

Towards a Theory of Information Systems: The FRISCO Approach

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Abstract: *Information Systems (IS)* is among the most widespread terms in the Computer Science field but a well founded, widely accepted theory of IS is still missing. With the Internet publication of the FRISCO report, the IFIP task group "FRamework of Information System COncepts" has taken a first step towards such a theory. Among the major achievements of this report are: (1) it builds on a solid basis formed by semiotics and ontology, (2) it defines a compendium of about 100 core IS concepts in a coherent and consistent way, (3) it goes beyond the common narrow view of information systems as pure technical artefacts by adopting an interdisciplinary, socio-technical view on them.

In the autumn of 1999, a first review of the report and its impact was undertaken at the ISCO-4 conference in Leiden. In a workshop specifically devoted to the subject, the original aims and goals of FRISCO were confirmed to be still valid and the overall approach and achievements of the report were acknowledged. On the other hand, the workshop revealed some misconceptions, errors and weaknesses of the report in its present form, which are to be removed through a comprehensive revision now under way.

This paper reports on the results of the Leiden conference and the current revision activities. It also points out some important consequences of the FRISCO approach as a whole.

1 FRISCO history: goals, target groups and scope

More than 10 years ago, the IFIP task group "FRamework of Information System COncepts" (FRISCO) was founded by several scientists of Western and Northern European countries in order "to provide a suitable conceptual framework, i.e. wherever possible, simple, clear and unambiguous definitions of, and a suitable terminology for the most fundamental concepts in the information systems field ..." (cf. [5], preamble, p.3).

While fashionable methodologies understand a *method* for IS development as a compendium of a notation together with a process model (see e.g. UML & RUP - Rational's Unified Modelling Language & Process), the FRISCO authors have emphasised the importance of a theoretically consistent and pragmatically sound *foundation* of the IS field. Among other issues, such a foundation requires some deeper investigation of its relations to underlying and neighbour disciplines such as philosophy, mathematics/computer science, linguistics and social science.

Therefore, the FRISCO authors have tried to avoid a techno-centric view and have aimed for a broad, interdisciplinary approach from the very beginning of their work. This implies a focussing of (and on) the FRISCO target groups: First-line addressees are neither database specialists working on IS implementations nor high-level managers engaged in strategic IS planning but system analysts and modellers, researchers, methodologists and advanced students (on the Master's or Ph.D. level). Furthermore, the FRISCO results should appeal to anyone interested in the foundations and fundamental principles of their working area beyond their daily activities.

Another implication concerns the scope of the framework. The FRISCO group never intended (and always was aware that this would contradict its consistency and unambiguity goals) to develop a mere glossary covering as large a variety of IS-related terms as possible. Since the FRISCO definitions are intended to form a common basis for various methodologies (including UML-related ones), the authors have avoided covering methodological aspects of IS modelling in detail. Thus there are almost no links and relationships to particular methods and method-specific concepts in the FRISCO report. However, the report contains a large list of references covering such relationships.

The FRISCO group has developed its ideas through many group meetings, working papers, reviews and on-line discussions and has reflected its work discussing it with the scientific community in four ISCO conferences held in Namur (1989, [2]), Alexandria (1992, [3]), Marburg (1995, [4-95]) and Leiden (1999, [6]). With the Internet publication of the FRISCO Report [5], some of the FRISCO authors consider their work as terminated. However, the Leiden conference has clearly shown that

(a) in spite of its generally acknowledged aims and achievements, the report in its present form suffers from some misconceptions, inconsistencies and weaknesses which deserve to be corrected,

(b) the technical evolution and the resulting changes in the application of IS do not make work on IS foundations obsolete but on the contrary they make it an even more important task. In the age of the internet and world-wide IS a consolidation of the conceptual foundations is more important than ever before.

For these reasons, IFIP WG 8.1 representatives have agreed to continue the FRISCO work and to ask a small group of former FRISCO authors for reviewing the work done so far and preparing a revised version of the FRISCO report. As members of this (sub-) group we should like to report on this work in the following sections of this paper.

2 The FRISCO report and its achievements

In its present form, the FRISCO report is organised in seven chapters:

- an introduction (ch. 1) setting out the aims, goals and overall approach of FRISCO,
- an overview chapter (ch. 2) presenting a broad "line of reasoning" of the report without going into any details,
- a tutorial chapter (ch. 3) presenting the philosophical and linguistic background (the FRISCO ontology and semiotic foundation) as well as a framework of IS concepts ranging from "things" and "predicators" up to "organisation" and "information system",
- a formal chapter (ch. 4) rephrasing most of the definitions of chapter 3 in a formalised, mathematical language,
- a demonstrator chapter (ch. 5) illustrating the FRISCO concepts for a sample case,
- a supplementary chapter (ch. 6) containing material further elaborating chapters 2 and 3, and
- a concluding chapter (ch. 7) containing reflections and dissenting positions of FRISCO authors and associates.

The FRISCO report was subject to a comprehensive review during the Leiden conference. It was generally acknowledged that

- with the constructivist view adopted in its baseline definitions FRISCO has reached a profound philosophical anchoring and has succeeded in bringing the philosophical basis to the forefront,

- the FRISCO approach is among the first attempts to fill the gap between reality and modelling concepts and to yield a summary of the ontology¹ we use,
- the FRISCO definitions and terminology have been kept independent from particular methods or methodology schools,
- the overall approach to build a layered framework and to follow a systematic construction plan has proven superior to the idea of building a large glossary of rather randomly selected terms,
- the formalisation of informally presented concepts provides a valuable test of their consistency and soundness (simultaneously illustrating the complexity of expressions needed for doing so).

One of the fundamental questions often neglected or marginalised by common methodologies is the relation of "reality" and IS concepts "mapping" its parts or aspects. The contribution of FRISCO to this question was summarised by H. Kangassalo during a recent workshop: "*FRISCO helps to understand the basic concepts of IS better than before. This implies in particular a better understanding of the relation of symbols to reality.*" (cf. [7]). We are convinced that in the age of the Internet, of evolving global IS and computerisation and "virtualisation" of many processes and human activities a critical dealing with the foundations has not become obsolete but is even more important than it was 10 years ago.

The semiotic basis

The FRISCO approach to bridge the gap between "reality" and its modelling concepts is based on *semiotics*, i.e. the theory of *signs*, their *form* (syntax), *meaning* (semantics) and *effect* (pragmatics). The whole framework of FRISCO definitions is anchored in the *semiotic triangle* which was extended by FRISCO to a tetrahedron placing an "actor" in its centre (cf. fig. 1).

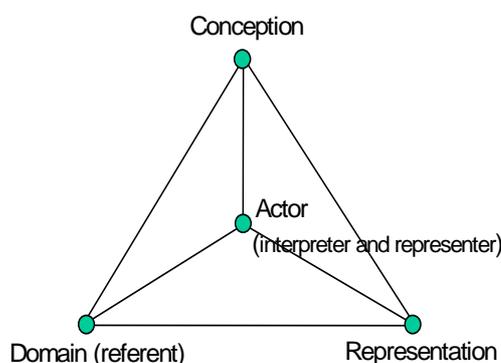


Fig. 1: The semiotic tetrahedron of FRISCO

The extended triangle reflects the constructivist view of FRISCO: There is a *domain* consisting of phenomena (the *referents*, cf. the lower left hand corner of the triangle) observed by some person called the *actor*. As a result of physical and mental activities (namely, *perception* and *interpretation*), this person forms so-called *conceptions* (cf. the top corner) and decides to treat these as individual, separable and identifiable "*things*". He/she may then represent them by physical symbols (the *representation*, cf. the lower

¹ *Ontology*: [for FRISCO] "view of the world", based on perception, interpretation and representation of phenomena

right hand corner of the triangle). This overall subjective construction process is "objectified" (or better: socialised) by subsequent human communication processes: Whenever a social group or community (maybe, after some negotiations or even disputes) agrees in treating a certain phenomenon as a "thing" it *becomes* a thing (by social construction) and is treated as such as long as it is not forgotten or made obsolete by other conflicting constructions.

The role played by the representation of a conception (i.e. of a thing that has a physical or imagined counterpart in some domain) is that of a *sign*, that is to say, a collection of (sign) tokens (or *symbols*), that stand for the domain in question (as conceived by the actor). Thus in the context of internet communication, the sequence of tokens :-) [which jointly constitute a well-recognised "icon"] stands for someone's *conception* like "smile" referring to a certain effect (the "*referent*") in the real world domain like expressing agreement, favour or sympathy.

The semiotic triangle is a helpful tool for illustrating the differences between representations (physical, symbolic entities), their meaning or intention (mental, abstract entities) and their counterpart or effect in the physical world (physical entities, actions or processes). For example, a physical person (*client Brown* - the *referent*) can be conceived as some collection of aspects (a *conception*) and be represented by some data base entry (a *representation*). The central role in these processes is taken by a person who is responsible for linking referents, conceptions and representations with each other. Because of the combined roles of interpreter and representer, we shall refer to that person as the "observer" (cf. fig 2).

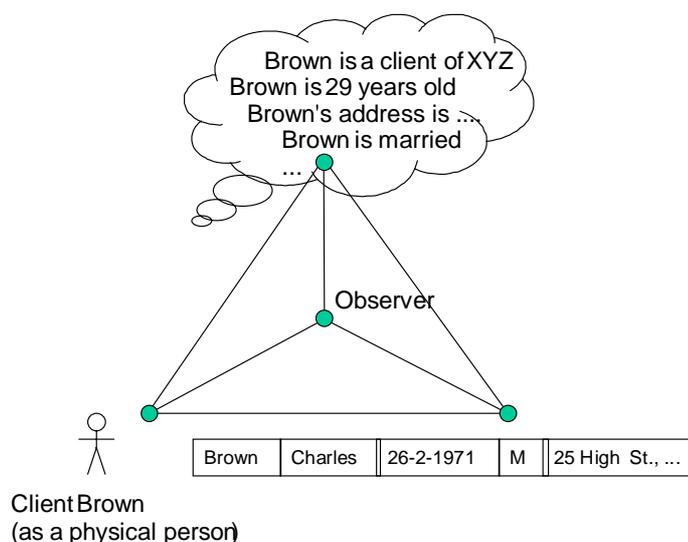


Fig. 2: Example of the use of the semiotic tetrahedron

Since the FRISCO "world" is composed of *things* and every thing one communicates about is a *conception*, the latter play a pivotal role in this framework (cf. fig. 2). Therefore, conceptions need careful explanation. It is not surprising that they have provoked some divergent interpretations and controversial debates. Ron Stamper, one of the FRISCO authors argued that conceptions are not an appropriate basis for a theory on Information Systems since "*we cannot observe the 'conceptions' locked inside our skulls ...*". He advocates for replacing *conceptions* by "*repertoires of behaviour*" and thus avoiding the explicit reference to mental states and results of introspection [9].

On the other hand, v. Braun et al. have emphasised the inter-subjective role of human communication and have pointed out that, as a result of communication and shared understanding, conceptions become "*social constructs*" and as such can well be used as a basis of the conceptual framework [1].

FRISCO ontology and underlying assumptions

Any conceptual framework which does not admit circular definitions (for both their theoretical and practical problems and inconveniences) has to be based on basic terms taken "for granted" from natural language, i.e. not further explained in the form of explicit definitions. Examples of such terms are "world", "domain", "human being", "perception", "mind", "conception", "pattern", "time", "process" etc. In the "dependency graph" of fig. 3 the definition dependencies of some static kernel concept definitions are depicted. Basic terms are all those appearing below "Thing".

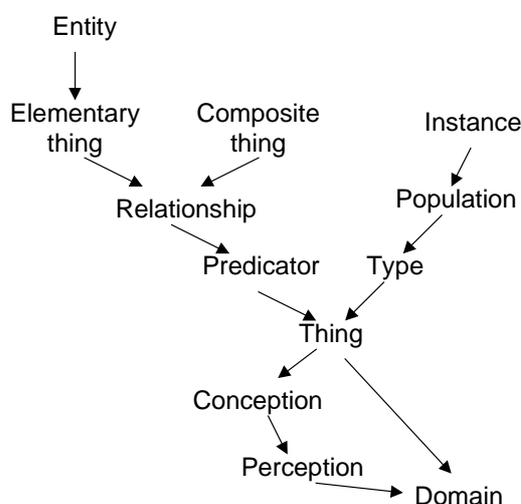


Fig. 3: Dependency graph of some static kernel concepts (simplified)

In chapter 3 of the FRISCO report, the authors have chosen the form of *assumptions* to introduce such basic terms and to clarify their starting point by using and relating them to each other. These assumptions represent the FRISCO *ontology*, i.e. the way the authors perceive the surrounding "world" (their "Weltanschauung") and what they consider important to share with the reader before entering the explicit definitions.

An example of such assumptions is the following

Assumption [b]: Human beings are able to observe and perceive "parts" or "aspects" of the "world" (which we will call *domains*) with their senses, thus forming *perceptions* in their mind. Perceptions can be considered as specific patterns, generally changing in time.

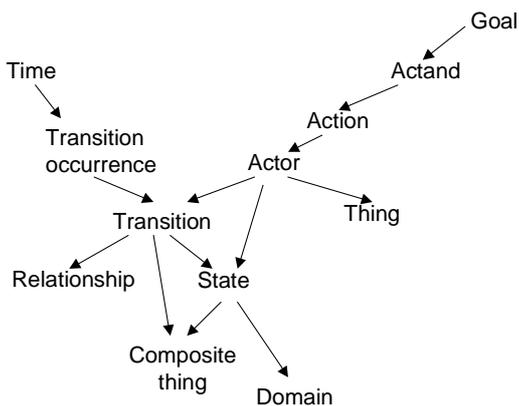


Fig. 4: Dependency graph of some dynamic kernel concepts (simplified)

The three layer structure of concept definitions

The concepts explicitly defined by FRISCO can be roughly grouped into three classes:

- static kernel concepts,
- dynamic kernel concepts,
- system level concepts.

Since the definitions grouped in these classes build on each other, the classes constitute a layered structure ranging from the basic terms below "thing" through elementary concepts like "thing" or "relationship" up to complex structures like "organisational system" or "information system". A rough overview of the terms and their dependencies involved is given in figs. 2-4.

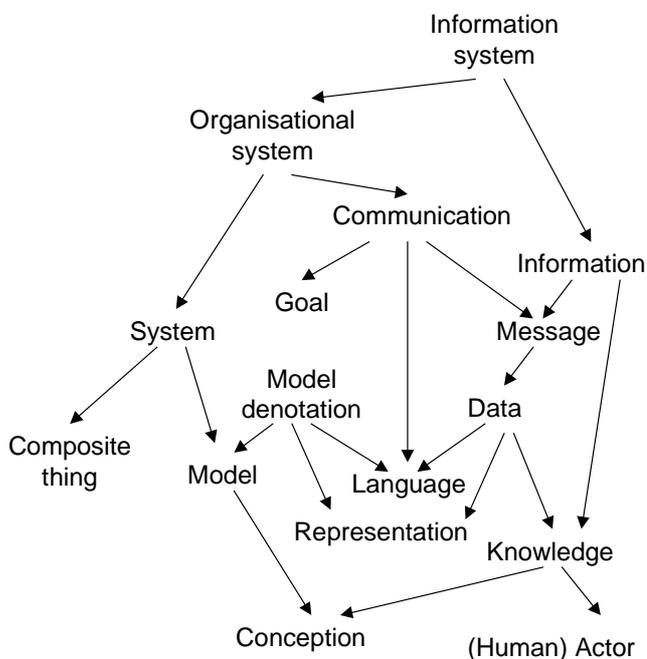


Fig. 5: Dependency graph of some system level concepts (simplified)

3 Errors, weaknesses and gaps of the report (including points of debate)

Besides its well-acknowledged strength and merits, the FRISCO report in its present form suffers from some errors, weaknesses and gaps which should be corrected or removed in a revised version. During the Leiden workshop, the following problems - among others - were brought up and ideas for improvements were discussed (cf. [7]):

Clarification of the foundations

In the FRISCO report, perceptions and conceptions play an ambivalent role. In the introductory assumptions they are used to explain the human cognition process leading to the separation and identification of "things" in a subjective way. For example, conceptions come in via

Assumption [c]: Human beings are able to form *conceptions* in their minds, as a result of current or past perception, by means of various cognitive or intellectual processes,

Later on in the report, an attempt is made even to "formalise" this individual approach by an explicit definition (cf. def. E20 in ch. 3 and the subsequent discussion). On the other hand, a conceptual framework for Information Systems has to address large groups of human beings involved in such systems up to world-wide IS with globally dispersed communities. As (justified) critics have pointed out (cf. e.g. [10]), subject-oriented cognition theory based on perceptions and (individual) conceptions is not sufficient to form the broad and stable basis required for this kind of systems.

Thus a reformulation of the perception/conception parts towards an inter-subjective, socially based foundation is required. In their ISCO-4 paper, v. Braun et al. have shown a way for that by extending *conceptions* to *socially negotiated and agreed constructs* which become (relatively) "objective" as a result of human communication processes [1].

Circular definitions and separation of layers

One of the leading goals and principles of the FRISCO work is to provide a coherent, consistent and unambiguous network of definitions based on each other in a systematic, circle-free way. However, such a rigid goal is compromised with various respects. It necessarily implies to start from a set of undefined terms (see above) - in the FRISCO report resolved by the introductory *assumptions*. It further implies that any term to be explicitly defined must not occur in the assumptions or, the other way around, any term occurring in the assumptions is excluded from being explicitly defined in the later sections.

In order to systematise this approach, a layered structure of the definitions was conceived (see above, section 2). Nevertheless, in the original report, the layer structure is corrupted and the above principles are hurt at some places. Most of these problems can be solved by rather minor corrections. However, there is at least one severe circularity concerning the terms conception, thing, and actor/actand (cf. [7] and fig. 6):

Roughly speaking,

- a *conception* is explained as a (special) *actand* using the *actor* and *action* concepts (def. E20),
- *actor*, *action* and *actand* are explained as (special) *things* (def. E13- E15),
- a *thing* is explained as a (special) *conception* (def. E1).

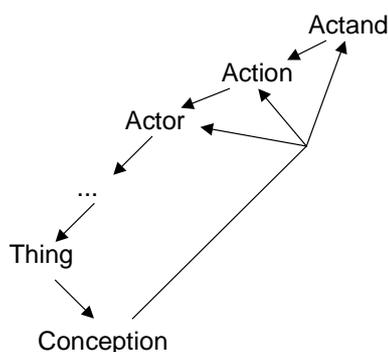


Fig. 6: The conception / thing / actor circularity (simplified)

This reflects the fact that *conceptions* originate (as *actands*) from *actors* (the "world observers" or "system analysts") and, on the other hand, persons - and in particular: *actors* - are *conceived* as *things*, i.e. are *conceptions* themselves.

The solution proposed in [1] and [7] basically relies on a stricter separation of the framework layers. For this purpose, a "base layer" of implicitly explained terms (explained by the FRISCO ontology and its introductory assumptions) is introduced. *Conceptions* are restricted to this base layer and do not occur again in the kernel and upper layers. This corresponds to IS modelling practice where "conceptions" would never play a role - except in domain-specific psychological or cognition-theoretical applications.

But even then, the *actor* still plays a double role: First, an actor acts as a "world observing" subject to produce conceptions which might then imply (mostly: other) actors as objects ("actands") of this conceiving action. The solution of this problem lies in distinguishing the different *roles* of actors in the different definition layers: At the base layer, a specific actor (in subject position) is needed as an originator of conceptions to explain the constructivist approach. (In fact, this "actor" represents a language community and its common understanding of what we often call "world knowledge" and what FRISCO condensed into the leading *assumptions*). This actor - further on to be called the *observer* - must not be identified with the IS actor (in object position from the analyst's point of view) which is explicitly to be defined at the kernel level as any kind of entity which is able to perform actions (including non-human entities).

In fact, there is a similar problem in connection with the "system viewer" [11]. Whilst what precisely constitutes a "system" is a matter of modelling (i.e. of conceiving) by that "viewer", it clearly has a greater significance in the social context. Once negotiation within a certain group has resulted in general agreement, the stable "system denotation" represents a "shared view" of that group. Thus the role of a system viewer is comparable to that of a "world observer".

"Over-formalisation" of some concepts

Formalisation is among the most controversially debated issues of FRISCO. In the more general debates, it is argued that Information Systems are more than pure technical systems, involve people and social relationships and thus are not an appropriate target for formalisation. On the other hand, the FRISCO task has been started in order to replace vague explanations and fuzzy use of terms by rigid and unambiguous definitions of concepts - which implies some degree of formalisation. The FRISCO group has tried to choose a middle way by emphasising the non-formalisable character of Information Systems as a whole (and, in particular, of their "social" parts) but providing in a separate chapter (no. 4) formalised counterparts for most of the kernel concepts defined in chapter 3.

Concerning the details, the borderline between formalisable and non-formalisable concepts has not always been drawn in an optimal way. This has led to some "over-formalisations" mostly concerning those concepts which are to be moved to the base level (perception, conception, language etc., see [1] and [7]).

Moreover, in chapter 4 the "set membership" concept (of FRISCO) has been identified with the corresponding mathematical concept which leads to definitional circles. This problem can easily be solved by dropping this identification and replacing it with a FRISCO-specific (and formalisable) composition concept.

Examples and sample application

In the original report, it was decided to include small illustrating examples as well as a comprehensive example in order to demonstrate the application of the FRISCO concepts to a more or less realistic case. In chapter 5 of the report, such a demonstration was attempted, based on the business of a fictive trading company. This presentation was criticised as lacking in explanatory power (some readers have even mistaken it as a modelling exercise), which rather obscured the universality of the FRISCO approach. Discussions at the Leiden workshop have shown that the expectations from such application examples vary widely (corresponding to the wide range of the IS field) and that it will be difficult to satisfy everybody's wishes.

Reflections of authors and associates

The FRISCO report contains seven essays of FRISCO authors and associates where these have expressed their personal reflections, assessments and positions - including dissenting ones. This chapter is a point of ongoing debate. On the one hand, it reflects the "democratic culture" of the FRISCO group and its work: It was - still is and hopefully will be - open for discussion and controversial arguments. On the other hand it is argued that FRISCO is expected to deliver a cohesive, unambiguous and instructive piece of work, the occurrence of dissenting positions in which might confuse or even deter the unprepared reader.

It is still an open question whether the compromise adopted in the original report (to provide a separate reflection chapter) should be maintained or not.

4 Revision of the FRISCO report

As a result of the review at the Leiden conference, a revision of the report and the preparation of a book version were suggested by IFIP WG 8.1 representatives. This revision has been delegated to a small subgroup of the original FRISCO authors and is currently under way. The main goals of the revision are:

- to restructure the report according to the above mentioned concept layers, integrating the corresponding informal, formal, example and supplementary sections,
- to rework the foundation part of the report, to introduce a new "base layer" (basically explaining the constructivist approach and related concepts) and to rearrange concepts, aiming at a clearer layer structure and removing circular definitions,
- to review the full text in order to adapt it to the current requirements, to replace or eliminate outdated sections and to rework examples and formalisations where necessary.

5 Some consequences of the FRISCO approach

The FRISCO Report provides a "framework", not a recommended methodology. It is based on a multidisciplinary line of reasoning and attempts to avoid the flaws of previous, more techno-centric approaches.

We consider the FRISCO view most important in connection with the functioning of IS in an organisational context. Both "information" and "communication" play crucial roles, the nature of which is normally taken for granted, without any questioning. Most people think that information and communication are merely useful selections of data (which, of course, is their substrate, but not their origin, nor their intention). In previous papers, we have stressed their social aspects and the need for always questioning the informational model (cf. [5], [11]).

For FRISCO, "information" and "communication" are not absolute but relative concepts. They are seen as linking the *individual* person ("information" = increase of personal knowledge) and the larger *community* of which that person is a member ("shared knowledge" resulting from communication, thus reflecting the purposeful informational arrangements of that community). While solid software engineering remains essential, the fact that information entails more than well selected data should not be a matter of lip service but of true awareness throughout the organisation. It concerns system designers and information users, both during the IS development process and its operation.

FRISCO also addresses the complexity of communication. Messages often have meanings at different levels, which should be understood within their full context. Message exchange may be a mechanical process, but the subsequent chain of decision processes may be so distributed that the relevance of the information content in the message for the specific decision support is not recognised as such. Misinformation or insufficient information may well result. In either case the "IS investment" is economically unjustified.

Computer-based packages and facilities often employ an idiosyncratic terminology, more in the nature of buzzwords than linked to clear and unambiguous concepts. FRISCO-like reasoning - in particular on the meta-model level, may assist in clarifying the proper context and thus contribute to the value of such investments.

An interesting conclusion was reached in Workshop 3 of the Leiden Conference (paraphrased): "The concepts one uses in practice are those that underly (or are built into) the commercially available (CASE and other comparable) tools"! In other words, only if the method engineers and toolmakers are well qualified good views will come about. FRISCO deliberately intends to contribute to this kind of qualification. It emphasises the need for replacing the customary "how-to" approach by one which we would circumscribe as "why-and-to-which-effect" oriented.

6 Conclusion

At the Leiden conference, there was a unanimous consent that the FRISCO group had undertaken a fairly difficult task, reached many of its goals and produced a comprehensive report. Being aware that such a report cannot fulfil everyone's expectations it was acknowledged that, as a whole, it forms an important step towards a well-founded theory of the IS field. All participants supported the suggestion that the work done so far deserves to be continued in a revision phase and concluded with the production of a (physically available) book.

Of course, that book should not be expected to provide the "ultimate theory of Information Systems". However, it could fill a significant gap in the IS foundation field, which has been neglected in a period of technical revolution and ad-hoc adoptions for fast-grown applications. In particular, it might provide managers and system designers with better insight regarding the significance of "information" in the organisational context and, hence, lead to more effective cooperation of all groups involved in the development and use of Information Systems.

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