it.

The tools to access and use the LexiCon based libraries should be provided by STABU, considering the fact that STABU foundation has created it. A demonstration should than be prepared to interest the B&C industry. Which aspect of the industry should be targeted first will be discussed below.

6.2.2 Mandates

Innovations have proven to need observable functionality as well as a clear advantage that was previously unavailable to be diffused by itself. (The fax had these advantages for the B&C industry and the mobile phone, well, look in your pocket) If these advantages do not appear so clear mandating the use of the innovation could prove helpful. But before it can be mandated applications need to be available, for which a demand and object libraries are necessary. By creating demonstrations in the use of the LexiCon as a tool in maintaining large building projects, customers that commission and maintain large projects (possibly governmental), the use of the standard can be demanded from the commissioning of the project. To get the assignment the organization will have to work with the standard.

Furthermore the difference between the roles of policy maker and the role of customer in this context is that the customer demands the use of the LexiCon in one project and the government would do it for all projects. Both ways are possible and work in their own ways. Mandating the LexiCon is considered to preferably be done by commissioning large public (and thus known) building projects one at the time to prove its efficiency in these pilot projects and help the diffusion process.

6.2.3 Marketing

For applications on all areas of building and construction there are various suppliers. So there is strong competition. Not making the software itself and entering areas with strong competition, but focusing on the exchange format, creates an advantage in the knowledge of the exchange format as well as the possibility for industry wide adoption.

Moreover, coupling with other standards like IFC's will have a positive impact on the acceptance of the LexiCon. Although CAD and hence IFC are not very much used in the Netherlands, worldwide they are much more accepted providing a basis for the international diffusion and adoption of the lexicon.

The software tools to access and use the LexiCon can best be provided as free software, in this way STABU is able to track developers that use it and certify applications. Next emphasis must be placed on a standard fort the exchange for information.

6.3 Recommendations

6.3.1 Awareness and applications

In order to diffuse the LexiCon in the B&C industry, applications are necessary, in order to get applications developed, support for the LexiCon by the research community is necessary. The recommended order in which to create awareness for the LexiCon is to start with the research community, then convince the software developers, and finally persuade the B&C industry by demonstrating the benefits.

Since funding is available for organisations (not foundations) and for application development (not for standard development), finding (or starting) a separate organisation that can apply for funding to start developing applications based on the LexiCon seems to be a logical choice[18]. The legal consequences should be subject for further research.

6.3.2 Future research

Development of applications
In order to determine what application should be developed first, more knowledge concerning the technical possibilities of the LexiCon should be gained. A study into these technical possibilities combined with a study into the demand from the B&C industry regarding new applications is recommended.
Subject of this study should be:

- The speed at which an application can be developed (is the LexiCon ready for the application, or does it need to be developed further)
- The profitability of the application (demand, competition etc.)
- In- or out-sourcing of this software development (legal consequences)

Opinion leadership
Next more knowledge about opinion leadership should be gained. Are there organisations that perform the function of opinion leader, or do research institutes play this role? Does this differ per stage of the building process? (Meaning; do architects look at different research institutes for guidance than for instance contractor firms?)

Connecting the LexiCon
A standard for CAD applications is being developed by the IAI in the form of IFC's, a standard for the cost-information is (on a national level) being developed by, amongst others, the Uneto/VNI and Building Plaza. Should the LexiCon be made to connect to these standards in development or should the LexiCon be developed further to incorporate this information in itself?
The technical knowledge necessary to predict the possibilities of both options is not yet mine; therefore I recommend further study into this subject.

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[18] For a more detailed step by step plan see appendix D

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The following websites have been used to gather information

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[WWW2] http://www.iai-international.org/iai_international/Information/History.html

[WWW3] http://www.bouwweb.nl/persmap/011127bouwenict.html

[WWW4] http://statline.cbs.nl

[WWW5] http://www.econstruct.org/6-Public/Summary/eConstruct_summary.htm

[WWW6] http://www.bouwspiegel.nl/sse/sseextract.asp?id=31&docid=7&L=2

[WWW7] http://www.bouwned.nl

[WWW8] http://www.bouwspiegel.nl

[WWW9] http://www.buildingplaza.nl

[WWW10] http://www.cram.nl/ieni/950106.htm

[WWW11] http://www.nbdonline.nl/

[WWW12] http://www.stabu.nl/

[WWW13] http://www.paisbouw.nl/

[WWW14[http://www.icis.org/

Appendix A

NL/SfB

In 1947 the "Samarbetskommittén för Byggnadsfragor" (roughly translated collective working committee for building related problems) got the assignment to develop a standardised system for the archiving of all information in the building process. In 1949 this resulted in the SfB system. The international building classification committee reviewed 50 different classification systems from numerous countries and recommended the SfB classification method. In 1966 the first international edition of was released. This consisted of tables one, two and three.

The English have added two tables (table zero and table four, thus creating CI/SfB) on which the Dutch based their system (NL/SfB).

In these five tables building elements are categorised into recognisable groups. **Table zero** contains the build environment; consisting of building types, residential areas (country, province, city) and spaces (living room, kitchen etc.)

Table one consists of parts (elements) of buildings.

Table two and three are used in combination where the construction shape can be found in table two and the means of production, for instance bricks (table two) of baked clay (table three)

In the last table (four) abstract concepts like activities and properties, for instance vibrations, have their place.

Table zero and one are built with nine rows and nine columns table two three and four are based on letters as well as numbers and have twenty-six columns and nine rows. This shows one of the shortcomings of this method in the fact that it cannot be extended.

The representation of any element consists of a string of numbers and letters from all tables.

Example:

The vibration of an exterior wall of a house build by bricks of baked clay is represented in the following form:
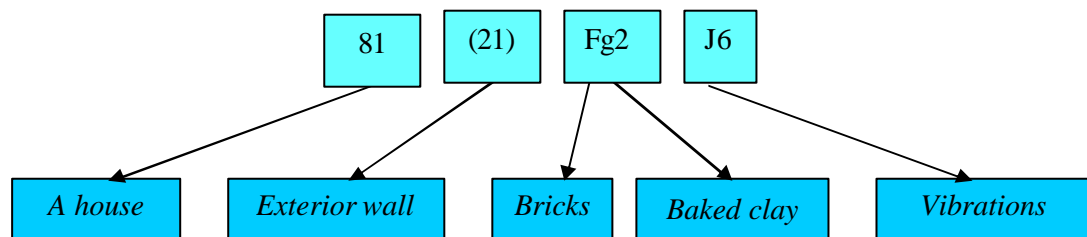

Figure A.1: example of NL/SfB

The SfB method was developed in order to create a logical classification for elements in the B&C industry. One of the drawbacks of this method has already been given (the fact that it cannot be extended). Other weak points are that it is solely a classification system; it cannot contain information about the built objects and the fact that, unless the numerical codes to the elements one wants to describe are known, it takes time to find the correct code in the tables.

Appendix B

Founding of STABU

STABU foundation was founded in 1976, under auspices of the association of UGCB (Uniform foundations and coordination of information in the building industry), as a result of conversations between, amongst others, Ministry of Waterways and Public Works, Foundation RAW (rationalization and automation of ground, road and waterways), MVRO (ministry of public housing and environmental planning), CCP (communication civil projects) and committee A17 of the SBR (foundation of building research).

Management of the foundation was in the hands of a steering committee which consisted of: MVRO, BNA (confederacy of Dutch architects), ONRI (order of Dutch consulting engineers) and the AVBB (general association of building industry). From the beginning the main goal of STABU foundation was to develop a master specification system for the Dutch building and construction industry. In 1979 it became clear that the original estimate of 2 years and one million guilders was not enough to develop the specification system, moreover it was decided that STABU foundation should become more independent in guiding and controlling itself. In addition to these organizational changes four new members were invited to play an active role in the management of STABU foundation. These were UNETO (union of electro technical entrepreneurs), the ACL (general association of central heating and air treatment industry), the AVOL general association of plumbing-, sanitary fitting-, and gas heating entrepreneurs) and the ministry of defence. On top of that the possibility of joining the user circle of STABU foundation was created, through payment of a contribution big suppliers and sector organizations got the opportunity to participate in the development of the standard.

ICT development by STABU

All this resulted in a national building specification standard that was presented to the public in 1986. In light of the developments in information technology it was decided that, in addition to the paper format of the specification system, a digital version was to be made. Considering the wide variety of applications being used in the construction industry, STABU foundation decided to outsource the development of the applications using the STABU specification system in order to ensure compatibility between different building specifications software. Users of any software based on the STABU specification system have a license agreement with STABU foundation and the developers of the software themselves have development licences with STABU. Because of the integration of SRW (standard reference specifications for house-building) and the SROW (standard reference specifications for housing maintenance) in the STABU specification system and the leap forward made by information technology a new specification system, STABU2, was developed. This system was still text based, as was the first one, however this time it was based on a relational database and thus easier to use. In 1991, most of the licensed STABU users transferred to the new system.

Evolution of STABU foundation

The completion of the building specification system also entailed the change from a developing organization to a service organization. STABU foundation now provides service for users of the STABU specification as well as courses in writing building specifications.

To control the emerging STABU specifications building materials manufacturers started to incorporate in their product descriptions, STABU foundation started to provide a new service to manufacturers; describing their product with STABU specifications.

STABU

After STABU2, which is still widely used in the B&C industry in the Netherlands, STABU foundation is now busy developing "STABU-element". This development combines the current STABU2 system with the NL/SfB. It is considered to be a logical step between STABU2 and the LexiCon. Because most calculation applications in the Dutch B&C industry are based on the NL/SfB, "STABU-element" should ease the coupling of building specifications and calculation applications.

In combination with the development of "STABU-element" STABU foundation is asked to provide the next issue of the NL/SfB. The next issue of NL/SfB will only differ from the existing one (dating back to 1991) in places where additions are deemed necessary. The current content will stay the same and will be supplemented with 'elements' that are not yet incorporated in the system.

Appendix C

History

In this paragraph a short introduction into the history of the B&C industry is given. A short explanation of the classification system for building object that is currently the most used system is presented in the second sub paragraph. After that the evolution and use of ICT in the B&C industry gets some attention and this history lesson is concluded with a history of STABU foundation.

Building and construction industry

In 2003 over seventy thousand organisations were active in the B&C industry in the Netherlands alone. Less than one percent of these organisations had over 100 employees.

Concerning the degree of specialisation a two-way division can be seen. On the one hand more specialised organisations have evolved; consider for instance a contractor that specialises in the placement of aluminium window frames. On the other hand, and this is usually the case in bigger organisations, more diversification is sought. HBG (Holland Beton Groep) has broadened their work field through acquisition of other organisations.

Since the European Union demands large projects to be realised by international consortia and people from different backgrounds, the communication difficulties inherently involved in building and construction have only grown further. One of the first initiatives to unify the terminology in the B&C industry is the SfB method developed in Scandinavia in the late 1940's.

ICT in construction

Basically the information needs in the B&C industry consists of three different types of information: geometry, quality and cost. Geometry handles all graphically represented data, quality concerns the building specifications and cost speaks for itself. How these information needs have been met by ICT over time is subject of this paragraph.

Type of technology

The types of technology used in the B&C industry evolved in the same way as in many other businesses. First mainframe computers were used. These mainframes needed to be programmed from scratch each time they were used. Later stand alone work stations became common practice. Consequently these stand-alone workstations were connected through a network creating networked environments. When these networks became connected to external networks, wide area networks (like internet) were created. This offered new possibilities in geographically distributed cooperation. The next step in internet technology, as developed by W3C, is the semantic web. This semantic web uses web ontology language (OWL) which means data on the web can be interpreted not only by humans, but also by computers.

Type of use

The use of information technology got more divers as the technology evolved. The mainframe computers were basically good for one thing; calculating. In a design environment they were used to calculate forces on objects to be build. When PC's became small enough to function as stand alone desktop computers designing building via computers became possible. Drawings and building specifications were now created using a computer instead of a drawing board, pencil and paper.

It was not until computers became interconnected that planning and budgeting could easily be done using computers. The networked computers were necessary for this step, because information from several different stages (which different individuals had created) needed to be combined.

When the internal networks were connected to external networks, it became possible to order supplies on-line and to interconnect geographically distributed offices from one organisation. Various uses of internet evolved, amongst others application service providers and online project databases. (All information about one project is collected in one database and various users can always get the most up to date information)

The semantic web will create new possibilities that can hardly be overseen so early in the development of this technology. [M. Bohms]

BIM

In the second part of the 1980's the Dutch government tried to stimulate innovations in ICT by means of an innovative research program for the B&C industry (iop-bouw). In 1989 the iop-bouw presented the BIM, an information model for the B&C industry. The objective of BIM was to create a standard for information exchange in the B&C industry. Because of the broad scope of this project (covering aspects of the building sector) and the fact that the research was conducted more or less without interaction with the actual B&C industry, it was very abstract and complex. Hence it was not a success.

On a positive note, the avbb points out that the iop-bouw has led to more cooperation between the research and the building community. Moreover, an important result of this program is the use of object oriented data models.

Recent events in ICT for the building and construction industry

In the building and construction industry communication is extremely important. In every building project several parties – clients, financiers, architects, designers, several building contractors, suppliers etc – cooperate to create one building. To facilitate this process ICT could very well be used, however, although the benefits are realized, the use of ICT has not evolved as quickly as one would expect. The B&C industry can therefore be classified as a slow adopter when it comes to ICT innovation. In this paragraph I will discuss technologies and organisations, direct or indirect, responsible for the development of new technologies.

National (Dutch) level

Research on the use of ICT in the Dutch BC industry is conducted by a large number of organisations. It is "a jungle of abbreviations" which all seem interconnected. Based on interviews with a number of experts in the field of ICT in the B&C industry, three will be discussed briefly below.

STABU

After STABU2, which is still widely used in the B&C industry in the Netherlands, STABU foundation is now busy developing "STABU-element". This development combines the current STABU2 system with the NL/SfB. It is considered to be a logical step between STABU2 and the LexiCon. Because most calculation applications in the Dutch B&C industry are based on the NL/SfB, "STABU-element" should ease the coupling of building specifications and calculation applications.

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Pais

In 2001 the ArtB commissioned ir. D spekkink, to conduct a study into the ICT-development in the B&C industry. This resulted in the 'Quick-scan ICT in de bouw'. To profit from the benefits ICT could offer structure is needed in the information and information flows in the B&C industry. This problem has an organisational basis, not an ICT basis; hence it needs to be solved within the B&C industry.

Based on this report six initiatives, concerning the structuring of information and information flows, were considered to be complementary rather than exclusive. Therefore, representatives of these initiatives were brought together to co-operate and harmonise all structures. PAIS is the platform in which these six initiatives are cooperating. The LexiCon is one of these initiatives. [WWW6]

PAIS has already drawn the conclusion that a new industry wide information standard will only be used when the B&C industry is forced to do so by its customers. The Dutch government, as

commissioner of large building projects, should, according to PAIS, play a large part in this by demanding the use of a new standard in the project.

PSIB
PSIB is a committee responsible for coordination of innovation initiatives in the B&C industry. Its aim is to establish a general direction for innovations in the B&C industry. Cooperating with knowledge platforms, research institutes and universities, it tries to converge all initiatives in order to create coherence. Funding of research initiatives can be granted by PSIB and comes from a 30 million euro budget at PSIB's disposal.

International level

On the international level various initiatives have been taken. As is the case on a national level, the research community on an international level comprises of a jungle of abbreviations that are all interconnected somehow. Three initiatives are highlighted here because of their link with STABU or the effort to standardise building and construction information.

IAI
In 1994 12 companies in the US felt there would be substantial economic benefit gained from interoperability of different software applications. When it had been proven possible, the realisation of the global nature of the industry persuaded the members to take the message abroad. This resulted in nine national chapters of the International Alliance for Interoperability.
It was decided that the development work would be based on the EXPRESS data definition language that had been developed as an ISO standard within the STEP project. This decision meant that a lot of basic research was already done and the IAI could focus on applied research (for explanation of these terms see chapter two) and utilise R&D efforts from many leading businesses that based their work on EXPRESS.
Although the mission statement of the IAI "Providing a universal basis for process improvement and information sharing in the construction and facilities management industries" gives the impression of a multidisciplinary standard, IAI and their Industry Foundation Classes (IFC's) are commonly linked to CAD applications.
Currently, STABU foundation participates in IAI XM7. The objective of this work-group is to harmonise object libraries based on ISO 12006-3 with the IFC's and property sets developed by the IAI.

ICIS
In 1989 STABU foundation organized a meeting between similar organizations in Europe; this successful meeting resulted in the establishment of the building specification group. This name changed to ICIS, international construction information society, in 1993. Currently this society has grown into a global organization since Japan, the USA, Canada and New Zealand joined.

eConstruct
The objective of the eConstruct project is to help the European B&C industry to build faster, cheaper and better, by developing, demonstrating and disseminating a new Communication Technology that is specifically tailored to the industry's needs.
To do this eConstruct has developed bcXML, a computer interpretable language describing products needed within the B&C industry. eConstruct focuses on e-procurement, by describing product catalogues in bcXML in order to easily communicate about and order building parts.

Future developments in ICT in the B&C industry

According to Edwin Dado [Dado 2002] the future of ICT in the B&C industry will aim at the support of three basic reasons for improved ICT support.

1. A shift form paper based information systems to electronic information systems.
2. Improved and integrated support for the time-critical construction information transformation process and the material transformation process.
3. The integration of applications.

He considers object technology, Java, Internet, XML and product data modelling to be the ICT founding for these changes.

Integrated systems; full building cycle

Specifications needed in different stages of the building cycle can be linked to one object and it should therefore be possible to interchange them. To get to a standard that has full compatibility with all the stages of the building process and is accepted by the B&C industry problems have to be overcome, but the benefits appear worth it.

Supplier information

In the Netherlands, Uneto/VNI has set up an object library for the use in e-commerce for specific sectors as part of the ETIM/ITI project. Supplier information is presented in a uniform way in this project which helps customers to clearly describe what they want and compare different suppliers more easily. For suppliers the advantage is the fact that information stored in this way can be imported into different software applications. In the design stage the supplier of different parts could be specified.

Drawing and designing with objects

More and more CAD applications work with objects, meaning that instead of drawing a line, a designer virtually builds a wall in the computer. The IAI is currently working on IFC's to be the model for these object libraries for CAD applications. The LexiCon seems to connect with these IFC be it with more specification options. Linking both is an option now under investigation both by the IAI and STABU.

Maintaining building objects

If throughout the entire building process a single information standard has been used, it would be possible to produce maintenance schedules or budgets etc based on this LexiCon based building information. However for this to work properly not only the basic design of the building object will have to be known, changes made later will have to be added to this.

International developments

The fact is that, through increased communication possibilities and fast transport as well as the unifying of Europe and international commissioning of building projects, international compatibility of information is gaining importance. Moreover contact with the IAI on the subject of connecting IFC's with the LexiCon could provide international support. The ICIS can help STABU gain more international support and possibly help developing applications based on the LexiCon.

Appendix D

The first step; creating awareness

This step will not actually be concluded when the next step is taken, because different parties that will adopt the LexiCon do not do so at the same time and have different interests.

Researchers for instance are interested in the theoretical background of the LexiCon and are likely to be more perceptive to the opportunities it offers. Software developers are interested in the technical structure and the possibilities it offers them. They will have to adopt, because no matter how well an information standard is thought out, it is only as good as the applications that work with it.

The time at which to diffuse the LexiCon in the research world and in the software development branch is not necessarily different. Researcher and software developers will probably use the same software tools to access and work with the LexiCon.

To be able to use the LexiCon throughout all the stages of the building process various different applications will be needed. For instance design, budgeting and calculation software. The order in which these applications should be developed will determine the order in which organizations from different stages in the building process will be able to use, and thus be able to adopt, the LexiCon. Last but not least suppliers should be made aware of the advantages of presenting information about their products in such a way that the LexiCon can work with it. The advantages for the buyer of building products (easier comparison of different suppliers) are not the same as the advantages for the seller (being incorporated in software for the early stages of design)

Research community

The LexiCon definitions are already publicly available. The research community can contribute to the development via the LexiCon website [WWW1]. Creating support however, means more than just availability. It means the LexiCon is perceived as the ideal standard for the B&C industry.

National

In order to diffuse the LexiCon throughout the B&C industry, support from various groups is necessary. As the LexiCon is still in the development phase (see paragraph 2.3.2) support from the research community is necessary. The number of Dutch organisations active in researching building information models and standards is huge. On the international level this number seems to increase exponentially. Various attempts at mapping these organisations and their interrelationships have been made, with varying results. P. v Pelt, gave up the attempt to create an overview two years back, and T. v Leeuwen is still working on his version, but admits to leave some organisations out in order to keep the overview just that, an overview. (His book on information exchange in the B&C industry in which this overview is presented is scheduled for release in the beginning of 2005)

PAIS (see paragraph) has already suggested the LexiCon as the ideal form of a standard for the B&C industry on the level of public and utility buildings (based on the 'Quick scan ICT in de bouw' by D. Spekkink) this helps because PAIS as a platform might be able to get funding from PSIB. Support from TNO would be very useful, because everybody in the Netherlands knows of TNO and the name is associated with quality.

International

Although I would recommend starting diffusion of the LexiCon on a national level, for future acceptance on an international level it is wise to involve international organisations in the development. Currently STABU foundation communicates with ICIS to involve all national master specification systems (quality information). In order to create a broader support for the LexiCon in other categories of information (graphical and cost) other organisations like the IAI (for interoperability with CAD applications) should be sought. Since the IAI is working on IFC's, which are supposed to make the output of CAD-applications uniform, this will also have an impact on the national level. Most designing is done with CAD applications.

Government

Currently the LexiCon is not yet complete; the money necessary to do this can come from different sources. Government funding is one of them and being part of the PAIS project does help. However, government policy currently prescribes that the development of applications based on a new standard can apply for government funding, but the development of the standard itself cannot. All possible means to change this should be utilised.

Furthermore the government as a customer in large building projects should be made aware of the benefits of the LexiCon from this perspective.

Software developers

As was mentioned in the previous chapter, the B&C industry cannot use the LexiCon per se, but only the applications based on it. Therefore support from software developers is necessary. Once applications are built and the benefits of applications based on the LexiCon can be shown, the B&C industry will follow. The LexiCon definitions should be made publicly available (as they are) in order to create wide support in de software development community. Tools to work with the LexiCon can be licensed for a small fee. But in order to get maximum interoperability, the LexiCon should be treated as an open standard.

The building and construction industry

The B&C industry has been classified as a slow adopter of new technologies and tends to turn to an expert (IT consultant) or 'their' software supplier for advice on new technologies. Therefore identifying the experts on whose view organisations base their decision concerning ICT (these ca be seen as opinion leaders), is necessary. (See recommendations in paragraph 512.62993320.9)

How to

With the exception of the government most of these parties can be made aware of the LexiCon through publication in professional journals, seminars, workshops, internet publications and contacts etc. the government will have to be persuaded in a more personal way.

Make potential users (in the B&C industry) aware of applications based on LexiCon and start to persuade them once the applications are developed to a state in which they can be demonstrated. A finished product is needed in the decision state of the innovation decision process.

The second step; developing applications

In contrast to the first step, in this step actual choices will have to be made. The first part of step one; creating awareness within the research and software development community, is pretty much mandatory for the LexiCon to have any future. The second part of the first step, creating awareness within the B&C industry itself, will depend on the choices made in this step.

The direction o the development of the applications is yet to be determined. A number of considerations (should) play a part in this decision.

The type of information involved

Information can be categorised into graphical information, quality information and cost information. According to P. v Pelt, the LexiCon in its current form is best suited for qualitative information. Considering the background of K. Woestenenk, this is not surprising. On top of this, STABU foundation already has a good reputation in the area of building specifications and moreover a large amount of know-how on the subject.

Mono versus multi disciplinary

Considering the basic idea of the LexiCon, to be an industry wide information standard in the B&C industry, multidisciplinary applications seem to be the obvious choice. However, in the current state, the LexiCon is not ready to be utilised in such a way, therefore STABU foundation should first focus on a mono-disciplinary application and considering the expertise of STABU foundation and the current state of the LexiCon, an application for writing building specifications is the obvious choice.

In the previous chapter it was shown that in order to link cost information to any other form of information, graphical and quality information should be linked. Therefore current efforts

concerning the future developments of the LexiCon, in my opinion, should be directed at this coupling of graphical and quality information.

Monodiciplinairy

Simplest are the mono disciplinary applications. This saves time in developing the LexiCon to incorporate all data from all different categories. However this type of applications is already available and competition is plentiful. Whether or not the development of mono disciplinary can be profitable for STABU foundation and the type of application to develop is worth its own research. Examples of mono disciplinary applications are:

- An application for writing building specifications. Although STABU is already market leader in this area, the current system is not based on the LexiCon and will thus have to be replaced before the LexiCon is adopted throughout the B&C industry. The negative aspect is that STABU would be conquering a market already theirs, however, it could be the ideal starting point of the diffusion process for a number of reasons: STABU is already familiar with building specifications and the applications to create them, and has a number of (loyal) clients that might be easily persuaded.
- An application to calculate building costs. Currently calculating building costs is done based on the drawn design of the construction project (for providing measurements) and the quality information in the building specifications. In order to create a LexiCon based application to do the calculating, information about the quality of the objects and information regarding the dimensions of the building (resulting in the amounts of each object) is necessary. The quality information is already part of the LexiCon, the building dimensions (drawn information) are not.
- An application for drawing. In the not so distant past, CAD applications supported only two dimensional objects. An architect drew a line and said it was a wall. Later CAD applications started using multiple layers in order to distinguish between the lines representing walls and those representing plumbing for instance. The latest developments in CAD applications are the use of IFC's, this means designers use objects in a CAD library rather then draw lines. The LexiCon (being an object library) fits into this new development very well. Communication with the IAI in order to couple the LexiCon with IFC's is already underway. The competition in this area is very big (AutoCAD Bentley, Archicad etc. etc.) making it less attractive to create yet another CAD application.

The application for calculating and the application for writing building specifications can be linked with product catalogues (possibly on-line) to provide specification writers with pre-written specifications and calculators with up to date product information regarding prices and delivery times. Coupling CAD applications with this up to date product information can give architects an indication abut the financial consequences of his design.

Multidisciplinary

Considering the intention of the LexiCon as an industry wide standard, multidisciplinary applications should be made, bridging the gap between the different categories of information. Examples are:

- A CAD application that incorporates designing with object in such a way that the building specifications are generated based on the drawings and that gives the architect the opportunity to pre- (or de-)scribe quality aspects on different levels of detail. (Closing the gap between graphical information and qualitative information.
- An application that combines quality information with cost information. Enabling a calculator to calculate the cost of a design based on the building specifications for example. The problem with this link is that the cost of the building project depends on its size combined with the quality demanded. Therefore integrating quality and quantity information (from building specifications and building design) seems the logical step before this one.
- Coupling cost information and graphically represented information would enable the architect to monitor the cost of a building project closer during its design. This way designing within the budget becomes easier. However, just like with the coupling of quality information with cost information,
- The cost of a building project depends on the size (quantitative information) and the materials used (qualitative information), hence before the quantitative and qualitative information can be linked with cost, they should be linked together.

In-house development or outsourcing

Whether or not to outsource the development of applications based on the LexiCon, various aspects should be taken into consideration.

In-house development means STABU foundation is in total control of the functionality of the application. However, this is not the core-business of STABU foundation which means additional investments are necessary. Knowledge of software development will have to be gained (via training of current personnel or hiring new personnel). A feasibility study should be undertaken.

Outsourcing entails its own pitfalls. Like unintended knowledge sharing, the decrease of influence on the end-product and the cost.

Applications based on the LexiCon should be developed in areas where the LexiCon has been accepted as 'the' standard.

Another choice to be made in this step is whether or not to outsource the development of applications. Creating applications, especially without a lot of experience, can be very time and money consuming. Outsourcing the development of the applications will reduce the influence STABU has over the end-product, but could prove much faster and cheaper. In the long run however the quality of the LexiCon will be measured by its applications, therefore STABU should make sure that the applications built are of the highest possible quality. The quality of the application can be monitored very close if the applications are developed internally, if the development of the applications is outsourced, STABU should try to stay as close to the development process a possible in order to ensure quality.

International connection

Considering the possible advantages of an industry wide information standard, a successful implementation should automatically diffuse the innovation abroad. However it has to be noticed first. This can be achieved by keeping contact with as much research communities as possible and by sharing to progress made and problems faced.

Appendix E

Algemeen

1   Wat is uw naam?
2   Waar bent u werkzaam
3   Op welke wijze bent u betrokken bij ICT in de bouw

ICT in de bouw

4   Welke standaarden kent u op het gebied van ICT in de bouw?
5   Op welke aspecten van het bouwproces hebben deze standaarden betrekking?
6   Welke voor en nadelen kleven er aan deze standaarden?
7   Kunt u aangeven waar de nadruk van een standaard in de bouw volgens u zou moeten liggen, op de context of op de inhoud? (Context; abstract niveau waarin relaties duidelijk worden. Inhoud; kwantificeerbaar niveau wat zijn de specifieke kenmerken van het object)
8   Op welke wijze dient een ICT standaard in de bouw ingevoerd te worden?
9   Wie is er verantwoordelijk voor de ontwikkeling van een ICT-standaard in de bouw? Welke partijen kunnen een ICT-standaard voor in de bouw verplicht stellen, aanpassen of anderszins beïnvloeden?
10   Informatie in de bouw kan grofweg in drie soorten worden ingedeeld: grafisch kwalitatief en kostenbeschrijvend. Voor het bewerken van al deze soorten informatie zijn diverse applicaties ontwikkeld. Nu wordt er meer gefocust op de link tussen de diverse soorten informatie. In uw ogen welke link is het belangrijkst? Gr->kwal; kwal->kost of gra->kost
11   In welke mate zijn de diverse applicaties van van Meijel automatisering geïntegreerd? (kan een ontwerper al een voorkeur aangeven voor een leverancier bijvoorbeeld?)
12   Acht van Meijel automatisering een informatiestandaard in de bouw wenselijk/noodzakelijk? Zo ja welke?

LexiCon

13   Bent u bekend met het LexiCon?
14   Kunt u een aantal (3) goede en slechte punten opnoemen van het lexicon?
15   Op welk van de drie eerder genoemde informatiecategorieën is het LexiCon volgens u het best toepasbaar?
16   Welke overlap tussen twee van de drie informatie gebieden is het best haalbaar met het lexicon en bij welke overlap is er de minste concurrentie?
20   Wat moet er volgens u gebeuren om het LexiCon een (internationaal geaccepteerde) standaard te laten worden?

T.b.v. interview

A   Heeft u nog op of aanmerkingen die u naar aanleiding van dit interview kwijt wilt?
B   Heeft u op of aanmerkingen ten aanzien van het interview zelf? Zodat het volgende interview nog beter wordt dan deze?