Making the concept of information operational

Jens Holmström & Tuomas Koli
Department of Information Technology and Media.
Mid Sweden University, Östersund, Sweden.
E-Mail: jeho9800@student.mh.se tuomas.koli@telia.com Web: http://gathering.itm.mh.se/amsido/ovci

Abstract: There is a variety of definitions and models concerning the measurement of information. Some interesting approaches on measuring information have been done, but only regarding the amount of information, e.g. Shannon's model. As we see it, an operational definition and model that regards the *content* of information is needed, hence representing the meaning of the information.

With an ideal design method, other published definitions were examined and compared to our research purpose. Working with a case study, a new definition and a new model of information was created. The result is the Information Container and Package (ICP) model. 16 explanatory variable classes, connected to the model, make information operational regarding the content of the information. These classes altogether make it possible to represent the meaning of information, using the model.

We find our view on information important as a new way of measuring and classifying information. The model can, for instance, be used to measure and study information flows within organizational information systems or used when dealing with classification of information.

Keywords: Information definition, operational information model, information science, AMSIDO, the ICP model.

I. INTRODUCTION

The information science movement, which has been eager to find new ways of describing information, has kept an entire research discipline going for almost 60 years. Ever since Shannon's seminal work on communication theory was published in 1948, it was considered to be a "theory of information" [1]. Despite the fact that Shannon clearly said that he disregarded any semantic content [2,3], some researchers refer his work as a "theory of information" [4]. His work has been criticized for this fact [5], even if it was not his intention of creating such theory.

What later became the "Information theory" has later on been described as a science in honour of Shannon.

Shannon himself stated that the problem he issued was purely technical, the measure of information disregarded any content or meaning.

MacKay mentions Shannon's model as the only way of measuring information [6], which we oppose to in this paper. What Shannon in fact measured was a probability of sending an arbitrary binary message, i.e. *data*, through a channel, in order to see how much energy is needed to replicate that specific message at other location [2].

Some new approaches to measuring information have later on been introduced, e.g. Langefors' infological equation [7] and Brookes' fundamental equation [8]. These two are mathematical functions for calculating a measure of information, in the sense of being *informed* [7,8,9].

What these theories and models lack is a way of measuring information regarding its content. The focus of Shannon's model is at the *amount* of information [10], which messages contain. Where Shannon is considered technical, Langefors and Brookes emphasize the human aspects of information.

The purpose of this paper is to present a new way of describing, classifying and measuring information, a model for making information operational. By operational we mean a definition of a concept in terms of how the concept will be manipulated, measured and observed.

The model is a result from project OVCI (Operational Variables for Classification of Information).[1]

We believe that a different approach is to describe information by means of the content. Therefore we saw the need of measurable variables that could be connected to the information content, thus assigning measurability to information regarding its content. This is further described in sections IV, V and VI. Section II describes the case that we worked with. Section III examines the research method. We assess the reliability and validity in section VII. Section VIII addresses conclusions and reflections of our research.

II. THE CASE

OVCI, our project, is a subproject to project AMSIDO (Agent-based Micro world Simulation of Information Distribution in Organizations). AMSIDO is a joint-project between Mid Sweden University (MSU) and the Swedish National Defence College (SNDC) The objective of AMSIDO is to simulate an information system in a delimited part of an/or whole organization, in order to see the efficiency and/or effectiveness of a future information system.

In the first phase of AMSIDO[2], information was defined as a "token", a package with a serial number [11]. There was no interest in its content, only the route within the organization that was to be simulated. This definition led to some unforeseen problems in the simulations, and a new definition was needed.

We saw the lack of a practical model and definition of information, which was the trigger to our research. Therefore we sought a wider scope of information than just being a serial number.

III. METHOD

With our purpose, case and the different views of our precursors in information science, we set out to find a method for our research. Below is the explanation of our methodological steps during the process of making information operational.

---

[1] For a more extensive description of the OVCI project, please visit http://gathering.itm.mh.se/amsido/ovci
[2] For a more extensive description of the AMSIDO project please visit: http://gathering.itm.mh.se/amsido

A. *The ideal design*

The Banathy [12] and Stolterman [13] school of thought has influenced our method. They both say that design should be guided by the strive for ideals, not “what is”, rather “what should be”, using Banathy´s words [12].

Design, as we see it, is a problem solving process, guided by the thought of an ideal. Stolterman says that the designer has a vision in mind at the start of a design process [13]. This vision is later given a concrete form in an operative image. At a first glance, this operative image is quite diffuse, but it gets more concrete as the design process goes on. The operative image leads to a specification of the product. Stolterman and Löwgren say that this is applicable to design of information technology [14], but we see it as a general statement of how design processes are conducted.

Stolterman points out in his theory of design that design *is* a constructivist approach to a problem solving process, i.e. that we as designers are guided by our own visions [13].

The thoughts of ideal design were used to guide our work of making a model of information during our research.

B. *Method of inquiry*

Guided by the thoughts of design and a working process similar to the Local Systemic Intervention, (LSI), formerly known as the Total Systems Intervention (TSI), described in Flood [15,16], we set out to construct a model of information. We only used the *modes* and *phases* of LSI as generators for suitable methods. The idea of Critical Systems Thinking [16,17] in LSI was rejected due to the fact that “emancipation” in organizations is not applicable in our case. We needed a metaphor for the recursive and iterative method we planned to use, which, in our mind, LSI fulfils.

The first step of the method was to produce a suitable definition of information for our project. This was done through a literature analysis in comparison with our research objective and purpose.

Step two was to describe information in a new manner - variables that can describe information via the content were needed. To generate the variables we first had a brainstorming (brainstorming in the sense of being *creative*) session ourselves, which was used to prove that the concept of generating variables worked. Secondly we summoned a reference group seminar, where we used a Nominal Group Technique-like procedure, described in Delbecq et al. [18], more or less similar in Banathy [12] and Warfield [19]. We described the objective of our project to the group including our new definition of information and a metaphor for our view on information.

We chose to not use the selection and ranking part of NGT, instead we clustered the outcome into groups on a white-board. NGT is used either to make decisions or generate ideas about situations that are experienced as problematic. Striving to get as many variables as possible, we didn’t want to reduce the creativity by asking the group to choose the best variables from a large collection. We wanted to encourage divergent thinking during the seminar. The convergence of the variables was to be done in the modeling process.

C. *Modeling and validity*

Schmidt [20] argues that any model that has been constructed through the lens of the human eye is a conceptual model. Furthermore, Schmidt says that a model cannot capture the “real world” in the sense of describing it identically with the real world. We do not intend to make an exact copy of reality when modelling, rather a relevant model. What we have created is a conceptual representation of information.

The problem with the outcome of the seminar was that some variables were redundant and irrelevant. We reduced the outcome to a number of variables that were thought to describe information sufficiently.

During the modelling phase we scrutinized our classes and variables in order to determine the *credibility* [21] of our work.

To validate our result, we held a number of meetings, “peer reviews”, with people regarded as “experts”, to determine the content validity of our results. [22,23,24].

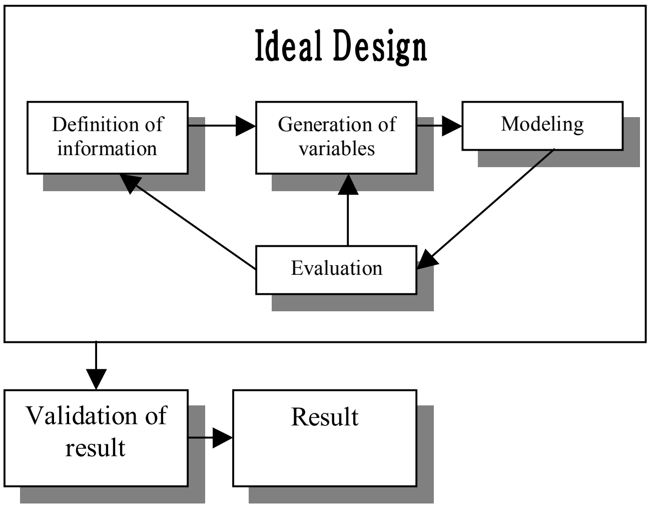

Fig. 1. Model of method process.

IV. DEFINING INFORMATION

As mentioned in the introduction, we had to define our own project related definition of information.

There are some different varying meanings of the word *information* and some extensive work has been done to describe the concept. [E.g. 1,25,26]. Despite all these efforts there is no general definition of the concept [27].

Shannon had for some 60 years come up with a definition, which operationalized the concept, although in a mathematical manner. MacKay [6] stated in 1969 that information is “operationally defined by what it does”, by comparing it to energy, which de Rosnay [28] also concludes.

The definition has to be able to convey all aspects on information, whether communicative, cognitive or the actual meaning. During this phase, we created a suitable metaphor that could give some guidance in our research, which was:

"*You can describe information like a freight container. Locked inside is the information, only described by the waybills or consignment notes on the outside*".

Information, in our opinion, is a container for sets of symbols (data, e.g. letters, sounds, pictures), which can be interpreted by a recipient (information, from now on called an *information container)*.

The containers require at least one datum (one symbol) [7] to be considered as a container.

All this has to do with communicating these symbols between sender and recipient and the recipients must be able to interpret these sets of symbols. Interpretation of data is the base for constructing information [29], hence also information as a process of converting/interpreting symbols into knowledge [9]. As defined by Lucey [29] he states that, when the symbols are interpreted, it is information. In our case, information containers are still information whether interpreted or not.

MacKay [6] argues that *meaning* arises when sender and recipient are included in an informative situation. Information has to have its own meaning to the recipient, who has its own "…store of factual information, repertoire of skills and a hierarchy of criteria of evaluation and priorities". These factors all lead to what MacKay refers to as "the state of conditional readiness (SCR)"[6]. The meaning of the information acts as a function for readying the recipient for action.

Understanding is seen as a crucial part when talking about information [8]. From our point of view, it is naïve to say that all people can or have the ability to understand every bit of information that is communicated. First of all, people must have contextual understanding (situation knowledge) and secondly, be able to connect content (frame of reference) with context. Here misinformation could be used to mislead, for example, enemies and competitors. Loose means that information only can be information when true [30], which we oppose to. As long as the content of the containers are well formed and meaningful [31], we regard it as information.

An organizational aspect of information is to decide the flow of information, i.e. senders, receivers, sources, media, information nodes. Information itself is a crucial factor in organizations, used as a function for making decisions and can be seen as a reduction of uncertainty [8]. These aspects must be integrated in the objectives of the entire organization and its information system. This covers the fact that all involved with the information system has to have knowledge of where to look for the right information.

A. Information Containers and Packages

When talking about information in the sense of a container, there also has to be a way of combining information. That is the possibility of producing new information from other information containers and still yet having the possibility of keeping the specific meaning of an information container.

As we see it there are two ways of combining information. The first is a combination regarding the information containers. When aggregating (combining) a number of information containers, new information is created. The consequence with this is that the meaning of the aggregated information containers is lost and the only one with a unique meaning will be the new information container.

The other way is to combine separate information containers, each with their own unique meaning, to new units called *information packages.* The information packages are the *transport device* for information containers, thus making information communicable. These aspects make it possible to represent information that holds more than one part-information, e.g. a phone call that holds both the sender's information containers and the receivers information containers.

An example of using containers and packages could consider an email. In the email, there are three separate pieces of information, each concerning diverse areas of interest.

By packaging these three information containers into an information package, the diverse unique meaning of the containers are represented when communicating the email.

The benefit with using information packages is that there is a possibility of detaching each information container from the package without losing the specific meaning of the information containers.

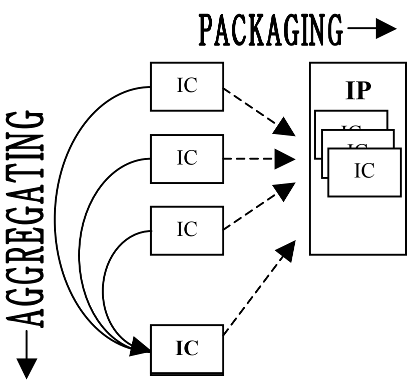

Fig. 2. Model of information aggregation and packaging. IC = Information Container and IP = Information Package.

B. The Definition

Regarding our objectives and area of research, we will work with information as an "artifact". According to the objectives of the OVCI project and our effort to define information led to the following definition:

Information is Information Packages that hold Containers of information, regardless of the media, which is open for interpretation, but not necessarily interpreted, by a recipient who has knowledge of the context of the Information Package.

V. THE OPERATIONALIZATION

With the information definition and the thoughts of aggregating and packaging information containers, we started our iterative process of model construction.

We clustered our variables into 16 classes that could be used to explain and measure information regarding its content. The reason of making classes was to bring some structure among the variables from the reference group seminar. After evaluating the variables we had sorted out and selected 32 variables of importance. Now came the part of making the variables operational. The results of our research process are presented below, beginning with our model of information.

A. The ICP (information container and package) model

As the model shows (figure 3), some of the classes are connected to the information package unit and the rest is connected to the information container unit.

The "information" in the containers is always sent in the packages, and therefore some classes are only applicable to the package. These classes are aimed to describe variables regarding sending information, e.g. sender, medium, source etc. The emphasis is that the packages are sent, but not regarding how and/or which channels they are communicated through. The classes applicable to the information container describe the "uniqueness" of the containers. i.e. pointing out the unique meaning of the container regarding the content.

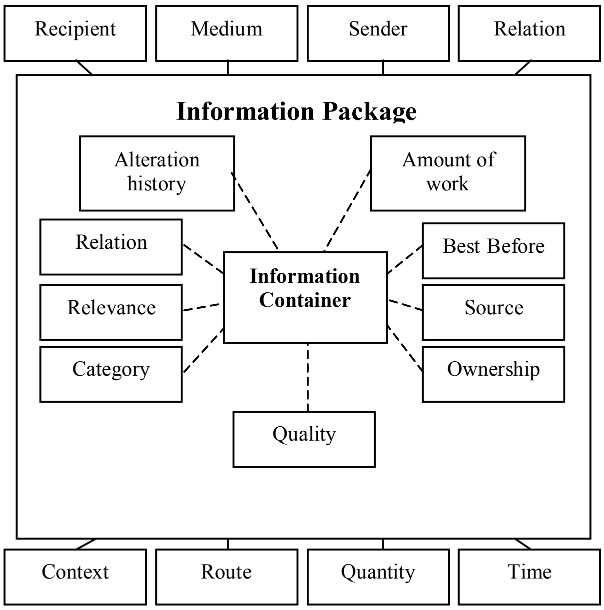

Fig. 3. The ICP model. A model of variable classes applicable to Information Containers and Information Packages.

B. Measurement

As stated in the introduction, prior to our work, information had only been measured by mathematical means [2, 32, 33, 34]. We believe that there should be another way of measuring it. De Rosnay [28] states that in order to measure information, "…all reference to its (information, authors comment) subject matter would have to be ignored and only the specific form of energy passing through the carrier considered".

In order to measure information, some aspects must be fulfilled. Information must itself be a measurable thing. Buckland [35] argues that all information cannot be measured, e.g. the actual *knowledge* that a human possesses. If we regard information as an "entity", a tangible thing that can be measured, this can be done. Buckland calls this entity "information-as-thing" [35]. We see this as a prerequisite for measuring information.

Instead of using Shannon's measures of physical size (the binary digit) [2], we assign the content measurability through our variables.

In our opinion there are two ways of choosing values of measurement. The first way is to put concrete values to a variable. One example here is the variable sender where the concrete values could, as an example, be the personnel within an organization.

The other way is to put appraised values and arbitrary scales to variables. In one case there could be a variable called "Useful". It is possible to put a scale from one to five or one to ten, to explain and measure the importance of the specific information. A value of one could mean that the actual information might not be very useful, but the other end of the scale might show a critical value for the recipient.

A problem with the model is that mixing different scales, can affect the *homomorphism* between the model and the "reality" it represents. [36,37]. Homomorphism is an important factor in measurement, since a homomorph describes that there is an identical structure in using numerals, numbers or symbols when measuring the output from a model [36].

Our purpose was not to create an exact model of reality, rather a relevant.

VI. CLASSES & VARIABLES

With the ICP model and the work with our variables we structured them in classes.

The following section will describe the classes in our model and the variables connected to these classes. The tables are divided into four columns. The first regards the variable names; the second gives a description of the variable, the third describes what to look at when measuring the variable, what makes the variable operational and the fourth column points out the scale of measurement, e.g. I (interval), R (ratio), N (nominal) or Time (time). It also describes if the variable has a concrete or an appraised value.

Classes connected to the information container are explained first, and then the classes connected to the information package.

A. Alteration history

This class examines if the information been altered or revised from the point of creation. This class examines the difference between the first information and the last, when distributing of the information.

Variable	Description	Measuring value	Measurement
Copy or original.	If it is a copy or original.	The original information.	N, concrete value. E.g. Copy or original.
Manipulated/unmanipulated.	If the information is altered in any way.	Other information.	N / I, concrete value. E.g. manipulated.
Successes other information	Describes in the information will success other information.	Other information that is likely to be true in current time.	N, concrete value. E.g. the serial number of the related information to success.

List of revisions.	Describes the revisions of the information.	Serial number.	N, concrete value. E.g. the serial numbers of information in list.

B. Relation

As described in our definition of information, information can be combined into new information. This presupposes that information can itself be parts and have relations. This is the only class that occurs in both the information containers and the information packages.

Variable	Description	Measuring value	Measurement
Serial number.	Describes the unique serial number of the information	The serial number of an information container or an information package.	N, concrete value. E.g. 123.434.22.34.
Relation	Describes the relation between other information containers.	Relation to other containers	N, concrete value. E.g. container 111.222.33.44-5

C. Relevance

This class describes the relevance and the usefulness of the information. The purpose is to point out how relevant/useful the information is for the recipient or the context. , i.e. what relevance one type of information has to a specific recipient, e.g. stock market shares are interesting for a broker, but not necessarily for a librarian.

Variable	Description	Measuring value	Measurement
Useful	How useful the information is for the recipient or the context.	Situation, profession, role. Context.	I, arbitrary scale and appraised value. E.g. 1 to 5.
Relevance	How relevant the information is for a recipient/s or context	Depends on what other information is known, situation, role and context and priority	I, arbitrary scale and appraised value. E.g. 1 to 5.

D. Category

Category is the class used to differentiate information. Categorizing information serves as reduction of possible information to gain or send. This class has strong connections to owner, sender, source and recipient.

Variable	Description	Measuring value	Measurement
Subject	Describes the subject of the information, e.g. an order of action to a recipient.	Content of information	N, concrete value. E.g. purchase order, process meetings.
Security level.	What level of secrecy the information has.	The content of the information.	I, arbitrary scale and appraised value. E.g. 1 to 10.
Authority.	Describes whom has access to the information	The content of the information and security level.	N, concrete value. E.g. the name of the one with access.
Category.	Describes the category of the information.	Measured against the content of the information	N, concrete value. E.g. order, general.
Requested.	If the information is requested in any way	The request from any person, machine, group, department etc.	N, concrete value. E.g. requested, yes or no.

E. Quality

The quality class focuses on qualitative aspects regarding the content of information. Quality aspects are important to reach a high point of secure and correct information. As mentioned earlier, information is a crucial factor in organizations, used as a function for making decisions. This can be seen as a reduction of uncertainty. Therefore we see the importance with the quality aspects.

Variable	Description	Measuring value	Measurement
Erroneous informati - on	Describes if the information is erroneous in some way.	Relation to other information, that either confirms or denies the information.	N, arbitrary scale and appraised value. E.g. 1 to 5.
Credible	Describes the credibility of the information.	Content of other information that either reliable or unreliable	N / I, arbitrary scale and appraised value. E.g. 1 to 5
Intelligible	What must one know to understand the information?	Language, context	N, concrete value. E.g. Swedish or English.
Ambiguity	Describes if the information is uncertain or doubtful.	Content or other information that contradicts the information.	N, arbitrary scale and appraised value. E.g. 1 to 5
Plainness.	If the information is simple or complex.	The complexity or simplicity of the information	N, arbitrary scale and appraised value. E.g. 1 to 5.

F. Amount of work

Amount of work is the performance that describes the amount of work a recipient acquires to gain or refine information. Amount of work is a very important factor when regarding efficiency and effectiveness of an information system.

Variable	Description	Measuring value	Measurement
Time for working the informat-ion.	Performance that describes the amount of work a recipient acquires to gain or refine information	Time	I / Time, concrete value. E.g. 2 hours or 4 units.

G. Best before

This class examines when information gets out of date. Information tends to get "old", and superseded by other information. Here time is the concrete value that easily could be connected to the class Time to calculate factors like length of life.

Variable	Description	Measuring value	Measurement
Best before	The "best before date", when will the information get old, out of date/time.	When other information supersedes the actual information or a specified date or time.	Time, concrete value. E.g. 20020516.

H. Source

A class that points out the source of the information. Here we consider the starting point of information. That is who originally composed the information in focus. This class has a strong connection to the class route.

Variable	Description	Measuring value	Measurement
Composer	The composer of the information.	The composer	N, concrete value. E.g. the name of the composer.

I. Ownership

This class describes who or what owns the information. The values here could vary from single persons, departments, groups to machines. It is important to point out the owner when for example considering the subject or context of the information.

Variable	Description	Measuring value	Measurement
Owner.	The owner of the information.	To whom the information belongs.	N, concrete value. E.g. the name of the owner.

J. Recipient

This class regards the recipient/s of information, whether a human or a machine.

Variable	Description	Measuring value	Measurement
Recipient	The recipient.	Recipient	N, concrete value. E.g. the name of the recipient.

K. Medium

This class deals with what medium is used to present information. It is connected to the information packages, which makes it impossible to mix different media types when sending several containers in an information package.

Variable	Description	Measuring value	Measurement
Medium.	In what medium is the specific information package?	Medium	N, concrete value. E.g. sound, text.

L. Sender

This class regards the last sender of the information in focus. Not to be confused with the class Source.

Variable	Description	Measuring value	Measurement
Sender	Describes the sender	Sender	N, concrete value. E.g. Tuomas Koli or Jens Holmström.

M. Context

Information leads to acts within a specific context. This class is used to point out in what different contexts information can apply to.

Variable	Description	Measuring value	Measurement
Context	Describes the context of the information.	The context of the information	N, concrete value. E.g. a meeting.

N. Route

The route of an information package is and can itself be further information about information. The class has strong connections to sender, source, recipient and time.

Variable	Description	Measuring value	Measurement
Route.	The route of information from one sender to one end recipient.	Senders and receivers during the route of the information.	N, concrete scale. E.g. the senders and recipient of the information.

O. Quantity

Describes the amount of information, e.g. the number of information containers an information package contains. It also describes a discrete quantity or complexity of information by measuring information containers in an information package.

Variable	Description	Measuring value	Measurement
Quantity	The number of information containers in an information package.	Number of containers in the information package	I, concrete value. E.g. five containers in an package.

P. Time

Time is the class that owns the variables that regards time as an important measurable factor. Here we point out the relevance of start and stop times when it comes to communicating and creating information.

Variable	Description	Measuring value	Measurement
Dispatch	Time stamping for the dispatch of the information.	The actual time when information was sent	Time, concrete value. E.g. 20020516.
Reception	Time stamping for the reception of the information.	The actual time when information was received.	Time, concrete value. E.g. 20020516.
Created	The time stamp when the information is finished and ready to send	Time of creation	Time, concrete value. E.g. 20020516.

As pointed out in some of the classes, there are strong connections between some of the classes. In our opinion there are some connections between all classes and we see this as the connection with *content*. The model, the classes and the variables have to be joined with a "holistic" view on information. All parts are important when regarding the measurability on the basis of the content of the information.

VII. Reliability and Validity

According to Svenning, reliability testing is aimed to ensure the ability to retest a survey [24]. Since we are conducting a design process, this leads to some complications. We said in the method that we see design as a constructivist approach to a problem solving process. It is hard to replicate the vision and the operative image, since they only exist in the mind of the designer.

Concerning the validity we addressed this through peer reviews. This was done to evaluate the content validity at face. The consensus was that the result is considered valid.

VIII. Conclusive Remarks and Reflections

Our purpose with the project was to make the concept of information operational, which resulted in the ICP-model, a new way of measuring and classifying information.

At a glance, the result may seem like a mix between information theory and communication theory, even though we disregarded some of the communicative aspects. We have stated that information is sent, but not *how* it is sent.

The division of the model into two units are in fact crucial when considering the "value" of information. One unit regards communicating the information and the other points out the meaning of the information. One could also discuss whether the classes and variables are sufficient or not when making information operational. Of course there might be other classes and other variables that could enhance the measurement. This is, in our opinion, a case connected enhancement, that changes from case to case.

Our model is considered to be operational regarding the statement in the introduction. We can manipulate information through variables, we have described in the definition how we are going to observe information. The measurement is done by means of the occurrence of the variables. We have attained an operational model of information.

Figure 4 shows that compared to the research of Shannon [2], Brookes [8] and Langefors [7], we have attained a model that fulfils the operational requirements stated in the introduction. Moreover, the definition explains information, and the model itself is descriptive. It is important to state that we have focused on the content of information, which was not the focus of the other researchers.

	Operational requirements			Requirements on model		
Model	**Ma**	**O**	**Me**	**Ex**	**De**	**Mg**
Shannon		√	√			
Brookes	√	√	√			
Langefors	√	√	√	√		
ICP-model	√	√	√	√	√	√

Fig. 4. Operational requirements on different models Ma is manipulation, O is observation, Me = measurement. Ex is explanatory, De = descriptive. and Mg = represents meaning.

The main aspect here is that we have designed a way of making information operational without neglecting the *meaning* of the information. We have brought forward a new "angle", a new view when considering the wide perspective of information.

A. Method discussion

We think that our choice of method has been successful and appropriate for this research project. Our thoughts of an ideal design of information and an iterative work process made it possible to keep the creativity level high during the research. A big part of keeping the creativity level, was the statement of our own metaphor on our view on information. This made it possible to keep the focus of our research and it was a great "creativity boost" during the seminars. However, if we should conduct this research again we would:

- Examine the choices of work processes similar to LSI.
- Evaluate other "brainstorming" methods in the sense of creativity.
- Work with more cases to get a wider angle of the use of the ICP model and when validating the results.

B. Further research

Our project is, from our point of view, regarded as base research to a new model and definition of information. Suggestions to further research/ a more extensive study are:

- The practical/technological feasibility of the model, in what scenarios is the model usable?
- Some development of methodological steps and instructions for usage of the model. Our research is only focused on the definition and the ICP model.
- Examination of the limitations to other available work and models. Can our model be complemented with other models?
- A more extensive work on the philosophical framework of the model would be of interest. Questions about the operationalization could be brought forward and compared with other philosophical views than the one described here.

IX. Acknowledgements

The authors would like to thank doctoral student Major Mats Persson at the AQUA project and SNDC for reviewing the paper and Professor Luciano Floridi at Oxford University for valuable "information" and feedback.

We would also like to thank the reference group and our supervisor, doctoral student Joel Palmius and other project members of the AMSIDO project both at MSU and SNDC.

X. References

[1] F. Machlup and U. Mansfield. The study of information. Interdisciplinary messages. Wiley, 1983.

[2] C. E. Shannon. "A mathematical theory of communication". The Bell system technical journal. Vol. 27, pp. 379-423, 1948.

[3] F. Webster. Theories of the information society. 2: nd edition. Routledge, 2002.

[4] C. Hillman. "What is Information?" URL: http://www.math.washington.edu/~hillman/PUB/wii.ps 2002-03-20.

[5] D. M. MacKay. "The wider scope of information ". In: F. Machlup and U. Mansfield. The study of information. Interdisciplinary messages, Wiley, pp. 485-492. 1983.

[6] D. M. MacKay. Information, mechanism and meaning. MIT Press, 1969.

[7] B. Langefors. Theoretical Analysis of Information Systems. 4:th edition. Studentlitteratur, 1973.

[8] C. Cole. "Calculating the information content of an information process for domain expert using Shannon's Mathematical Theory of Communication: a preliminary analysis". Information processing and management. Vol 33. No 6. pp. 715-726. 1997.

[9] C. T. Meadow and W. Yuan. "Measuring the impact of information: defining the concepts". Information processing and management. Vol. 33, no. 6, pp. 697-714, 1997.

[10] F. I. Dretske. Knowledge & the flow of information. Basil Blackwell Publisher, 1981.

[11] From "AMSIDO-1 Models: reference and discussion". URL: http://gathering.itm.mh.se/amsido/docs/models.pdf 2002-05-25.

[12] B. H. Banathy. Designing Social Systems in a Changing World, Plenum Press, 1996.

[13] E. Stolterman. Designarbetets dolda rationalitet: en studie av metodik och praktik inom systemutveckling. Doctoral dissertation. Umeå Universitet, 1991.

[14] J. Löwgren and E. Stolterman. Design av informationsteknik. Materialet utan egenskaper. Studentlitteratur, 1998.

[15] R. L. Flood. "Local Systemic Intervention". European journal of operational research 128, pp. 245-257. 2001.

[16] R. L. Flood and N.R.A. Romm. Critical systems thinking: current research and practice. Plenum, 1996.

[17] M. C. Jackson. "Critical systems thinking and practice ". European journal of operational research 128, pp. 233-244. 2001.

[18] A. L. Delbecq, A. H. Van de Ven and D. H Gustafson. Group techniques for program planning, Glenview, 1975.

[19] J. N. Warfield. The science of generic design: managing complexity through systems design, Salinas, 1990.

[20] B. Schmidt. The modeling of human behaviour. Gruner-Druck, 2000.

[21] A. Debons, E. Horne and S. Cronenweth. "Information science. An integrated view". G.K. Hall & Co., 1998.

[22] E. G. Carmines and R. A. Zeller. Reliability and validity assessment. Sage, 1979.

[23] S. Kvale (Ed). Issues of validity in qualitative research. Studentlitteratur, 1989.

[24] C. Svenning. Metodboken: en bok om samhällsvetenskaplig metod och metodutveckling. Lorentz, 1997.

[25] A. Debons and A. L. Larson. NATO advanced study institute on perspectives in information science. Noordhoff, 1975.

[26] W. Hofkirchner (Ed). The quest for a unified theory of information. Proceedings of the second international conference on the foundations of information science. Gordon & Breach, 1996.

[27] P. Checkland and S. Holwell. Information, systems and information systems: making sense of the field. Wiley, 1998.

[28] J. de Rosnay. The macroscope: a new world scientific system. Harper & Row, 1979.

[29] L. Floridi. "Is Information meaningful data?" Submitted URL: http://www.wolfson.ox.ac.uk/~floridi/pdf/iimd.pdf 2002-03-20 Unpublished paper.

[30] R. M.Losee. "A discipline Independent Definition of information". Journal of the American Society For Information Science. 48, (3), 254-269, 1997.

[31] L. Floridi, Information [draft # 1.0], chapter 5 of The Blackwell Guide to the Philosophy of Computing and Information, L. Floridi (ed.) (Oxford – New York: Blackwell, 2003) Received through correspondence with Mr Floridi.

[32] G. J. Klir and T. Folger. Fuzzy sets, uncertainty and information. Prentice-Hall, 1988.

[33] Y. Bar-Hillel. Language and information: selected essays on their theory and application. Addison-Wesley, 1964.

[34] G. Jumarie. Relative information. Springer, 1990.

[35] M.K. Buckland. "Information as thing". Journal of the American society for information science. Vol 42, no. 5, pp351-360, 1991.

[36] R. L. Flood and E.R. Carson. Dealing with complexity: an introduction to the theory and application of systems science. 2:nd ed. Plenm, 1993.

[37] G. J. Klir. Facets of systems science. Plenum, 1991.