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On Conceptual Temporal 'Ordering' Relations: A Terminological Approach

> "Surveying the field of terminology is like trying to read maps before satellites penetrated into every remote corner of the earth. [...] there are also some blank regions on each map on which we find printed: 'These regions have not yet been explored' or 'Hic sunt leones'. [...]. The subject of concept classes and terminological relationships can be placed into this area of uncertainty, of wishful interpretation bordering on phantasy. Most mapmakers claim their existence, virtues and even usefulness, but few are agreed on their exact nature, way of operation or number because some relate their new findings to old patterns of knowledge which have proved useful in other areas of knowledge but are unsuitable here, while others jump ahead and describe relationships without having previously established what, specifically, is being related." (Sager & Kageura 1994-95: 191)

1. Introduction

In discussions of relations between concepts, terminological research has so far mainly concentrated on investigating genus-species and part-whole relations, the so-called hierarchical relations. Less research has been carried out in the area of non-hierarchical relations, such as spatial, causal and temporal relations. In particular, little is known about temporal relations which are the focus of this paper. The main aim of this paper is to introduce a typology of temporal relations and to investigate empirically the validity of some of the relations proposed by means of a text-based conceptual analysis.

The paper is structured as follows. Section two starts with a short introduction to the overall research project in order to place the study into a wider framework. This is followed by a brief survey of the types of temporal relation that are known so far (section three). Then, in section four a typology of temporal relations will be proposed and its individual dimensions will be explained. The conceptual analysis of LSP texts (official aircraft accident reports) will be presented in section five. Section six provides the conclusion.

2. Brief Overview of the Ongoing Study

Although it is often emphasized that temporal relations are important for terminology work (e.g. Nuopponen 1994: 92), there have been few attempts to establish a typology of such relations and it has to be noted that most classifications are of a subjective and ad hoc nature. A major part of this research therefore involves the construction of a typology of temporal relations on the basis of philosophical, linguistic, psychological and artificial intelligence literature. As it is necessary to find out whether the theoretical types and subtypes identified in this typology really exist, empirical research in the form of a conceptual as well as linguistic data analysis is needed. In order to test the typology a text-based approach is being used. To this end several English and German aircraft accident reports consisting of ca. 22 000 words in each language have been converted into a machine-readable format.[1] The untagged texts have been analysed manually

[1] Originally, the English and German texts consisted of 275 000 and 120 000 words respectively. However, these figures needed to be reduced after pilot studies had shown that the conceptual analysis of temporal ordering relations was more complex and time-consuming than anticipated.

following a semi-automatic analysis using System Quirk[2]. The manual part of the data analysis is divided into three major phases:

(1) A conceptual analysis of the individual accident reports during which the individual types of temporal relation contained in the reports are revealed and matched against the types identified in the typology. The question of whether the temporal ordering of concepts or conceptual structures[3] that are linked to each other by temporal relations matches the order of the linguistic structures representing them is also investigated (iconicity).

(2) A linguistic analysis which focuses on the linguistic cues for temporal relations on the one hand, and on the linguistic structures representing the concepts/conceptual structures that are linked by temporal relations on the other.

(3) A comparison of the data from the English and German accident reports in order to gain some cross-linguistic insights.

The main goals of the study are as follows. By identifying any cues for underlying temporal ordering relations and also by investigating 'what' is linked by such relations, it is hoped to classify the linguistic cues as well as the types of concept/conceptual structure according to the particular type of temporal relation. Hopefully, such a classification model will allow and facilitate predictions regarding types of underlying temporal relation for the purposes of manual or computerized conceptual analyses in the fields of terminology science and knowledge acquisition.

In the next section the known types of temporal relation and their methods of classification are briefly reviewed and analysed.

3. Temporal Relations

3.1 Known Types of Temporal Relation in Terminology Science

In the terminological literature two types of temporal relation are generally distinguished, i.e. 'consecutive' and 'simultaneous' relations (e.g. Arntz & Picht 1995; Picht & Draskau 1985; Wüster 1974a), which are shown in Figure 1 below. In this classification concepts are organized according to the *type of connection* (either consecutive or simultaneous).

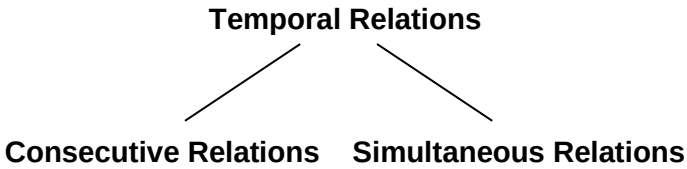

Figure 1: 'Traditional' classification using the ordering characteristic *type of connection*

In contrast to this, Nuopponen (1994) uses a different approach (Figure 2 below). Instead of the *type of connection*, she takes the *type of concept linked* as the ordering characteristic for her classification, dividing temporal relations into 'succession' and 'event' relations (1994: 94). The succession relation forms a temporal link between what can be termed 'entities' (e.g. predecessor, successor) whereas the event relation can be described as a relationship which creates a temporal bond between individual events (e.g. between phases or stages in a process).

[2] System Quirk, a text-processing terminology management system, has been developed by the Artificial Intelligence Group of the Department of Mathematics & Computing in collaboration with the Department of Linguistic & International Studies at the University of Surrey.

[3] The term 'conceptual structure' is used because, as will be shown later in sections 4.1.3 and 5.2.2.1, temporal relations can not only link individual concepts to each other but can also link more complex 'constructs' with each other.

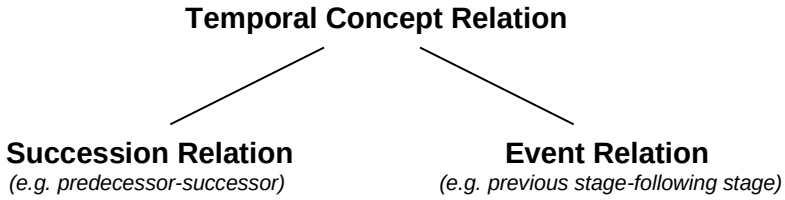

Figure 2: 'New' classification (adapted from Nuopponen 1994: 94) based on the *type of concept linked*

The succession relation (Nachfolge-Beziehung) was originally identified by Wüster (1974b) and has subsequently been mentioned by various authors (e.g. Felber & Budin 1989; Felber 1984). Event relations as such have so far been described in the literature in the form of 'consecutive relations', e.g. "first 'reap' then 'thresh'" (Picht & Draskau 1985: 82; cf. also Arntz & Picht 1995; ISO 704 1987).

It is interesting to note that Nuopponen's classification does not explicitly show the possibility of simultaneous relations as, for example, Wüster's does (cf. Figure 1). One could therefore get the impression that the concepts that are linked by either the succession or the event relation can only follow each other in time but not happen simultaneously. However, some of Nuopponen's examples do involve simultaneity relations, e.g. *Notification (**and** Confirmation)* ⇨ *Presentation of Documentation* (cf. Nuopponen 1994: 178). Furthermore, one aspect which is not considered in either classification is the possibility of 'types' of simultaneity, i.e. the fact that concepts can either fully overlap or exhibit various degrees of overlap.

To sum up, the major types of temporal relation known in terminology science are either subsequence and simultaneous relations or succession and event relations depending on the method of classifying them, i.e. the ordering characteristic chosen.

3.2 Types of Temporal Relation in Other Disciplines

In all the literature consulted there is a plethora of names in use for 'succession' relations, e.g. 'before-and-after' relations, 'consecutive' relations, 'precedence' relations, and so on. However, for the purposes of this study it has been decided to use the term 'subsequence' relation as the generic term whenever this type of relation is referred to.

- **Temporal Relations in Philosophy**
  Usually two types of temporal relation are identified, i.e. 'subsequence' and 'simultaneity' relations though different terms might have been employed for them (Kant 1995; Russell 1971; Newton-Smith 1980; O'Shaugnessy 1971; Rescher & Urquhart 1971). Russell, in particular, mentions a further type, i.e. 'partial simultaneity' relations arguing that "two events overlap, [...], or are (at least partially) simultaneous, if neither wholly precedes the other" (1971: 347).

- **Temporal Relations in Linguistics**
  Temporal relations are generally investigated as part of the temporal representation of discourse, i.e. they usually involve the parameters of speech time, event time and reference time (e.g. Hinrichs 1986; Comrie 1985; Partee 1984). There are, however, studies which focus on temporal relations linking actions and events (e.g. Ter Meulen 1997; Cann 1993; Kamp 1979) or propositions (e.g. Heinemann & Viehweger 1991). In general, it can be observed that temporal relations are investigated on different levels of abstraction, i.e. some authors have studied 'subsequence', 'total simultaneity' and 'partial simultaneity' in general terms (e.g. Ter

Meulen 1997; Comrie 1985; Kamp 1979) while others have identified specific types, e.g. 'overlap', 'inclusion' relations, and so on (e.g. Cann 1993; Hinrichs 1986).

- **Temporal Relations in Psychology**
  Here, the emphasis lies on the perception (e.g. Miller & Johnson-Laird 1976; Fraisse 1975) and the speed (e.g. Schliebs 1989) with which temporal relations are recognized, i.e. comprehended by humans. The types of relation usually identified are 'before' and 'after' relations.

- **Temporal Relations in Artificial Intelligence**
  Two major groups can generally be distinguished, i.e. 'quantitative' and 'qualitative' temporal relations. It is the latter group which is relevant to the current study. Qualitative relations are subdivided further into seven basic relation types, i.e. 'before', 'meets', 'overlap', 'start'', 'during', 'finish' and 'equal' relations (cf. Gamper 1996; Vila 1994; Allen 1991; Allen & Hayes 1989).

In all these disciplines it can usually be observed that 'inverse' relations are important, e.g. 'after' relations are the inverse of 'before' relations. In the present study, however, inverse relations are not considered to be relevant because it can be argued that on the concept level the basic relation remains the same regardless of whether it is looked upon as an 'after' or a 'before' relation. For example, in *the aircraft taxied after it had landed* it can be seen that on the linguistic level the events in this example could be described as being related either by an 'after' or a 'before' relation. However, regardless of the order in which the events are described linguistically the 'actual' temporal order of the concepts is never affected; the conceptual structure AIRCRAFT LANDS always 'takes place' before the conceptual structure AIRCRAFT TAXIES.

Finally, some remarks about the term 'temporal relations' are in order. It is proposed that in terminology science the term **temporal ordering relations (TORs)** should be adopted instead of 'temporal relations' in order to focus attention on the fact that not only subsequence but also simultaneity relations are included. It is conceded, however, that temporal order is generally perceived in the sense of 'before and after' whereas one would not necessarily think of simultaneity as a phenomenon which appears to order concepts temporally. Nevertheless, as has been shown in this section, concepts can not only occur before or after each other but also simultaneously in varying ways. It is therefore reasonable to argue that simultaneity also refers to some kind of temporal order.

In this section the individual types of temporal relation known in terminology science and various other disciplines have been reviewed briefly. In the next section a typology of such relations will be proposed taking the existing types as a starting point. Also, from now on the term 'temporal ordering relations' will be used.

4. A Multidimensional Typology of Temporal Ordering Relations (TORs)

As has been shown, any terminological classification of temporal ordering relations has so far been limited to a unidimensional single-level hierarchy by using just one ordering characteristic (cf. Figures 1 & 2). However, unidimensional classifications can often be regarded as insufficient because they may not allow terminologists to capture all the relevant concepts of a certain domain; also, different users may have differing needs or interests (cf. Bowker 1997: 137-138; cf. Kageura 1997: 120). Hence, in this study the attempt is made to construct a multidimensional classification of temporal ordering relations by combining several ordering characteristics. The characteristics, summarized in Table 1 below, are discussed briefly before the typology is introduced in section 4.2.

Ordering Characteristic One	*Temporal Objects*
Ordering Characteristic Two	*Relationable Categories*
Ordering Characteristic Three	*Type of Simultaneity*

Table 1: Types of ordering characteristic forming the various dimensions of the typology

4.1 Introduction of the Individual Ordering Characteristics

4.1.1 Ordering Characteristic One: *Temporal Objects*

Temporal ordering relations can first of all be classified according to the *temporal objects* which they link, i.e. time intervals (i) and time points (p). In artificial intelligence (e.g. Gamper 1996; Shoham 1988), time intervals are generally described as exhibiting 'positive duration' (*the pilots carried out their pre-flight checks*) whereas 'points' are 'timeless', which means they exhibit 'zero duration' (*the pilot was killed instantly*). Another way of describing time points is to say that they are the 'places' where two time intervals 'encounter' each other (e.g. *pilot is alive* ⇨ *pilot is dead*) as has been suggested by, for example, Gamper (1996: 56) and Allen & Hayes (1989: 226). A second consideration is whether the concepts (mapped onto time intervals or time points) which follow each other are separated by a certain amount of time or not. This phenomenon can be called **temporal gap**[4] (+/-*temporal gap*).

4.1.2 Ordering Characteristic Two: *Relationable Categories*

It can be argued that temporal ordering relations can only be properly understood if more is known about the types of concept which they link as already indicated by Nuopponen (1994), who, it will be recalled, distinguishes between succession and event relations depending on whether they link 'events' or 'entities'. In considering how these categories can be extended, we can refer to Sager & Kageura's work (1994-95) on concept types. They distinguish four major types, i.e. 'activity', 'property', 'entity' and 'relation' concepts. According to Sager & Kageura, 'activity concepts' represent *actions*, *events*, *processes*, *operations*, etc. (e.g. *control*) which are performed by or with entities (1994-95: 198-9). Activity concepts can be used to describe the dynamic aspect of the real world while in contrast to this, 'property concepts' can be said to represent the static aspect of the world (cf. also Gamper 1996). 'Property concepts' have been divided by Sager & Kageura into 'states', e.g. *dead*, and into 'characteristics', e.g. *shape* (1994-95: 200; 204). In the sense of 'characteristics', property concepts are described by Sager & Kageura as the group of concepts which in the real world denote qualities of entities as well as of activities. 'Entity concepts' have been defined by them as "the class of concepts obtained from the abstraction of items of our experience and reflection perceived as having a separate existence in time and space" (Sager & Kageura 1994-95: 198). Examples listed by Sager & Kageura include *persons, institutions, products*, and so on. 'Relation concepts' are understood by them as those concept types which are characterized as forming the link between entities, activities and combinations of these (1994-95: 197-8).

It can be said that Sager & Kageura's concept types 'activities' and 'entities' appear to be similar to Nuopponen's categories 'events' and 'entities'. In addition, Sager & Kageura have identified 'property' and 'relation' concepts. Out of these four categories, which can be termed ***relationable categories***, three can be used to classify temporal ordering relations for the purposes of this study. These are 'activities' (Sager & Kageura's terminology, i.e. 'activities' is preferred to Nuopponen's 'events'), 'entities', and 'properties'. Note that the concept type 'relation' is not included because it is the 'relation

[4] It should be pointed out that a temporal gap is in fact a time interval though it is of a different nature to those onto which, for example, activities can be mapped. The 'temporal gap intervals' occur in between these other types of time interval.

concept' itself, i.e. in the form of temporal ordering relations, which is being investigated. It has also been decided to use the term **occurrence** as the generic term for activities, properties and entities for the purposes of this study.

The question is now how these 'relationable categories' can be grouped in order to allow a systematic classification of temporal ordering relations. Let's first look at how the three categories are linked to time, i.e. 'time intervals' and 'time points'. Activities (e.g. *manoeuvring*) and properties (*tired*) can be mapped instantly onto a time interval, i.e. it can be said that they are directly connected to time. This has already been observed by Frawley who states that activities are "crucially defined by their association with a time interval" (1992: 187; though his term is 'events'). In contrast to this, an entity's (e.g. *captain*) link to time is not instantly recognizable because it can be argued that they do not have starting and end points in the same way that activities have. Vendler (1968) also sees a clear difference between the way entities and phenomena like 'events' (Vendler's term) are perceived temporally. He characterizes the relation between entities and time as an indirect one whereas events are essentially temporal (1968: 144). Nevertheless, in spite of their indirect link to time, entity concepts can still be mapped onto time intervals. For example, it could be said that the interval *senior first officer* is temporally followed by the interval *captain*.

Hence, for the purposes of this study, the relationable categories 'activities' and 'properties' can be classified in one group, which can be called **direct temporal conceptual structures**[5], since activities and properties are directly linked to time intervals and time points (activities only). The category 'entities' is classified in a separate group, which can be called **indirect temporal concepts**, because the relation of entities to time intervals is not direct. Temporal ordering relations can thus be established between direct temporal conceptual structures on the one hand, and between indirect temporal concepts on the other (cf. Figure 3).[6]

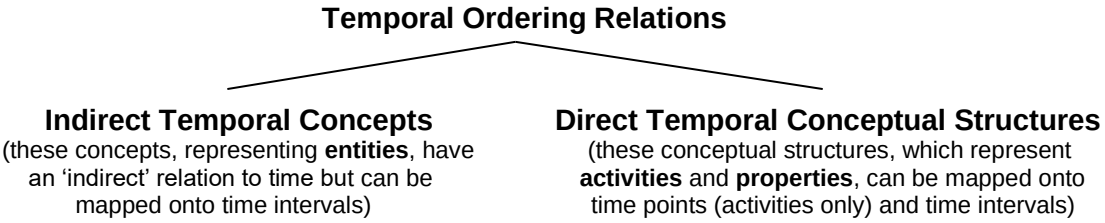

Figure 3: Classification by *relationable categories*

4.1.3 Ordering Characteristic Three: *Type of Simultaneity*

Temporal ordering relations can also be organized according to the *type of connection* as has been done by Wüster who divided these relations using 'consecutiveness' and 'simultaneity' (cf. Figure 1). The question is 'which' type of connection should be chosen for constructing the typology since using both 'simultaneity' and 'consecutiveness' would mean that some types and subtypes would appear twice in the classification. Hence, the decision has been made to choose 'simultaneity' in order to organize temporal ordering relations as it allows a neat and logical systematization and also because it is often considered to be an "essential temporal dimension in life" (O'Shaugnessy 1971: 144). The

[5] In contrast to entities, activities and properties (in the sense of 'states') are often represented on the conceptual level by more than one concept, e.g. *the aircraft's left aileron disintegrated* or *the ATC controller was exhausted* (cf. also 5.2.2.1). This phenomenon has been termed 'conceptual structure' for the purposes of this study.

[6] It ought to be mentioned that a slightly different classification would also be possible here as has been pointed out by Gamper (Personal Communication); he argues that since all three categories can be mapped onto time intervals anyway the bipartite division is redundant. However, for the differences in time-relatedness between the categories it has been decided to keep this division.

relations can thus be classified according to whether they display simultaneity or not *(+/-simultaneity*). The characteristic -*simultaneity* (**null simultaneity)** allows the classification of all relations characterized by a complete subsequence (no temporal overlap) of concepts or conceptual structures. In the following example, for instance, two conceptual structures follow each other without any temporal overlap: *the aircraft left its stand and was given take-off clearance ten minutes later.* With respect to +*simultaneity* the literature review has revealed different types of simultaneity, i.e. 'total' and 'partial' simultaneity (cf. 3.2). Therefore, when +*simultaneity* is present we can speak of **partial simultaneity** (e.g. *the hydraulic system pressure began to fall six minutes into the aircraft's climb*) and **complete simultaneity** (*at 13:32:01 hrs both artificial horizons began to malfunction but went back to normal 38 seconds later)*.

Table 2 below summarizes the three dimensions involved in creating the typology.

Dimension I	*temporal objects*	time intervals	positive duration	
		time points	zero duration; meeting places of time intervals	
		+/-temporal gap		
Dimension II	*relationable categories*	direct temporal conceptual structures	activities	can occur over time intervals or at time points
			properties	occur over time intervals
		indirect temporal concepts	entities	no 'direct' relation to time, but can be mapped onto time intervals
Dimension III	*type of simultaneity*	-simultaneity	null simultaneity	
		+simultaneity	complete simultaneity	
			partial simultaneity	

Table 2: The various ordering characteristics involved in the construction of the multidimensional typology

4.2 The Proposed Typology

In this section a typology of temporal ordering relations is introduced integrating the three dimensions that have been discussed above. Since explaining the full typology would go beyond the scope of this paper it has been decided to just concentrate on a small segment of it although the full typology is shown in Figure 6 below.

4.2.1 Preliminaries

Before discussing the typology, however, a few remarks with respect to the differentiation between 'relations of influence' (e.g. causal relations) and 'pure temporal relations' are in order. In the terminological literature pure temporal relations and relations of influence are usually distinguished from one another (cf. Nuopponen 1994: 240; Wüster 1974b: 94). Pure temporal relations can be understood as being based on a chronological order of concepts involving only the 'element of time' whereas relations of influence not only have the temporal element but also the 'element of influence', which means that the preceding concept influences or in the strongest case even 'causes' the succeeding concept (cf. Nuopponen 1994: 175). In other words, influence (cause) implies time but not vice versa. However, in the present study no difference is made between pure temporal relations and relations of influence. The main reason is that it is difficult to make decisions about whether there is any influence or a causal connection present between two concepts or not as has been experienced during the conceptual analysis of LSP texts (cf. section five). It can be reported that so far a division into 'temporal relations +*influence element*' and 'temporal relations -*influence element*' could not be supported empirically. Hence, the fact that no distinction is made means that any relation with a temporal element (in the form of temporal ordering) irrespective of any element of influence can be classified using the typology presented here.

typology

typology

4.2.2 The Individual Branches and Levels of the Typology

As can be seen in the typology (Figure 6), there are two main divisions (left and right). They will be described by going from the top to the bottom while concentrating on the left main division (TORs between Indirect Temporal Concepts) for reasons of brevity.

- **Dimension One (d1)**
  The highest level of the hierarchy, below the top node, is organized according to the characteristic *relationable category* and thus has two main divisions, i.e. relations between **indirect temporal concepts** (on the left side of the typology) and relations between **direct temporal conceptual structures** (on the right). Until this point, the classification corresponds more or less to Nuopponen's model (cf. Figure 2) because the division of indirect temporal concepts (representing entity concepts) can be equated to Nuopponen's 'succession relations' and the division of relations between direct temporal conceptual structures (referring to activity and property concepts) can be said to be similar to her 'event relations'.

- **Dimension Two (d2)**
  On the second level of the hierarchy the characteristic +/-*simultaneity* is introduced for both main divisions. In order to illustrate this more clearly, dimension 2 has been split into two subdimensions (d2i, d2ii). As has been shown earlier, +/-*simultaneity* can be broken down into complete, partial and null simultaneity (cf. d2ii). Hence, as can be seen in the typology, the left branches of each main division classify relations between concepts or conceptual structures which do not happen simultaneously in any way; in other words, the concepts/conceptual structures linked by these types of relation follow each other in time without any kind of temporal overlap **(null simultaneity relations)**. In contrast to this, the middle branches show relations between concepts or conceptual structures which are characterized by the fact that they begin and end at exactly the same time **(complete simultaneity relations)**. In the branches on the right of each main division, however, the concepts or conceptual structures linked all exhibit some sort of temporal overlap which means that to a certain extent they take place at the same time **(partial simultaneity relations)**.

- **Dimension Three (d3)**
  On this level of the hierarchy the relations have been organized with respect to which temporal objects *(time intervals; time points; +/-temporal gap)* are linked to each other. Looking at the typology's left main division (indirect temporal concepts), it can be seen that the three divisions of simultaneity relations (null, complete, partial) have been refined further into four individual subtypes according to how the individual time intervals representing these concepts can be ordered temporally (d3). Type 1, the **subsequence-with-gap entity relation** characterizes two entity concepts which follow each other in time with some time passing between the time intervals representing them. For example, a TWO-PIECE ESCAPE HATCH needs to be removed and then replaced by a more user-friendly ONE-PIECE ESCAPE HATCH whereby some time passes between the old hatch being taken out and the new one being fitted. For type 2, the **subsequence-without-gap entity relation**, one could say that a COMMERCIAL PILOT'S LICENCE becomes invalid the moment the AIR TRANSPORT PILOT'S LICENCE becomes valid, i.e. there is no temporal gap between the two time intervals representing the two licences. In the case of relations which link concepts that happen at exactly the same time there is one subtype, namely the **matching entity relation** (type 3). An example would be a CAPTAIN and a FIRST OFFICER reporting for duty at the same time as well as being off duty at the same time, i.e. the intervals representing these concepts start and end completely simultaneously. Finally, the branch that classifies relations

which connect concepts that overlap in time leads to type 4, the **overlap entity relation**. For example, a FIRST OFFICER reports for duty later than the CAPTAIN, i.e. the time interval representing the FIRST OFFICER starts after the time interval representing the CAPTAIN.

In this section a multidimensional typology of temporal ordering relations has been proposed after introducing the various dimensions involved in its construction. It ought to be emphasized that the typology is at this point a theoretical model; empirical validation of the individual types is done through a conceptual analysis of LSP texts, i.e. aircraft accident reports, which will be described below.

5. Conceptual Analysis of Aircraft Accident Reports

The main goal of the conceptual analysis, which represents one of the three major phases of the overall data analysis, is to corroborate the individual subtypes of temporal ordering relation that have been identified in the typology in order to find out which types really exist and are predominant in this text type.

Section five is structured as follows. First, some details about the aircraft accident reports will be given. Then, the various steps of the conceptual analysis will be outlined briefly and illustrated by some example sentences from an English aircraft accident report.

5.1 Aircraft Accident Reports

The main reason for choosing the domain of aircraft accidents is that in texts dealing with aircraft accidents the description and temporal order of events leading to such an accident is a prominent feature. For aircraft accident investigators, to understand how an accident happened depends, among other things, on the comprehension and reconstruction of the exact temporal order of events which caused an aircraft accident (Owen 1998).

The text genre ‘official aircraft accident report’, which is analysed in this study, is the predominant genre in the domain of aircraft accidents. These accident reports are issued by the investigating authority in whose country the accident occurred. Such reports are necessary in order to convey information about the reasons and causes of an accident. As there are international guidelines as to how such accident reports ought to be written, they usually display the same kind of internal structure. The reports are normally published in the language of the country in which the accident took place, but they are rarely translated into other languages. This means that it is difficult to find full reports in more than one language dealing with exactly the same accident, either as texts written in parallel or as texts whereby one is a translation of the other. Hence, the English and German reports for this study have been chosen in such a way that they all refer to similar types of accident.

5.2 The Conceptual Analysis

5.2.1 Preliminaries

The ‘textual units’ that serve as an entry point to the underlying conceptual structures are usually compound and complex sentences or a series of simple sentences. However, it is important to point out that analysing the conceptual structures often goes beyond the surface structures that are present. This has largely to do with the fact that different types of knowledge are involved in the interpretation of text. When humans process or interpret texts they not only bring in their ‘linguistic knowledge’ but also often knowledge that can be called **extra-linguistic knowledge**. For instance, whenever humans make inferences it means that they add their own knowledge to that contained in the text (e.g. Heinemann

& Viehweger 1991: 73; de Beaugrande 1980: 182-208; van Dijk 1977: 4). However, distinguishing between linguistic and extra-linguistic knowledge is problematic as has been pointed out by, for instance, Heinemann & Viehweger (1991: 95) and de Beaugrande (1980: 72). Some authors even go as far as believing that there can be no meaningful distinction, i.e. separation between these knowledge types at all (e.g. Wilks, Slator & Guthrie 1996: 255; Lutzeier 1985: 86; Langacker 1983: 163). Nevertheless, authors who demand that a "strict separation between linguistic facts and extra-linguistic knowledge of the things of the external world has to be maintained" (Staib 1988: 235) can also be found. Considering these conflicting views it is probably not surprising that problems have been experienced during the conceptual analysis, in particular when determining where one knowledge type ends or begins. Therefore, for the purposes of this study it has been decided that a clear distinction between these knowledge types cannot be maintained during the analysis.

5.2.2 The Individual Steps of the Conceptual Analysis

5.2.2.1 Step 1

Identifying the Temporally Related Concepts and Conceptual Structures
First, the concepts or conceptual structures that are temporally linked to each other need to be determined and their exact nature needs to be established (using the concept types 'activity', 'property', and 'entity'; cf. section 4.1.2). For the purposes of this research, the concepts/conceptual structures which are temporally related to each other can be said to form a **temporal ordering chain**. The 'elements' constituting such a temporal ordering chain can either be two or more individual 'concepts', such as COMMERCIAL PILOT'S LICENCE (entity), or two or more 'conceptual structures' which represent, for instance, activities (e.g. actions, events, processes), as can be seen in the example PILOT LOWERS FLAPS. Here, three individual concepts have been coalesced into a complex conceptual structure which underlies an action. This example illustrates that an action (*lowering*) always implies a human agent (*pilot)* who does something for a particular purpose in a specific situation (cf. Pilke 1997: 5) and also often involves an object with which or to which something is done (*flaps*). However, an agent may not always be expressed explicitly in the text. In a way, the similarity of the linguistic structures representing such conceptual structures to LSP phrases cannot be overlooked since the latter have been described by Picht as "two elements (concepts), one of which possesses object characteristics, and the other, verb characteristics" (Picht 1990: 35).

Determination of the Types of Temporal Ordering Relation
While the concepts/conceptual structures which form part of the temporal ordering chain are being identified, it also needs to be established in which temporal order these concepts/conceptual structures have to be placed. To this end, the types of temporal ordering relation need to be determined and matched against the typology (cf. Figure 6).

Creation of a Time Map
Once the individual concepts/conceptual structures that participate in the temporal ordering chain as well as the types of temporal ordering relation have been identified, this chain is presented graphically. Common methods used in terminology for representing temporal ordering relations tend to be in form of flow charts (e.g. Arntz & Picht 1995; Picht & Draskau 1985) but Arntz & Picht point out that so far there are no general recommendations for the graphic representation of such relations (1995: 102). Flow charts, however, are a good starting point and for the purposes of this study they have been developed further into what can be termed **time maps**. Such a time map involves two time axes separated by 90 degrees (cf. Figure 7 below). The axis which represents time line (t) goes from the left to the right indicating the **flow of time** from 'earlier to later'. The other axis, time line (d), extends from the bottom to the top representing what can be

called **depth of time** and allows the representation of various types of simultaneity (partial, complete).

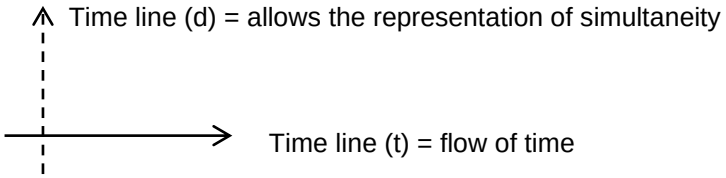

Figure 7: Time map

5.2.2.2 Step 2

During this phase the question of iconicity arises. If the temporal order of concepts/ conceptual structures matches the order of the linguistic structures denoting them then we can say that the linguistic representation of the concept level is iconic. This analysis is carried out on what can be termed the **transfer level**. Usually, this level is called the 'concept-term' level but this does not capture the nature of relations between conceptual structures and the various linguistic structures needed to express them.

5.2.2.3 Step 3

Domain experts need to be consulted in order to have the results validated. The English experts include a British Airways Captain and an aircraft accident investigator from the Aircraft Accident Investigation Branch (AAIB) in Farnborough. The German experts are several aircraft accident investigators from the German aircraft investigation office (Flugunfalluntersuchungsstelle beim Luftfahrt-Bundesamt) in Brunswick.

In section 5.3 below, two examples from the actual data analysis will be discussed illustrating the various steps of the conceptual analysis.

5.3 Examples of the Conceptual Analysis

The first example to be discussed is relatively straightforward (cf. Figure 8 below); the second one, however, illustrates a more problematic case (Figure 9). Both examples are taken from the same aircraft accident report (AAIB 1995).

5.3.1 Example One

Text No:	AAR96-2
Line:	2939
Example sentence:	Its airspeed in uncontrolled descent was well in excess of its maximum design speed so as to cause structural break up before the final impact.

STEP 1
The conceptual structures participating in the temporal ordering chain, shown in the time map below (Figure 8), are AIRSPEED IN UNCONTROLLED DESCENT IS WELL IN EXCESS OF ITS MAXIMUM DESIGN SPEED, STRUCTURE BREAKS UP, and AIRCRAFT IMPACTS. In order to linguistically label such conceptual structures the nominal style typical of labelling concepts has been discarded (except for entity concepts) whenever possible in favour of a verbal style as this is perceived to capture the essence of activities and properties more readily. This has been done in accordance with Sager & Kageura (1994-95: 195; cf. also Sager 1990: 26) who argue that the temporal characteristics of activity concepts in particular cannot be easily reproduced by using the nominal form. Furthermore, a temporal ordering chain can be said to remotely resemble the notion of 'chronologies' as they are used in historical writing. Hence, by analogy with

how chronologies are generally written, namely in the present tense, it has been decided to use this tense for the linguistic labels of conceptual structures, too. The present tense is used to abstract occurrences and also to lend them more immediacy.

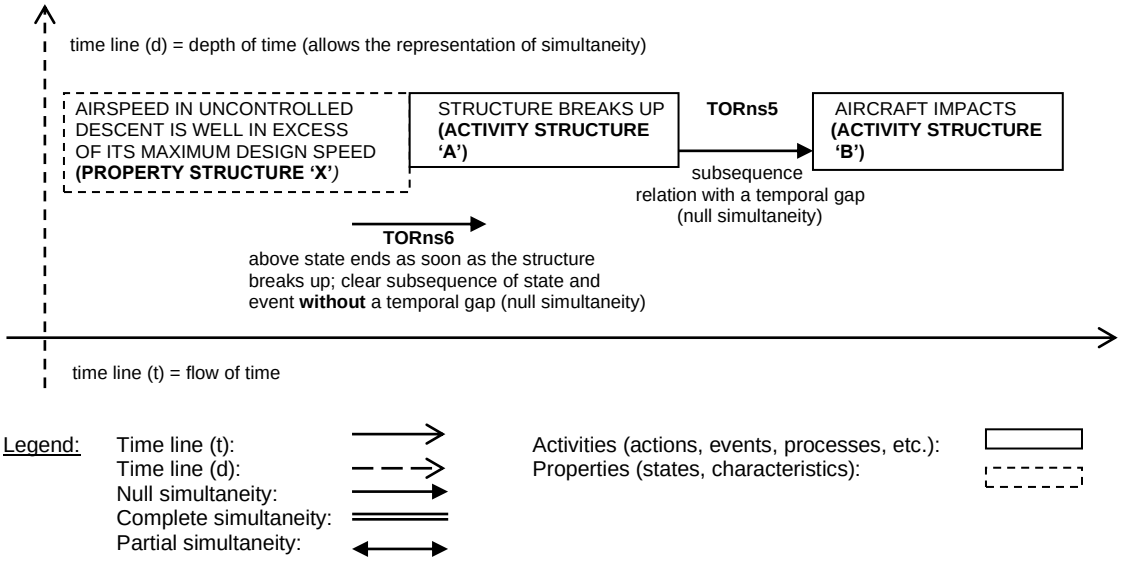

Figure 8: Time map of example 1

The conceptual structure shown on the left in the time map represents a state in the real world and can be classified on the concept level as a **property (conceptual) structure** ('X'). The remaining two conceptual structures represent events in the real world and can be classified as **activity (conceptual) structures** ('A', 'B'). The temporal ordering relations between these conceptual structures are as follows. Both activity structures happen one after the other, i.e. they are not simultaneous in any way; hence they are linked by a relation characterized by null simultaneity. Property structure 'X' and activity structure 'A' also follow each other in time, i.e. no degree of simultaneity is present either. The fact that no simultaneity is present in these relations can be established by interpreting the given text. However, further information is needed in order to determine the types more precisely, i.e. the question of whether the individual concept structures are separated by a certain amount of time or not (+/-*temporal gap*). This can only be established by consulting with domain experts (cf. step 3 below).

STEP 2
The linguistic representation of the concept level is iconic because the temporal order of the conceptual structures matches the order of the linguistic structures representing them (concept level: X–A–B; linguistic level: X–A–B)

STEP 3
According to the domain experts there is no temporal gap between property structure 'X' and activity structure 'A', which means they follow each other instantly (TORns6). However, there is a temporal gap present between activity structures 'A' and 'B', i.e. some time passes between the aircraft breaking up and its impact (TORns5).

5.3.2 Example Two

The analysis of this example will be presented differently, i.e. steps 1 and 3 have been merged, because the time map could only be created with the domain experts' help.

Text No: AAR96-2

Line: 382
Example sentence: The crew, which was not the one later involved in the accident, stated that all of the aircraft's systems and equipment had been serviceable during the flight and, after flight, the aircraft technical log was completed to this effect.

STEP 1 (including STEP 3)
There are at least three possibilities to conceptually represent the temporal ordering chain underlying this example sentence (cf. Figure 9):

① It can be represented by using a minimum amount of extra-linguistic knowledge. This is shown in the time map by the four unshaded rectangles which represent four activity structures ('A', 'B', 'C', 'D').
② It is also possible to represent the sentence by making explicit a further layer of knowledge which is mentioned in the 'that-clause'; this is shown by property structure 'X' (representing the 'state of serviceability') in the lightly shaded rectangle. It can be said that this state prevailed during the first flight, and by resorting to extra-linguistic knowledge, it can be inferred that this state must have also prevailed before the first flight as well as after and also until some time into the accident flight.
③ Using further extra-linguistic knowledge in addition to what has been extracted already it is possible to arrive at another property structure ('Y') representing the state of 'unserviceability' (darker shaded rectangle). It can be argued that the 'serviceability state' must have finished at some point during the accident flight (otherwise the aircraft probably would not have crashed) and thus the aircraft's systems and equipment instantly entered a 'state of unserviceability'.

The difference between these possibilities consists in the different layers of knowledge that have been extracted. The question is which one of these possibilities should be used for the present analysis. Since, as has been mentioned before, the boundaries between extra-linguistic and linguistic knowledge are difficult to determine, it has been decided to temporally interpret this example sentence using only a relatively small amount of extra-linguistic knowledge. Hence, the time map used for the analysis only includes the lightly shaded rectangle because there is a textual cue present (that-clause). The darker shaded rectangle is only shown for illustration purposes.

Determination of Temporal Ordering Relations
For demonstration purposes the relations between 'all' the extracted conceptual structures will be explained. The relations could only be determined with the help of domain experts.

➲ 3 relations between activity structures 'A', 'B', 'C', 'D':
The relations between the four activity structures are all of the same nature: the conceptual structures follow each other in time (subsequence) with temporal gaps separating them (TORns5).
➲ 1 relation between property structures 'X' and 'Y':
It can be said that one state changes over into another and this changeover happens instantly and without any temporal overlap (TORns6).
➲ 3 relations between property structure 'X' and activity structures 'A', 'B', 'C':
Activity structures 'A' and 'B' exhibit 'embracing' relations with property structure 'X', i.e. the SERVICEABILITY starts before the FIRST FLIGHT TAKES PLACE and continues until after THE CREW COMPLETES THE AIRCRAFT TECHNICAL LOG (TORps13). Activity structure 'C' (ACCIDENT FLIGHT TAKES PLACE) is also partially simultaneous with property structure 'X' except that they are linked to each other by an 'overlap' relation (TORps12).
➲ 1 relation between property structure 'Y' and activity structure 'C':
The relation between activity structure 'C' (ACCIDENT FLIGHT TAKES PLACE) and property structure 'Y' (UNSERVICEABILITY) is characterized by a temporal overlap, i.e. 'C' begins before 'Y' starts. According to the experts, 'C' and 'Y' end at the same

time, because it can be argued that once the accident is over the 'state of unserviceability' also ends (TORps15).

➲ 1 relation between 'state changeover' and activity structure 'C':
The 'moment' at which the 'state of serviceability' changes over to the 'state of unserviceability' is called a time point and this happens during the 'time interval' of the 'accident flight taking place' (TORps16).

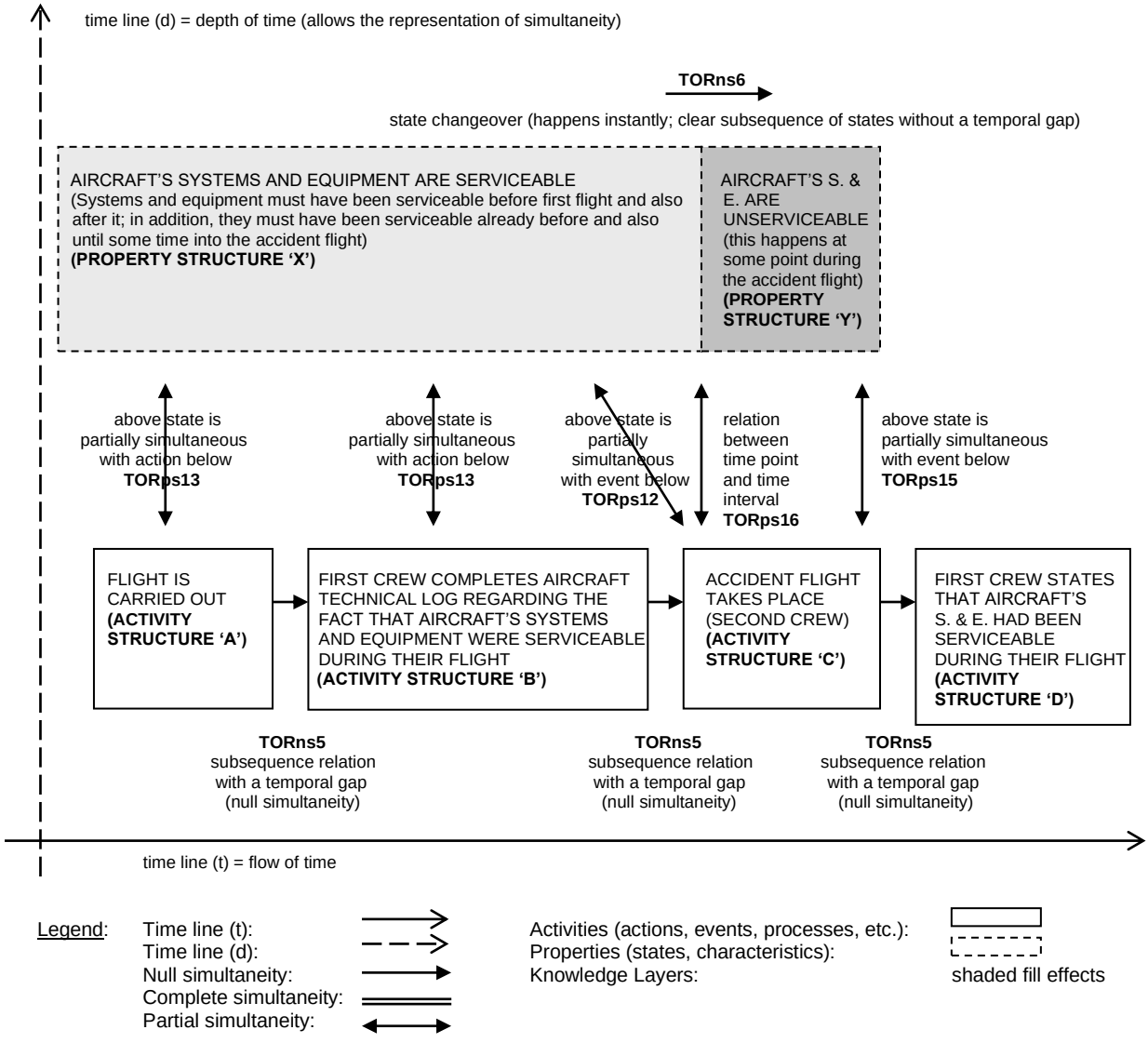

Figure 9: Time map of example 2

STEP 2
Iconicity is not present in this example.

6. Conclusion

In this paper a typology of temporal relations was proposed after having carried out a brief survey of the types known in terminology science, philosophy, linguistics, psychology, and artificial intelligence. Three major types of relation could be identified, i.e. 'subsequence', 'complete simultaneity' and 'partial simultaneity' relations. The suggested typology, which took these existing types as a starting point, resulted in a multidimensional classification

based on several ordering characteristics, i.e*. type of temporal object*, *type of relationable category*, and *type of simultaneity*. By doing so, the typology produced 18 individual subtypes of relation. The suggestion was also made that the traditional term 'temporal relations' is modified into **'**temporal ordering relations' in order to focus attention on the fact that not only subsequence but also simultaneity relations are included. Furthermore, the paper demonstrated how some of these relations can be validated empirically, i.e. by means of a conceptual analysis of LSP texts (aircraft accident reports) which was illustrated using a couple of example sentences from the actual analysis. The analysis of these examples showed that the existence of some types and subtypes identified in the typology could be confirmed. The example sentences also highlighted that extra-linguistic knowledge played a significant role in their (temporal) interpretation. A clear distinction, however, between linguistic and extra-linguistic knowledge could not be maintained.

Future work will involve a linguistic analysis focusing on two aspects: On the one hand, the linguistic structures representing the concepts/conceptual structures that are linked by temporal ordering relations will be analysed, and on the other, the attempt will be made to investigate the linguistic 'cues' for temporal ordering relations.

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