



**KTH Technology  
and Health**

# **Using Tentacles in Planning and Scheduling Work**

## Activities, Roles and Contributions

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# Abstract

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Handling production scheduling is increasingly difficult for many enterprises, and human involvement is necessary. The overall objective of this research was to gain further understanding of planners' and schedulers' work within the manufacturing industry, to elucidate how their work situation is formed, and to explain their significance to other employees' work and company activities. Scheduling work was studied in four companies in the Swedish woodworking industry; a sawmill, a parquet floor manufacturer, a furniture manufacturer and a house manufacturer. The method used was activity analysis which is based on the analysis of work activities in real work situations. Data collection included 20 days' observations and 65 interviews. Cross-case analysis with British cases on planning work was also included.

The findings revealed that the schedulers' tasks lead to many activities. Two thirds of these are what can be expected. The remaining third constitutes activities that depend on the schedulers' individual attributes and the context in which they work. The schedulers serve as problem solvers in a number of domains and constitute efficient information nodes, making them an important service function. Furthermore, they have an alignment role between different organizational groups. This role is specifically remarkable in dealing with production enquiries that must be aligned with production capability. Here, both planners and schedulers play an essential role in linking the manufacturing and the commercial sides and their different functional logics.

Planners and schedulers in daily work exert strong influence on others. They do not hold legitimate power. Instead their influence emanates mainly from access to and control of information and their ability to apply expertise to interpret this information and examine the impact of decisions made across different areas of the business. Personal power related to social skills is also significant.

Furthermore, they facilitate others' work in continuous personal interactions, serving the technical scheduling software system, and aligning different organizational functions. In combination with expert knowledge and developed social skills, they significantly contribute to quality operations performance. Finally, the schedulers influence the decision latitude of other employees and may indirectly promote job satisfaction, thus contributing to developing appropriate working conditions for others in the company.

**Keywords:** activity analysis, woodworking industry, work analysis, informal organization, ergonomics, human factors



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Linköping in April 2009

Martina Berglund

# Appended Papers

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This thesis includes an extended summary and eight appended papers, which are referred to in the text by their Roman numerals.

- I Berglund, M., Karlton, J. (2007). Human, technological and organizational aspects influencing the production scheduling process, *International Journal of Production Economics*, 110, 160-174
- II Karlton, J., Berglund, M. (2009). Contextual conditions influencing the scheduler's work at a sawmill, conditionally accepted for publication in *Production Planning & Control*
- III Berglund, M., Karlton, J. (2001). Schedulers' reality – expectations and dependencies. In Proceedings of the 16th International Conference on Production Research, July 29-August 3, Prague, Czech Republic
- IV Berglund, M., Karlton, J. (2006). Schedulers' work content – a quantified analysis. In Proceedings of the 16th Triennial Congress of the International Ergonomics Association, 10-14 July, Maastricht, the Netherlands
- V Guinery, J., Berglund, M. (2009). Production planning aligning customer requests with production capability  
Submitted for publication
- VI Berglund, M., Guinery, J. (2008). The influence of production planners and schedulers at manufacturing and commercial interfaces, *Human Factors and Ergonomics in Manufacturing*, 18(5), 548-564
- VII Berglund, M., Guinery, J., Karlton, J. (2009). The unsung contribution of production planners and schedulers at production and sales interfaces  
Submitted for publication
- VIII Karlton, J., Berglund, M. (2002). Schedulers' work activities and decision making influencing working conditions of other employees. In Proceedings of the 34th Annual Congress of the Nordic Ergonomics Society, 1-3 October, Kolmården, Sweden

# Division of Work between Authors

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- Paper I      Berglund, M., Karlton, J.  
Berglund initiated the paper. Berglund took main responsibility for data collection in two of the four case studies (the parquet and the house manufacturers). Berglund and Karlton jointly wrote the paper.
- Paper II      Karlton, J., Berglund, M.  
Karlton initiated the paper and wrote the findings from the case study. Berglund drafted the theoretical perspective, partly wrote the paper and reviewed it.
- Paper III      Berglund, M., Karlton, J.  
Berglund initiated the data collection and drafted the paper. Berglund was responsible for the findings from the parquet manufacturer case. Berglund and Karlton wrote the paper.
- Paper IV      Berglund, M., Karlton, J.  
Berglund initiated and drafted the paper. Berglund was responsible for the analysis and findings from two of the four cases (the parquet and the house manufacturers). Berglund and Karlton jointly wrote the paper.
- Paper V      Guinery, J., Berglund, M.  
Guinery initiated the paper. Berglund prepared the data collection and was responsible for the findings in the parquet floor case. Guinery and Berglund wrote the paper jointly.
- Paper VI      Berglund, M., Guinery, J.  
Berglund initiated the paper. Berglund was responsible for the findings from the parquet manufacturer and the sawmill case. Berglund and Guinery wrote the paper together.
- Paper VII      Berglund, M., Guinery, J., Karlton, J.  
Berglund and Guinery initiated and wrote the paper. Karlton reviewed the paper.
- Paper VIII      Karlton, J., Berglund, M.  
Karlton initiated the paper. Berglund took main responsibility for data collection in two of the four cases (the parquet and the house manufacturers). Karlton and Berglund wrote the paper.



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# 1 Introduction

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*The aim of this introductory chapter is to provide a background to the topic of this thesis, human work in industrial planning and scheduling, and to describe the problem area and in what scientific field the research took place. Furthermore, aim and research questions, delimitations and outline of the thesis are presented.*

## 1.1 Background

This research deals with human work in industrial planning and scheduling. This process is carried out in many branches, e.g. process industry, manufacturing industry, and the service sector. In particular, the manufacturing industry is highlighted in this research. For this industry, a number of challenges are apparent. The business environment is a highly competitive business. The companies need to take into account economical aspects such as productivity and costs, while at the same time show concern for customer oriented aspects such as quality, lead times and delivery reliability. They also need to consider the use and development of human resources to gain sustainable production systems (Dabhilkar, 2005). The fulfilment of customer orders is challenging as it includes resolving contradictory demands. Production planning, scheduling and control are the business processes that ensure the coordination of resources to achieve effective order fulfilment by coordinating demand, materials, manufacturing and human resources (Guinery, 2006). The current market conditions make production scheduling increasingly difficult to handle for many enterprises. To succeed in handling these difficulties, improvements in production scheduling activities are critical (Vollman *et al.*, 1997). Another observation is that along with increased complexity in the planning and scheduling environments, the planning and scheduling process may require more human involvement, especially when the production situations become more complex (MacCarthy and Liu, 1993; McKay and Wiers, 2001). Human contribution in planning and scheduling has therefore been identified in empirical research as crucial for company success. MacCarthy *et al.* (2001) identified the skill and performance of production schedulers as making a significant contribution to the achievement of high productivity and flexibility. There is thus reason to deepen our understanding of the human

aspects of planning and scheduling, what the human aspects consist of and in what way these contribute to business operations.

The author's interest in investigating production planners' and schedulers' work emanates from earlier research conducted with a focus on other white-collar employees working close to production: production engineers and white-collar employees in a technical support role (Berglund, 1998). In these prior studies, the white-collar employees' work and work conditions following a decentralisation of company organization were investigated using a qualitative research approach. The studies resulted in a deepened interest in white-collar employees close to production and further inquiries about their role and contribution in the organization arose. Furthermore, the research brought forward methodological issues regarding how white-collar work in practice could be studied. It thus served as strong inspiration to investigate a new white-collar group close to production, the production planners and schedulers, this time also encompassing some further methodological development.

In manufacturing, both the terms planning and scheduling are used. The distinction between planning and scheduling is somewhat unclear. One definition is that scheduling is associated with decisions made when the production process is running, while planning is associated with decisions made before the production process starts (Nakamura and Salvendy, 1994). As the precise interaction between production planning and scheduling is not easily defined it may be justified to assume that planning and scheduling represent a continuum of activities across space and time (Crawford *et al.*, 1999). Dispatching may also be included in this continuum of activities. It deals with deciding which operation to perform next at an individual workplace, but there is also here an overlap; in this case between scheduling and dispatching (McKay and Wiers, 2003). When studying production control tasks in practice it is therefore difficult to clearly separate a planner from a scheduler or a scheduler from a dispatcher (Crawford and Wiers, 2001). On the whole, the work activities studied in this research are the activities dealing with capacity, scheduling of production, as well as dispatching individual orders. In most studies production scheduling constituted the largest proportion of these activities. Depending on the studies referred to or if general themes are elaborated that apply for both planning and scheduling, the terms are used independently or combined.

This research is carried out within the ergonomics and human factors discipline. Although having different origins, the terms ergonomics and human factors may now be regarded as interchangeable terms (Wilson, 2005). In its origin, ergonomics was primarily associated with physical aspects of human work, such as human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to *physical*



*activity*. This is now referred to as physical ergonomics (IEA, 2000). Human factors, on the other hand, had its original focus on operations analysis, operator selection, training, and the environment associated with cognitive aspects such as signal detection and recognition, communication, and vehicle control (HFES, 1995-2009). Similarly, there is *cognitive ergonomics*, which is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. A third sub-part of ergonomics is *organizational ergonomics*, which is concerned with the optimization of socio-technical systems, including their organizational structures, policies, and processes (IEA, *ibid*). This research is primarily carried out within this last sub-part of ergonomics.

With specific reference to the definition of the term ergonomics, many different ones were brought forward over the years. One is that it is the scientific study of the relationship between man and his working environment (Murrell, 1965). It is also defined as “the study of human abilities and characteristics which affect the design of equipment, systems and jobs. It is an interdisciplinary activity based on engineering psychology, anatomy, physiology and organizational studies. Its aims are to improve efficiency, safety and operator well-being” (Corlett and Clark, 1995, p 2). The Swedish standard from 1983 for ergonomic principles in the design of work systems similarly states that the design of the work process shall safeguard the workers’ health and safety, promote their well-being, and facilitate task performance. Another view of ergonomics states that its main aim is to transform work itself, also to transform the view of work (Daniellou, 1998). In this process the ergonomist has the task of contributing to the work design so that:

- it will not impair the operator health, but will provide an opportunity to exercise competence and to receive appreciation
- it will meet the economic objectives of the employer (Guérin *et al.*, 2007)

Common to many definitions of ergonomics are the human, work and the relationship between the work environment, technology and the organization. The International Ergonomics Association extends its relevance to any system with which the humans interact and makes the exchangeability with human factors clear in its definition:

“Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.” (IEA, 2000)

To conclude, the essence of this research within ergonomics and human factors is its focus on planning and scheduling work in practice and it strives to contribute to a deeper understanding of these work activities, in what context these are performed, and their contribution to overall business operations. Furthermore, this work contributes to an emerging research stream focusing on human and organizational aspects in industrial planning and scheduling, see further section 2.2.

### **1.2 The problem area**

At the early phases of the research, a number of issues were prevalent. At the time the dominant research and development emphasis in production scheduling had been aimed mainly at solving technical, logical or mathematical problems (MacCarthy and Wilson, 2001). Some research, however, had highlighted the complex scenarios for many companies in which production scheduling was increasingly difficult to handle for many enterprises, that production scheduling activities were critical (Vollman *et al.*, 1997), and more human involvement was needed (McKay and Wiers, 2001). During the late 1990s the problems with planning and scheduling were identified by Swedish woodworking SMEs as important triggers for changes as these problems negatively affected the companies' competitiveness (Karlton, 2007). Furthermore, there was an identified gap between theory and industrial practice (Buxey, 1989; MacCarthy and Liu, 1993; McKay and Wiers, 1999). Scheduling activities could often not be executed as planned and re-planning was a recurrent phenomenon (Crawford and Wiers, 2001; Bazet, 2002a). The extensive number of scheduling tools on the market had not proven able to fulfil the needs of the individual planners and schedulers. Despite great efforts, many system implementations to support the planning and scheduling process had been problematic (Wiers, 1997a; Davenport, 1998; MacCarthy and Wilson, 2001). There was thus an identified need to learn more about planners' and schedulers' actual work operations to fill out the identified gap between theory and practice.

A further reason for pursuing a deeper understanding of planning and scheduling work was the trend of downsizing and rationalizations at many companies, a trend which affected all groups of employees, also white-collar employees as identified by the Swedish Union of Clerical and Technical Employees in Industry (Nilsson, 1992). In a downsizing process it is of great importance to have a good understanding of work activities carried out by the groups concerned and their contribution to business operations in order to assess the consequences of downsizing. This is especially the case for white-collar groups, whose work tasks are not always clearly described. There was therefore reason to highlight what value was created for the organizations by these groups of employees. There was a discussion in

Sweden of where the production scheduling process should take place in the companies, by specialist schedulers or as integrated in the work of production teams, thus being part of their extended work tasks (Berglund, 1998). A transfer of production scheduling to production teams was also reported (Berglund, 2000).

During the course of this research further issues regarding planning and scheduling emerged. Extensive field studies have highlighted the multi-faceted role of the schedulers, in which they link and net different functions, hub and filter information and balance and valve in for instance problem solving processes (Jackson *et al.*, 2004). Other detailed field studies investigating how knowledge is used in planning and scheduling decision making identified production planners and schedulers in knowledge integrating roles (Guinery, 2006). In addition to that planning and scheduling had been identified as strongly related to the interface between production and sales/marketing (Parente, 1998). This interface is characterized by conflicts between the functions (Crittenden *et al.*, 1993; Spencer and Cox, 1994; Gunasekaran *et al.*, 2002) and co-ordination needs to be improved (e.g. Konijnendijk, 1993; Mukohpadhyay and Gupta, 1998; Gonzalez *et al.*, 2004). In spite of this research, there is still a lack of study on this at an operational level (Parente, 1998; Swamidass *et al.*, 2001).

These reports indicate that the planners' and schedulers' roles should not be underestimated and that they perform far more than purely compensating for inadequacies in planning and scheduling systems. Instead their roles and contributions to business operations need further investigation to gain insight in how this role is practised in their dealing with everyday planning and scheduling issues and in what ways they are crucial for company success. This leads us to the aim and research questions of this thesis.

### **1.3 Aim and research questions**

The overall objective of this case study research is to gain further understanding of planners' and schedulers' work within the manufacturing industry, to elucidate how their work situation is formed, and to explain their significance to other employees' work and activities in the company. To fulfil this objective, the following research questions were put forward:

- RQ1: What tasks, activities and roles are inherent in planning and scheduling work?
- RQ2: What does production planning and scheduling work imply with respect to the commercial and manufacturing interfaces?
- RQ3: By what means do planners and schedulers exert influence in the organization?

RQ4: What aspects of planners' and schedulers' work contribute to and influence business operations and the work of other employees in the company?

## **1.4 Delimitations**

Planning and scheduling exist as a process in a number of domains. It is assumed that some results from this research are applicable in other non-manufacturing domains, such as maintenance work and rail work planning. Nevertheless, the conclusions drawn from this research are primarily based on studies in the Swedish woodworking industry. Other manufacturing businesses are included in cross case analysis with other domains such as the DIY business and steel manufacturing in Great Britain, see appended papers.

The work in this research focuses on human work, and why the individuals performing work activities are specially highlighted. The level of analysis, however, extends towards looking at collaboration with other employees and functional interfaces. Organizational issues are therefore also elaborated.

## **1.5 Reader's guide**

In this thesis the author will argue for and show that scheduling work is not mere optimization but strongly influenced by human, technological and organizational aspects in the work context. It will be argued that planners and schedulers, although lacking a strong formal position, in practice exert substantial influence at manufacturing and commercial interfaces. Furthermore, their work activities and decision making influence the working conditions of other employees. Finally, this work will highlight how schedulers in practice align manufacturing and sales when handling customer requests. In this way, they contribute to bridging the gap between manufacturing and sales as well as playing an essential role in the companies' overall organizational performance.

These ideas are developed as follows. The thesis commences with an introductory chapter, in which the background to this research is presented, followed by problem description, overall aim, research questions and delimitations. Chapter 2 presents the domain in which this research is carried out, production planning and scheduling, and human factors aspects related to the domain. In chapter 3, some theoretical considerations are made regarding four main areas: work task and activity, role, formal versus practised organization, and systems. Then the research approach for studying work in practice and the methods used are presented in chapter 4. Chapter 5 describes the Swedish case study companies. Extensive summaries of the appended papers and their contribution to this research are presented in chapter 6. Chapter 7 consists of an overall discussion and

reflection on the findings in relation to the aim, the research questions and chosen methods. Finally, in chapter 8 some concluding remarks are made and avenues for future research are identified.

The order of the appended papers follows the order of the research questions as far as possible. Although many of the research questions are covered to some extent in several of the appended papers, the research questions are mainly examined in the papers as shown in Table 1.1.

*Table 1.1 Main contribution of appended papers in relation to research questions*

Paper	I	II	III	IV	V	VI	VII	VIII
RQ1: What tasks, activities and roles are inherent in planning and scheduling work?	X	X	X	X				
RQ2: What does production planning and scheduling work imply with respect to the commercial and manufacturing interfaces?					X		X	
RQ3: By what means do planners and schedulers exert influence in the organization?						X	X	
RQ4: What aspects of planners' and schedulers' work contribute to and influence the business operations and work of other employees in the company?		X	X					X

Paper I examines production scheduling work in four Swedish case studies from a systems perspective including human, technological and organizational aspects.

Paper II describes in great detail the work of the human scheduler in a Swedish sawmill and under what conditions it is performed.

Paper III examines the expectations held on the scheduler and dependencies in the organization based on two of the Swedish case studies.

Paper IV presents a quantified analysis of the work content of the schedulers, including proportional time spent on different activities and intervening activities, in four Swedish case studies.

Paper V proposes a model to describe how schedulers in practice align manufacturing and sales when handling customer requests, thus contributing to bridging the gap between manufacturing and sales.

Paper VI is a cross case analysis of two of the Swedish and two British cases with a focus on how planners and schedulers, although lacking a strong

formal position, in practice exert influence at manufacturing and commercial interfaces.

Paper VII brings forward the contribution of production planners and schedulers at production and sales interfaces by analyzing their work and role from different perspectives. The paper is based on a combinational analysis of four Swedish and two British case studies.

Paper VIII, finally, discusses how schedulers' work activities and decision making influence the working conditions of other employees in the four Swedish case studies.

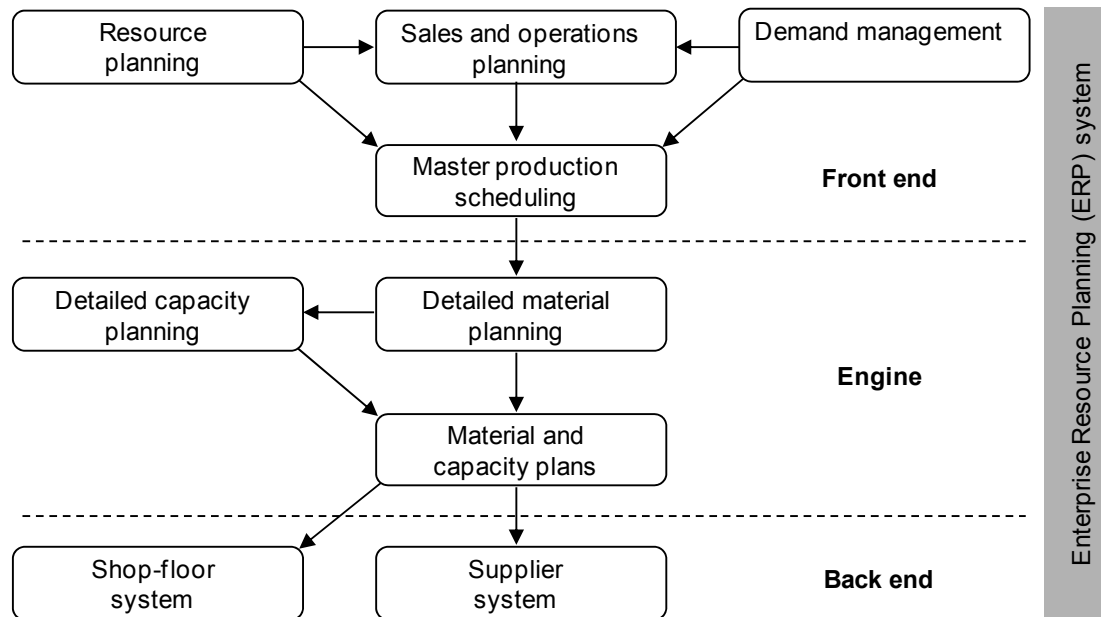
## 2 Production Planning and Scheduling

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*This chapter contains a short overview of how planning and scheduling is viewed from an organization management perspective and the types of issues that are often referred to in the literature. Furthermore, some earlier research on human and organizational aspects in planning and scheduling are presented.*

### 2.1 Planning and scheduling in an organizational perspective

There is a vast amount of literature in operations management and strategy that highlights the importance of manufacturing planning and control. As described earlier the exact distinction between these processes is somewhat vague. One way of describing the manufacturing planning and control system (MPC system) is to divide it into front end, engine, and back end processes (Vollmann *et al.*, 2005). The front end processes then constitute activities and systems for overall direction setting and include resource planning, sales and operations planning, demand management, and master production scheduling. The master production schedule (MPS) is the disaggregated version of the sales and operations plan. The engine processes encompasses detailed material and capacity planning. The back end processes, finally, consist of MPC execution systems, such as shop floor systems to control the factory and supplier systems to manage incoming materials (Vollmann *et al.*, *ibid*), see Figure 2.1.



*Figure 2.1 Overview of (simplified) manufacturing planning and control system. Source: Redrawn from Vollmann et al. (2005).*

The tasks of planning, scheduling and execution in relation to the front end, engine and back end processes may be described as (Hill, 2005, p. 271):

- **Planning** – front end planning provides key communication links between top management and operations. It helps form the basis for translating strategic objectives and future market needs into operations plans and resources and is essential in determining what can be achieved, the investments and decisions to be made and the timescales involved.
- **Scheduling** – the scheduling phase is the ‘engine’ of the system. It involves determining capacity several weeks, months and sometimes up to one year ahead. It details the way in which demand will be met from available facilities and ensures that the capacity and material requirements are in place.
- **Execution** – the ‘back end’ phase of the system concerns execution day-to-day operations by determining and monitoring material and capacity requirements to ensure that customer demands are met and resources are used efficiently.

There is little, if anything at all, written in traditional organization management (OM) literature about the individuals who perform planning and scheduling work, in what context this is performed and major challenges in operational work. Examples include analyses of existing goal conflicts (Olhager, 2000), that performance objectives must be matched



with market competitiveness (Slack and Lewis, 2002), and that “the challenge confronting most organizations is how best to meet both the needs of their markets and the performance targets that a business places on its operations function” (Hill, 2005, p. 331). Operative work is for instance described as: “detailed scheduling is somewhat complex and tedious and will not be presented here in spreadsheet form” (Monk and Wagner, 2008, p. 104). Focus in this literature is rather on major concepts and models to cope with the complexity of these processes. Concepts such as the system view Enterprise Resource Planning (ERP), Materials Requirements Planning (MRP and MRP II), the Japanese Just-in-Time (JIT), Production Activity Control (PAC) and so on are described in most operations management literature (e.g. Olhager, 2000; Vollmann *et al.*, 2005; Hill, 2005; Monk and Wagner, 2008).

The co-ordination between manufacturing and marketing/sales has received significant attention in extensive research from different perspectives. This includes the conflict between manufacturing and marketing/sales (Clare and Sanford, 1984; Crittenden *et al.*, 1993; Spencer and Cox, 1994; Gunasekaran *et al.*, 2002), that co-ordination between these functions needs to be improved (e.g. Crittenden, 1992; Konijnendijk, 1993; Mukhopadhyay and Gupta, 1998; Gonzalez *et al.*, 2004), and that the co-ordination between these areas is crucial for company success (Skinner, 1969; Hill, 1997; Mukhopadhyay and Gupta, 1998). Many researchers have identified different processes within the MPC system to be directly involved in the interface between manufacturing and marketing/sales. Shapiro (1977) has listed potential problem areas where marketing and manufacturing need to cooperate, in which capacity planning and production scheduling are included. Moreover, key decision areas related both to manufacturing and marketing/sales include for instance decisions regarding marketing/sales planning and manufacturing planning decisions (O’Leary-Kelly and Flores, 2002). Furthermore, production planning has been identified as one of the most frequently occurring topics for research concerning the manufacturing-marketing interface, as it provides the bridge between them (Parente, 1998). Similar to the traditional OM literature, however, there appears to be a lack of research on this at the operational level (Whybark, 1994; Parente, 1998; Swamidass *et al.*, 2001), which is the focus of this research of planning and scheduling in real world practice.

## **2.2 Human aspects of planning and scheduling**

During the last decades there has been an emerging stream of research, focusing on human aspects of planning and scheduling. There has been an increasing interest to investigate the practice of planning and scheduling in field studies. Crawford and Wiers (2001), in their review of existing

knowledge on human factors in planning and scheduling, showed that early studies in the 1960s and the 1970s focused on issues such as human behaviour in complex manufacturing situations, production scheduling decision behaviour, and the use of mental models to handle scheduling issues. Many of these studies focused on individual or organizational decision-making with the aim of developing models for decision-making and human behaviour.

With increased development and use of mathematical and computer-supported modelling of planning and scheduling, a number of studies have later identified a gap between theory and practice. The practical limitations of classical scheduling theory, especially regarding its lack of use in manufacturing environments are highlighted (Buxey, 1989). The mathematical models are static and appear to ignore the complexity of the real world, in which scheduling is both dynamic and ill defined (Stoop and Wiers, 1996), and only a small percentage of factories use scheduling tools or theories in everyday practice (Wiers, 1997a). McKay and Wiers (1999) similarly highlight the discrepancy between theory and practice in that the researchers are speaking about sequencing issues at the same time as the schedulers are conferring about day-to-day challenges. The use of theoretical results is possible in higher levels of production control, such as capacity planning, in process industry, or in production situations with few machines with substantial setups. McKay and Wiers (*ibid*) further state that there are few examples of optimization models which are used or proved to be usable in dynamic job shops, and Jackson *et al.* (2004) point out that in classical scheduling theory most researchers adopt the mathematical approach while ignoring the significant human contribution. Scherer (1998), taking a systems view on shop floor control, highlights that traditional design approaches are based on the formal organization of shop floor control, while operations practices in shop floor control deviate substantially and in some parts are very informal. Another reason behind the gap between mathematical models and practice is that it is unrealistic in dynamic and complex production environments to make predictions at the detailed level required for a model. Instead, human expertise and judgment is most often required in such a context (MacCarthy, 2006).

One research contribution, which is widely referred to by researchers focusing on the human aspects in production control, is the model of the human scheduler by Sanderson (1991). Although not built on practice, the model is based on the assumption that scheduling is a decision-making function which is predominantly cognitive and individual. The aim of the model is to develop a framework for a model human scheduler to improve our understanding of human contribution to scheduling functions, but also to support design decisions for Advanced Manufacturing Systems. Another

framework for the human factor of planning and scheduling, which is based on extensive field studies, has been developed by MacCarthy *et al.* (2001). The understanding of the scheduling process is then developed from three dimensions: the environment, the scheduling unit and scheduling approaches. The understanding of performance, on the other hand, is reached from three perspectives: how well schedulers think they perform, how well the organization thinks they perform and how well they actually perform.

Different studies of planning and scheduling tasks as carried out in practice have been undertaken. A major research contribution is the extensive field studies of production schedulers in actual scheduling activities performed by Jackson *et al.* (2004). In this research three categories of task and three categories of role behaviour have been identified. The tasks consist of:

- *Formal tasks* recognized by the business as scheduling tasks to be carried out;
- *Maintenance*, in which the scheduler organizes data according to the way the scheduler carries out work; and
- *Compensation*, in which the scheduler compensates for some level of problem or failure in the overall system.

The research also identifies work activities that are not formally recognized, but essential and in themselves require knowledge. These are described as the following three roles. In the research of Jackson *et al.* (*ibid*), roles are considered as enablers of the tasks and filling the gap between the formal and informal systems that operate within a business:

- *Interpersonal role* which includes the development of interpersonal networks, informal bargaining, friendship and favour networks, and mediating;
- *Informational role* in which the scheduler acts as an implicit and explicit information hub ensuring that information is accessible and visible, including the identification of the relevance of information and filtering it; and
- *Decisional role* which captures three types of decision making behaviours: problem prediction and problem solving, interruption handling, and resource allocation.

Jackson *et al.* (*ibid*) integrates these tasks, roles and the schedulers' monitoring into a new model of scheduling in manufacturing. The aim of this model is to serve as a contextual framework consisting of the following interdependent factors: the manufacturing process, the organizational structure, planning and scheduling information systems, people and

performance measures. The authors state in the paper that the schedulers perform coordinating, monitoring, communicating, problem-solving, facilitating, and interfacing types of activities. How these activities are carried out in practice is, however, not described in the paper.

That planning and scheduling include more than mere optimization of logical problems has also been highlighted by other researchers. McKay *et al.* (1992) shows that scheduling also involves social interaction and issues such as trust and respect. Planning and scheduling are further characterized by many everyday disturbances (Stoop and Wiers, 1996) and handling conflicting aims and conditions and continual adaptations to changes (Bazet, 2002a, 2002b). A large amount of the scheduler's time is further spent on identifying, communicating and negotiating on constraints (Wiers, 1997a). This also includes the need to renegotiate the basic demands and constraints on their own work (de Terssac *et al.*, 1993; de Terssac and Lompré, 1995; Bazet, 2002b).

Other research has focused on uncertainty and the need of control to carry out planning and scheduling work. This includes McKay *et al.* (1989) who observe that the scheduling processes in practice are driven by uncertainty. McKay and Wiers (1999) describe the uncertainty in scheduling as related to a number of factors:

- *The tightly coupled problem space* where elements of a scheduling problem are tightly coupled and a change in one element can have predicted results in another);
- *On-line problem solving* as problems must be solved on-line or in a very limited amount of time, and it is often very urgent to change schedules; and
- *Little human recovery* as there is no intermediate control level to recover from errors. Scheduling is the lowest control level in a factory, so the only human recovery possible lies on the shop floor.)

The need of control to carry out work has also been focused in the research by Wiers (1997b), in which four types of control are identified (detailed control, direct control, restricted control and sustained control) and how the schedulers deal with these types of control. In this work, the importance of feedback regarding schedule execution and fulfilment is described. The need for information has also been highlighted in other studies. Nakamura and Salvendy (1994) describe how schedulers need to be able to see and access relevant and critical information to be able to carry out the scheduling task and to make timely scheduling decisions (Nakamura and Salvendy, *ibid*). The importance of information collection and validation in order to have access to accurate data and be able to make scheduling decisions has also been

reported as one main task in scheduling work (McKay and Wiers, 1999; Jackson *et al.*, 2004).

Decision making behaviour and the development of decision support tools have received attention throughout the years as described before. More recent studies include the quantitative approach to study the decision behaviour of production schedulers using performance, action, and disturbance variables (Wiers, 1996) and that naturalistic decision making takes place in planning, scheduling and control (Guinery, 2006). Detailed field studies investigating how knowledge is used in decision making in planning, scheduling and control identify different forms of knowledge that planners and schedulers possess. These forms of knowledge include situation awareness, knowledge of consequences, events-experience knowledge, organizational knowledge, and knowledge of planning rules (Guinery, *ibid*). The same research highlights that the planning environment interfaces can be a challenge to knowledge integration, and it identifies the three types of interfaces: the shared decision making, the judge-adviser, and the directing interface.

One way to support decision making is by means of a computerized support system. In this case, it is important with performance feedback and transparency of the production process and status (Wiers, 1997a). Other requirements on the decision making system is that it must infer cause and effect relationships, minimize human limitations such as short-term memory, have flexibility, be easy to use, etc. (Nakamura and Salvendy, 1994). Successful implementations of scheduling software are, however, limited (Wiers and van der Schaaf, 1997). A methodology for designing scheduling tools that support schedulers working in dynamic environments has been developed by Higgins (2001). This model provides a decision making architecture of scheduler behaviour generated from field data. It focuses on the design of user interfaces and provides analysis approaches to determine the cognitive support needed. The benefit of allowing the decision maker freedom to act toward different directions is emphasized.

Other reported studies on the actual use of existing computerized support systems include a description of the evolution of a production planning system, from a sequencing system to a system supporting decision making in the scheduling task (McKay and Black, 2007) in a description of a long term evolution of a production planning system. A recent study also reports that planners systematically and largely neglect the system's recommendations for how to act. The extent of neglect is found greater if the planning problem is more complex (Fransoo and Wiers, 2008).

The contributions within the research stream focusing on human and organizational factors in planning and scheduling is evidence of the

difficulty to automate the planning and scheduling process. Human involvement is necessary in this process. The human performance is, however, not only based on the individual's cognitive ability. The humans also provide a social and organizational contribution which supports the planning and scheduling process. At the same time social and organizational factors constitute the contextual setting which influences scheduling performance (Jackson *et al.*, 2004).

The research presented in this thesis contributes to the research stream of human aspects in production planning and scheduling by focusing on how this work is carried out in practice. The individual planner's and scheduler's roles and contributions are highlighted, in particular with respect to their relations with other individuals and different functions such as manufacturing and the commercial side. By examining the planners' and schedulers' work content, under what conditions they perform their work, and their influence on others' work and systems performance, this research also seeks to contribute to the body of knowledge within the ergonomics and human factors discipline. In the following chapter, the theoretical background is presented on how human work is viewed in this thesis.

## 3 Human Work: Activity, Role, Organization and Systems

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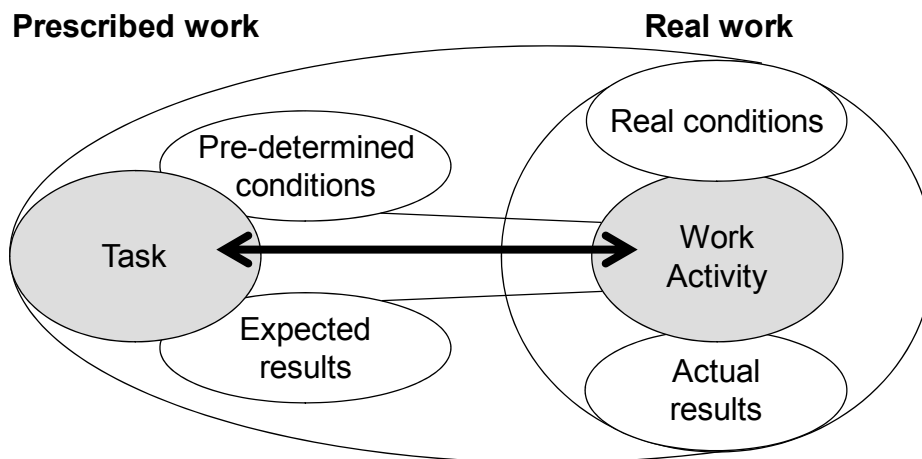
*This chapter summarizes some theoretical aspects considered during the empirical work. These theoretical considerations are divided into four areas: work task and activity, role, formal versus practised organization, and finally, work in a system of humans, technology, and organization. For each area, basic concepts and terms are described as used in this research. These areas are central and related to the problem area and have served as a guide for the subsequent research approach and analysis of the planners' and schedulers' work.*

### 3.1 Work task and activity

In this research, human work in planning and scheduling is in focus. Related to human work is the task that is to be performed as well as the work activities that are performed in reality. The term "task" can be defined in different ways. In this research it is defined as the goal to be achieved within set conditions (Leplat, 1990). It may also be defined as the task to be carried out (Leplat, *ibid*), as the prescribed task or the anticipated result to be achieved under predetermined conditions (Guérin *et al.*, 2007). The task may be prescribed in a number of different ways. It may be prescribed in a direct way which allows the individual to directly perform or it may serve as a direct guide for performance. There is always an implicit part in the prescribed task, and sometimes there is not even any explicit prescribed task at all (Leplat and Hoc, 1992). The planners and schedulers belong to a group of employees with a work task that is not explicitly prescribed in detail.

In the same way as for the term task, there are different ways to view and define work activity. In this work, the actual work activity is what the individuals do in detail to fulfil the task. This is, however, not included in the prescribed task. This actual work activity is what is actually performed (Guérin *et al.*, 2007; Rasmussen, 1994) in a work task. It is described as the way in which results are obtained and the means that are used to obtain them (Guérin *et al.*, 2007). It includes what is observable and not observable, such as mental and intellectual activity. This activity will generate a certain behaviour (Falzon, 2004). Activity is here regarded as a construction to find

operating strategies in given situations. As there often are various task constraints, which vary over time, the individual actively needs to handle these constraints in everyday work. It is thus particular circumstances that influence how individuals act in specific situations, while the prescribed intentions for how to act are vague. Suchman (1987) similarly reports the discrepancy between plans and what she calls situated actions. No matter the detail level of prior plans, the situated actions are affected by particular circumstances and there should be sensitivity for these local circumstances and resources to cope with them. As described earlier (McKay *et al.*, 1989; McKay and Wiers, 1999; Jackson *et al.*, 2004), planners and schedulers perform their work under varying conditions. Therefore, these local circumstances constitute a particularly strong characteristic feature of their work. This also implies that there is a discrepancy between the prescribed work and what is actually performed in real work for the planners and schedulers. For a general view of the relation between task and activity as described by Guérin *et al.* (2007), see Figure 3.1.



*Figure 3.1 Relationship between prescribed work and real work*  
*Source: Redrawn from Guérin et al. (2007).*

As the overall aim of this research is to gain understanding of what planners and schedulers actually do in everyday work, their work activity is strongly focused. There are different work activity oriented perspectives. Although emanating from different scientific traditions, there are some common features that highlight some important aspects of the work activity performed by an individual (Daniellou and Rabardel, 2005). Those especially relevant for the context of this thesis include:

- The activity is object oriented in order to reach one or more goals that may not be evident. The activity is thus not a mere behavioural reaction to any event that arises.



- The relation between the individual and any object is mediated by technical devices, psychological schemes and organization
- The activity includes relationships between the individual and others who may be physically present or present via tools and/or rules and procedures which mediate activity.
- The activity is unique and specific to given individuals in a certain context. It is furthermore influenced by inter-individual diversity and intra-individual diversity and exposed to industrial or contextual variability. Disturbances and unforeseen tasks are therefore highlighted to gain understanding of the activities that take place.
- The activities carried out in a given context are affected by the individual's life experience and therefore bear traces of the past.

All these aspects are considered highly relevant for the study of the planners' and schedulers' work. In the following section the notion of role as used in this research will be described and reflected upon.

### 3.2 Roles

The notion of role is widely used in a number of different research topics and disciplines, and has also been focused in earlier research on planners and schedulers (Crawford, 2000). The role perspective arose in several disciplines in the late 1920s and early 1930s. Biddle (1979), who is extensively referred to in later research, states that the notion of role is related to patterns of human conduct; to expectations, identities, social positions, context, social structure as well as individual response. A common notion in role theory is that roles are related to social positions, and that roles are induced through the sharing of expectations for role behaviour. The role is then learned through role playing by practising the roles performed by others and role taking by internalizing expectations from others (Biddle, *ibid*). As role theory has been used from different angles of approach and terms and concepts used in role theory are widely used in common language, there has sometimes been some confusion about the use of the terms such as role, identity<sup>1</sup>, position etc. in different role perspectives.

In this research, role theory as described by Katz and Kahn (1978) from a sociological perspective was used as a base to understand the role of the planners and schedulers. Katz and Kahn (*ibid*) describe the organization as a

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<sup>1</sup> Role theory is closely related to identity theory (e.g. Ashforth and Mael, 1989), in which social identification is a perception of oneness with a group of persons and which leads to activities that are congruent with the identity. Role theory was, however, considered as a useful tool for this research, which is the reason the author made a delimitation to role theory.

system of roles. The role behaviour is regarded as one concept out of four, which constitute the taking of organizational roles. They define a causal chain where organizational factors to a large extent determine the role expectations on an individual and the role-sent which consists of communications from organizational members stemming from the expectations. Biddle (*ibid*) puts forward that these expectations may be brought forward in different ways and has therefore made a differentiation in the terminology referring to role expectations. First, the expectations can be expressed in different ways, what he refers to as *expectational modes*. These are:

- Prescription (approved or requested role characteristics)
- Cathexis (declared feeling about role characteristics)
- Description (objective statements about role characteristics)

Second, Biddle differentiates between the *expectational forms*:

- Conceptions (covertly held)
- Enunciations (overtly expressed)
- Inscriptions (written)

These differentiations in expectational modes and forms generate a number of different types of expectations, see Table 3.1, which can be used in the analysis of role expectations in a specific situation.

*Table 3.1 Terms for expectations. Source: Biddle (1979)*

Expectational modes	Expectational forms		
	Conceptions (covertly held)	Enunciations (overtly expressed)	Inscriptions (written)
Prescription	Norm	Demand	Rule
Cathexis	Preference	Assessment	Appraisal
Description	Belief	Assertion	Representation

In this thesis, the author argues that these expectations, no matter if explicitly described or implicitly, constitute part of the prescribed work as described above. This is especially the case for individuals who do not have less explicitly prescribed tasks, such as the planners and schedulers. In Katz and Kahn's terminology the focal individual's received role is then the perception of the role-sending, while the role behaviour is the individual's response. Role behaviour among organizational members is then referred to as "recurring actions of an individual, appropriately interrelated with the repetitive activities of others so as to yield a predictable outcome. The set of

interdependent behaviours comprise a social system or subsystem, a stable collective pattern in which people play their parts” (Katz and Kahn 1978, p. 189).

Furthermore, organizational factors such as technology, the structure of the subsystem in which the individual is working, its formal policies, its rewards and penalties determine to a large extent what an individual is supposed to do, with and for whom. In the case of the planners and schedulers, they interact with various groups of employees in the organization. The differences concerning the aims and working practices of these groups or subsystems will likely have a large influence on the behaviour that is expected and developed. Katz and Kahn (1978) put forward that roles become more complex when they require the focal individual to be involved in two or more subsystems, since each is likely to have its own priorities and subculture. Looking at the planners’ and schedulers’ work context, this is especially the case between the marketing department's expectations on flexibility, short delivery times and responsive customer service and the manufacturing department's expectations on more stable conditions. The conflict between these subsystems has long been recognized (Lawrence and Lorsch, 1967). Here, we know that these subcultures exist and may thus draw the conclusion that the planners’ and scheduler's work is complex and comprises many contradicting priorities.

Another role perspective also applied in this thesis is taken from the operations management theory. Modelling is then applied to represent and visualize a process (Kalpic and Bernus, 2002; Cheung and Bal, 1998), in this case the planning and scheduling process. A role activity diagram is then developed to model individual and group roles within a process, their component activities, and their interactions together with external events and the logic that determines what activities are carried out and at what stage (Ould, 1995).

In the role activity diagram, the focus is on the role as the primary unit of analysis as opposed to the activity and provides a useful structure to collate and represent activities captured in field study. The role then involves a sequence of activities that are carried out as a particular responsibility. In this research, activities are, as stated before, defined as what is actually performed to carry out a work task (Leplat, 1990; Guérin *et al.*, 2007). Any individual may have a number of different roles and this representation may be used to analyze one specific role in a certain situation, but a certain activity may also be broken down into another role and analyzed into sub-activities. Here, this approach was found useful for better understanding the scheduler’s functional role in the production enquiry process.

Biddle (1979) further highlights the notion of influence as one central concept related to role theory as assumptions made about it stand behind many propositions stated for role behaviour. In this thesis, power and influence were identified as important in understanding the role behaviour of the planners and schedulers. Looking specifically at interpersonal influence, Handy (1993) distinguishes between influence and power by stating that influence implies the use of power, while power is the resource behind it. Handy further states that having influence is the same as having the power to influence. Extensive literature identifies many sources of power in organizations. The categories considered in this thesis are in relation to interpersonal influence and are mainly based on Handy's (1993) power categories that in turn are derived from French and Raven (1959), see Table 3.2.

*Table 3.2 Categories of power. Main source: Handy (1993)*

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**Resource power** derives from possession of valued resources. To be an effective power base an individual must have control of the resources and these resources must be desired by others. Resources can be material or non-material as for instance in the case of grants of status. Resource power can be compared with Etzioni's (1966) control over resources and rewards.

**Position power** is legal or legitimate power related to an individual's formal position in the company (Bolman and Deal, 1991). This can also be described as the legal prerogatives to have the exclusive rights to impose choices (Mintzberg, 1983). It gives the occupant of a role in the organization all the rights of that role. It includes access to information and right of access to networks. In the latter case it is possible to form alliances to gain more power. It will also give access to those who have power (Mintzberg, *ibid*). Position power may also include the right to organize for instance the physical and social environments, the flow of communication and the right to decide. Furthermore, it includes control over agendas.

**Expert power** is based on individuals' possessing expert knowledge that is needed and acknowledged by others. It is a power base that does not require any sanctions and is the socially most accepted. As stated above, French and Raven (1959) define informational power as a form of expert power; it includes control over information, which may be the result of a certain position.

**Personal power** emanates from an individual's personality and is sometimes referred to as charisma, popularity (Handy, 1993) or referent power (French and Raven, 1959). It can be enhanced by an individual's position. Studies show that individuals who efficiently execute power are characterized by eloquence, ability to listen and quick comprehension (Pfeffer, 1981).

**Physical or coercive power** is the power of superior force and it is rarely used in modern organizations. It does not need to be used in order to be effective, but the belief in its existence is enough.

**Negative power** is when power is used contrary to accepted practice and includes the ability to interfere with things that happen. It is a latent power base and may be more evident in stressful situations.

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### 3.3 Formal versus practised organization

Similar to the reasoning about the discrepancy between the prescribed task and real work activities, there is a discrepancy between the formal organization and how it is in practice. In organizations, there is a normative or official side presented, a formal structure often to be found on organization charts. The reality, the so-called practised side of an organization constitutes what actually takes place; how people collaborate, perform activities etc. This is particularly interesting in this research about planners and schedulers as the organizational structure as applied in reality probably affects the work practice of the planners and schedulers and how they interact with others within and outside the organization. Westlander (1999a) discusses the relationship between the normative and practised organization by pointing out that there are various reasons why one should not expect complete concordance between the two. The formal structure may be more or less detailed, giving more or less space for collaboration. Or, the formal character may more or less correspond to what members of the organization consider effective. Other reasons may be that the formal character may be more or less motivating to follow, or that the content of the formal structure is more or less observable due to the members' lack of knowledge of it.

One approach to ergonomic assessment of organizations (Guérin *et al.*, 2007) is the activity analysis, which is applied in this research, see chapter 4. In this approach, a great deal of emphasis is placed on assessing differences between the formal and practised side of an organization, the prescribed work and real work (Daniellou and Rabardel; 2005). The difference between prescribed work tasks imposed by company management and how these work tasks are actually performed is then an indicator of the degree of difference between the formal and the practised.

The organizational structure may be regarded as consisting of a collection of official rules related to work procedures, organizational charts etc. This organizational structure may also be reflected in the physical layout, who has access to computer systems etc. (Carballeda, 1999). The organization is, however, also the result of human activity, in particular the result of human interaction. These interactions will, in their turn, produce new autonomous rules which are applied in the organization (Carballeda, *ibid*). The official rules and the autonomous rules do confront each other. This takes place in, what de Terssac and Lompré (1995) call, hot and cold adjustments. The *hot adjustments* take place in daily work activities when dealing with the discrepancy between the official rules and control systems and the autonomous rules developed by the humans in their interaction at work. The hot adjustments are characterized by:

- being an integrated part of the work activity
- concerning all actors, both those who prescribe and those who execute
- being limited by the discrepancies immediately found and their consequences
- generally resulting in a provisional compromise, for instance in tolerating that formal rules are not obeyed in a specific situation
- more seldom, resulting in a modification of a formal rule

The hot adjustments do not necessarily need to be undertaken in a discordant manner. However, they may still result in a cost for the people involved. The hot adjustments allow for daily treatment of a large number of discrepancies between formal rules and the execution of real work activities. Sometimes these are not enough, however, to ensure a normally functioning work system, and can result in lack of efficiency or personal costs for some employees (Carballeda, 1999). Then cold adjustments are sometimes necessary. The *cold adjustments* are characterized by (Lompré and de Terssac, 1995):

- taking place outside daily work activity, in a meeting room and with the purpose of discussing a change
- those participating not being the individuals concerned but representatives for their professional groups
- having a longer time horizon and not only finding an immediate compromise to cope with an urgent situation

The results of the cold adjustments are the development of “meta rules” that will guide the modification of the control system and eventually also the autonomous rules (Lompré and de Terssac, *ibid*). The model by Lompré and de Terssac has been developed by Carballeda (1999) to include activity and interactions, see Figure 3.2.

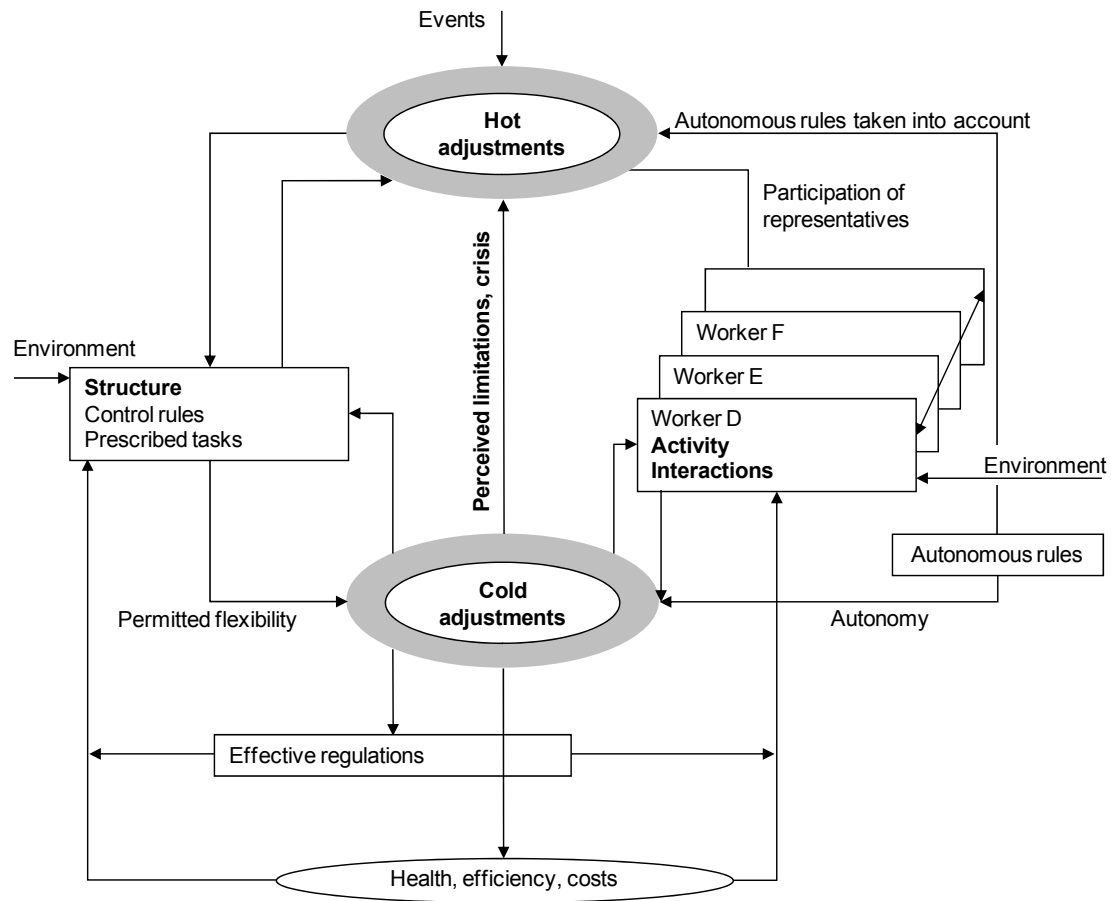


Figure 3.2 Adjustments between organizational structure and activity.  
Source: Redrawn and translated from Carballada (1999).

Another important feature in organizations, which is manifested both in the formal and informal side of the organization is the multitude of company logics. A company logic is defined as the sum of high-level purposes and constraints that are the result of the judgement of a group of actors (Carballada, 1999). This means that the company is always exposed to a diversity of logics. The different parts of the company have their fixed physical constraints and social actors who strongly maintain their values. Some of these logics may be related to (Carballada, *ibid*):

- characteristics or demand from customers
- characteristic features of the raw material or company products
- the production process
- costs and types of profit
- human resource aspects or social relations
- environmental legislation

- geographical and industrial environment

A specific logic constitutes the agenda and perspective adopted by an organizational group. It can also be identified through an “objects and ends analysis” (Carlile, 2002). Then the objects and ends used in a given practice are focused. *Objects* are identified as the collection of artefacts with which individuals work, for example tools, numbers, computer screens, blueprints, and machines that the individuals create, measure or manipulate. *Ends*, on the other hand, are different outcomes of the individuals’ creating, measuring and manipulating and demonstrate success in for example a signed contract, a written work order or a batch of produced goods. As described earlier, the planners and schedulers interact with different groups of employees as well as management, why they in their daily work need to deal with different logics and handle different objects and ends.

Drawing from the earlier described role theory, expectations on an individual’s role and consequently his/her work tasks, can be conveyed explicitly or implicitly. As described earlier, individual roles may be related to the formal organization in terms of for instance formal position, but roles may also emanate from how the organization is applied in practice. Based on earlier research describing the complexity of planning and scheduling work in practice, there is reason to investigate how the planners’ and schedulers’ roles are affected by both the formal and practised side of the organization.

### **3.4 Work in a system of humans, technology and organization**

Throughout the study of the planners’ and schedulers’ work, a range of aspects or components emerged. These components were assumedly intertwined and included physical layout, technical tools, organizational structure, cognitive demands, communication patterns etc. One way to reach a profounder understanding of scheduling work including the interaction of these components might therefore be to view planning and scheduling work as performed in a system (von Bertalanffy, 1968; Churchman, 1968; Checkland, 1981). A system is a set of components and the relation between them (von Bertalanffy, 1968; Churchman, 1968). A basic assumption in a systems view is that a system has different qualities from the separate parts (von Bertalanffy, 1968). Furthermore, the parts of the system can be described and understood only in relation to the whole system (Arbnor and Bjerke, 1997). This is particularly useful when looking at complex phenomena, in which several factors interact and there are multiplicative effects or synergisms, for instance in the organization and planning of operations and business (Wallén, 1996). One specific aim for using a systems perspective includes improving both organizational



performance and working conditions as in the sociotechnical systems theory (Pasmore, 1988), as means for organizational development (Porras and Robertson, 1992), or for design of any artefact, including social and organizational artefacts (Wilson and Morrisroe, 2005).

The sociotechnical systems theory and approach to designing organizations and works tasks was developed at the Tavistock Institute in the beginning of the 1950s. To optimize a work system the optimal fit between the technical system and the social system was sought. The sociotechnical system was based on four major concepts (Klein, 1994):

- The technical and the social systems are interdependent. They influence each other, in both directions.
- There is a choice in the way one is organized around any given technology
- The work system is an open system.
- There is a choice in the way in which technology itself is designed.

The sociotechnical systems theory served as an important source of inspiration in the development of new organizational structures in Sweden in the 1970s (Forslin, 1990). These were based on psychological demands that an individual may put on work content (Thorsrud and Emery, 1970) to satisfy human needs and mainly concerned individuals in subordinate positions. The sociotechnical ideas received a revival in the 1990s with the introduction of information technology and have since then also come to comprise individuals with management roles (Westlander, 1999b).

A systems perspective, which is related to the sociotechnical ideas and which is used to analyze, evaluate and improve human work, includes the humans, technology and organization. The notion HTO is used to symbolize a focus on the three interlaced subsystems; Humans, Technology, and Organization (Rollenhagen, 1997). The concept was developed during the 1980s within the nuclear power industry. The aim was to improve overall safety. When developing safety, strong focus was first put on technical improvements, which resulted in a reduced number of near-accident incidents caused by technical failures. As a result, the incidents related to human activities became more “visible” as they represented a larger share of the incidents. After a period focusing on the field of potential “human error”, safety further improved. Thereby, it became obvious that it was necessary also to consider organizational issues, i.e. all three components in the system to improve safety (Eklund, 2003).

The system view of the HTO-concept was considered successful for improving safety and developing a more thorough safety culture and has

thereafter spread to other domains (Rollenhagen, 1997; Rollenhagen, 2003). The HTO-concept has then reached wider use in Sweden as a meta-concept that may be applied to analyze and develop further understanding of any type of business or activity of high complexity. The main point is that successful development is only achieved if all three components are regarded. The concept is complementary to the research, in which a special focus is chosen, for instance focusing technology while human and organizational aspects are treated as influencing factors (Westlander, 1999b).

The HTO-concept distinguishes between the individuals and the organization, which is why it is suitable for the study of individual schedulers' work. In the HTO-perspective, the "H" stands for the importance of aspects that are strictly individual and at the same time considered important for the ability to perform a task or a change. Such aspects may e.g. include individual skill, knowledge, experiences or established relations, and they are not easily replaceable in a short term perspective. The component thus focuses on the individual's contribution to the business process. The "H" may be described at any of the following four levels: 1) The biological level, regarding the human as a physiological system. 2) The cognitive level, where the human is considered as an information processing system, including thought processes, representations, decision-making etc. 3) The psychological level, where the human has a unique history, leading to a specific subjective processing of the situations he/she experiences. 4) The social level, emphasizing that every single individual is a member of several social groups with different cultures, which will partly determine his/her values and habits (Daniellou, 2001). Other perspectives of the "H" are for instance to regard the humans as exposed beings, as actors in organizations, or as learning individuals (Westlander, 1999b).

The "O", on the other hand, represents the H-component in an aggregated sense. It is therefore not considering single humans but humans in a statistical interchangeable way (Westlander, 1999b). However, the O-component consists of more than humans. It also comprises how the work is organized and structured, both formally and informally (Westlander, 1999a). Furthermore, it includes rules, procedures and cultural factors as well as relations between system components and subsystems. Examples of this are job definitions, responsibilities and powers, hierarchical positions, policies, business goals and strategies. All these contribute to the conditions under which the schedulers are to perform their tasks. In addition there are physical aspects of the O-component regarding where people are located and how premises are designed.

The T-component, stands for the technical system. This can be divided into two different parts. First, there is the primary technical production system including the production equipment that is devoted to maintain the

capability of the company. This technical system can be described in different ways concerning technical limitations, problems (both recurrent and stochastic), availability, reliability etc. The complexity also requires these systems to be regarded as networks of linked autonomous parts which are to a large extent separately controlled and managed. Main examples are the entire machinery in for instance woodworking companies. A secondary technical system is the system that assists the administration and procedures of the company but is not directly associated with the business as such (Wäfler, 2001). In this research, the secondary technical system consists of the information system, including both hardware and software, which the schedulers use as decision support tools.

In a system, its components will interact in different ways. In a systems approach, the main idea is to take a broad view of a problem, but concentrate on interactions between the different parts of the problem (Checkland, 1981). In this thesis, focus is on understanding the content of planning and scheduling work, how their work situation is formed, and their significance to other employees' work and activities in the company. The systems view of humans, technology and organization was considered as a suitable starting point to get a thorough picture of the complexity of planning and scheduling work. In research with an HTO systems approach, it is, as stated before, common to emphasize any of the HTO subsystems and regard the others as influencing factors (Westlander, 1999b). In this research, the organization is the part of the HTO system that is emphasized for different reasons. First, the distinction between the formal and the practised side of the organization is essential as this research aims at understanding the work in terms of how the real work activities are carried out. Second, the aim of understanding how the planners' and schedulers' contribute to other employees' work and overall operations is strongly related to their role in an organizational perspective.



## 4 Methods for Studying Scheduling Work Practice

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*In this chapter some methodological considerations for studying scheduling work practice is presented initially. Issues that are discussed include case study research and the notion of external validity. Some approaches to understanding work practice are then briefly overviewed, before the presentation of the basic ideas behind activity analysis and how activity analysis was applied as a research approach in this thesis. Furthermore, the level of analysis in this research is presented in brief, the individual perspective and the chosen systems perspective on work including humans, technology and organization. The selection of case companies and the research procedure are described followed by the data collection methods used. Finally, the procedure for data analysis of the Swedish case studies is described along with the cross-case analysis with the British cases.*

### 4.1 Case study research

With the aim of gaining a deeper understanding of how planning and scheduling work is executed in real work in a normal situation, a case study approach was considered as a suitable choice for various reasons. First, a case study may be described as an “examination of an instance in action” (Walker, 1980). Second, case study research is particularly valuable where the intention is to examine phenomena in their natural setting and where research is exploratory in nature (Meredith, 1998). Third, it can provide a rich set of data on real world practice (Eisenhardt, 1989; Voss *et al.*, 2002). The type of research questions may also guide towards a certain research approach. According to Yin (1994), where study questions include “how” or “why”, a case study may be the most suitable approach. In this study, gaining further understanding of the schedulers’ work is in reality a “how” question with some “why” elements. Another reason for choosing case study research was that detailed descriptions of context were likely to generate more questions, knowledge, and different perspectives on the planners’ and schedulers’ work.

In the discussion of case study methodology, there are some “sub-topics” to be taken into account, one is the distinction between qualitative and quantitative assessment. In many case studies, either a qualitative or

quantitative approach may be taken. Qualitative and quantitative researches are often considered to be two different ways of carrying out research. In practice, however, research that is dominated by a qualitative approach may also use quantitative information and *vice versa* (Patel and Tebelius, 1987). This research on planners' and schedulers' work is made with a qualitative research approach, as its aim is to gain deep understanding of naturally occurring phenomena in naturally occurring settings (Patton, 1980; Magne and Krohn, 1991). This is to be achieved by learning about the planners' and schedulers' values and experiences as expressed in their own words (Patel and Tebelius, 1987). To conclude, the aim of this research fits well with the arguments for the qualitative perspective: understanding, intersubjectivity, theory generation, validity, discovery and curiosity (Starrin *et al.*, 1991). As will be shown the data collected in the cases studies was mainly qualitative. Nonetheless, some of the data was quantified.

## **4.2 External validity**

The question of generalizability, or external validity, is often used as a quality criterion of research. Case studies are often criticised in that they provide little basis for scientific generalization (Yin, 1994). There is, however, also a discussion about how to deal with this issue. The case study researcher should instead strive for analytical generalization, that is, to generalize the case study findings to some broader theory (Yin, *ibid*). If more than one case study would support the same theory, then replication could be claimed. Glaser and Strauss (1967) similarly point out that one single case based on detailed, grounded data can indicate a general conceptual category, which later may be confirmed by a few more cases.

Since qualitative case studies do not aim at statistical generalization (Yin, *ibid*) and this is not the aim of this research about planning and scheduling work in practice, it is more relevant to discuss other notions than generalization. Cronbach (1975) suggests that in the investigation of complex practical and social phenomena the notion of generalization should be replaced by working hypotheses. If appropriate attention is paid to local conditions, as in qualitative case studies, any generalization may be regarded as a working hypothesis and no conclusion. Stake (1978) argues for reframing the notion of generalization, to work with naturalistic generalization, drawing inspiration from tacit knowledge and personal experience. Extensive knowledge about the particular will then result in the prospect of recognizing similarities of objects and issues in new and unknown contexts. One may also refer to reader or user generalization (Wilson, 1979; Walker, 1980). Since generalization is related to what readers may learn from a case, then a detailed description of a specific case is the base from which they may draw their own conclusions about the possibility

to generalize to other situations or cases. The striving for rich descriptions in the case studies was therefore a fundamental feature in this research on planning and scheduling work.

One way to validate research results and enhance credibility is through triangulation (Denzin, 1978). There are four types of triangulation:

- Data triangulation: the use of several data sources.
- Investigator triangulation: the use of several researchers.
- Theory triangulation: the use of multiple perspectives to interpret a single set of data.
- Methodological triangulation: the use of several methods to study a single problem.

Methodological triangulation is often used in fieldwork with the aim of increasing the validity and reliability of evaluation data. There is not, however, full agreement on the usability of triangulation. Patton (1980) states that triangulation is ideal but very expensive, and that there is a risk that attempts at triangulation may result in a number of poorly implemented methods rather than one method thoroughly done. Fielding and Fielding (1986) further argue that the use of theoretical triangulation does not necessarily ensure a reduction in bias nor does methodological triangulation necessarily increase validity. They argue that theories often have emerged from quite different traditions and that different methods are the product of these traditions. A combination of theories and methods may therefore add breadth and depth to the analysis, but not result in the “objective” truth.

In this thesis, the strategy of triangulation as described by Denzin served as inspiration during planning and design. Furthermore, in the development of the study approach, inspiration from the strategy of data, methodological and theory triangulation was drawn; not to find the “true” picture of planners’ and schedulers’ work, rather to achieve various angles of approach. By collecting data not only from the schedulers in focus, but also from a number of other employees and management in the studied companies, the intent was to obtain various subjective descriptions and perspectives. By this exercise, various pictures and subjective “voices” would be developed; these multiple realities (Guba and Lincoln, 1981) would then contribute to the knowledge about the problem area, give focus and support analyses of collected data. Different types of methods such as interviews, observations and document studies were applied to give rich data and complementary views of planners’ and schedulers’ work. Various theoretical perspectives were similarly used to view the data about planning and scheduling work from different angles of approach.

### 4.3 Selection of case companies

An important distinction to make in case study research is between single and multiple case studies. Single-case studies may be undertaken for instance to test a theory, to describe a unique circumstance, or to analyze a phenomenon that has not earlier been investigated scientifically. When undertaking multiple-case studies, Yin (1994) states that the cases then should be considered as multiple experiments, thus being part of some replication logic and not as samples within an experiment. Multiple case studies thereby provide the researcher with more compelling evidence. In this research, scheduling work was studied in four companies in the Swedish woodworking industry; a sawmill, a parquet floor manufacturer, a furniture manufacturer and a house manufacturer. These companies were selected according to two criteria, that:

- the company had at least one employee regarded as a full time scheduler
- each company had different types of production characteristics

The latter criterion was set to establish whether the same phenomena in the investigated scheduling work existed at some sites but not at others (Stuart *et al.*, 2002).

In Yin's terminology, this research is thus a multiple-case study regarding the four case companies in the Swedish woodworking industry.

### 4.4 Understanding work practice

Planning and scheduling work is one of many white-collar tasks that take place close to production. White-collar work tasks are often impossible to describe in great detail. So how do we understand and study work in practice in general? Depending on what is in focus, there are a number of different perspectives and methods. One may limit the analysis to physiological or cognitive aspects, while some state that also psychic, interactional, social and cultural aspects should be included to understand human work activity (Daniellou, 2005). Human work is performed under certain working conditions. Any method used to evaluate working conditions may also be considered as a method for analyzing work itself (Leplat, 1992). One way of analyzing work is task analysis, which is widely used in different forms to analyze work tasks, and divide them into subtasks, which are placed in a hierarchical structure. Task analysis may be defined as "the study of what an operator (or team of operators) is required to do, in terms of actions and/or cognitive processes to achieve a system goal" (Kirwan and Ainsworth, 1992, p. 1). This definition puts task analysis into a normative approach to work analysis (Vicente, 1999). Task analysis is often used to identify what people do and what skills are needed. A main purpose



is to examine further the demands that a system places on the human (Shepherd and Stammers, 2005). To achieve high value, however, the task analysis should include representations of both the constraints on and the requirements of the individuals involved (Wilson and Morrisroe, 2005).

There are also descriptive approaches to work analysis, in which understanding is sought of how employees actually behave in practice. This is reached through conducted field studies to learn about practical challenges and how these are handled. Understanding current practices is then used to suggest ideas for new designs (Vicente, 1999). Examples of descriptive work analyses are ethnomethodological analyses as they distinguish between the given task and what is actually performed (Norros, 2004).

Another approach to study human work is through activity theory which is applied within education as well as occupational health (Engeström, 1990). In this approach, the collective activity of a group is in focus. This activity takes place in an activity system consisting of a number of components (subject, object, tools, rules, community and division of labour). The tensions and inner contradictions that may arise within and between these components during changes are then highlighted as well as the historical background to the constellation of the components and the inner relations. Another contribution to understand practice highlights that there is a contextual character to human activity and that human activity related to learning especially should be understood in relational terms (Chaiklin and Lave, 1993).

In an interpretation of Vicente's (1999) categorization of different work analyses, Norros (2004) has developed an overview based on the object that is analyzed and the type of modelling. The object of analysis is then either the task or the work domain. The task is in turn divided into instruction-based or constraint-based orientations, see Table 4.1.

Table 4.1 Categorization of work analysis methods. Source: Redrawn from Norros (2004)

Type of modelling \ Object of analysis	Task		Work domain
	Instruction-based	Constraint-based	
Normative	Defines what <i>should be done</i> ; utilizes an input-output or <i>sequential</i> approach and instrumental vocabulary	Defines tasks as what <i>should be avoided</i> in reaching the result; utilizes an <i>event-oriented</i> sequential approach and instrumental vocabulary	
Descriptive		Describes <i>actual behaviours</i> ; utilizes <i>event-oriented</i> sequential approach and instrumental vocabulary; <i>constraints</i> emerge	
Formative			Defines outcome-critical boundaries of action; utilizes vocabulary that orients toward behaviour-shaping intrinsic work constraint
=>Type of explanation	Causal explanations of actual realizations of performance		Functional explanations based on explicating the potentials of performance in action

Formative approaches to work analysis focus on identifying requirements, both technological and organizational, that need to be satisfied for productive work (Vicente, 1999). By looking beyond particular ways of performing work, it is possible to identify new potential to carry out productive work. Norros (2004, p. 63) describes this as “by showing the lay of the land independently of any particular activity on that land, the map indicates possibilities for action”. Outcome critical boundaries of action can then be defined as indicated in the table above. Norros (*ibid*) has made a

further development of Vicente's work in the concept of core task which includes both the work domain and the practices.

In the work of Vicente and Norros action is referred to as individual action. In this thesis, however, the term activity is used to describe how individuals act while carrying out their work. This leads us into introducing activity analysis, which is applied in this thesis to understand practice.

Activity analysis takes a comprehensive view of human work activities. Analyzing work then consists of defining the task, the activity and their relations (Leplat, 1992). Activity is a central concept among French-speaking ergonomists as a way to understand work in order to be able to change it (Daniellou, 2005). It is a work analysis on a specific and descriptive level, as it focuses on what the employee is doing in a given situation (De Keyser, 1991). It is therefore based on analyses of work activities carried out in real work situations in order to learn about the employees' knowledge and competence, how information is collected and treated as well as how decisions are made (Guérin *et al.*, 2007). Furthermore, understanding work activity generates knowledge about physiological and psychological aspects, how the individual is solicited and any personal costs that may result, the use of tacit knowledge, and personal interactions (Daniellou and Rabardel, 2005). As stated earlier there is an emphasis on the discrepancy between prescribed work and work as it is carried out in reality. This is based on variability in the individuals themselves as well as in contextual factors. It is therefore not enough to base any interventions on the formal descriptions of work or formal procedures (Daniellou, 2005). In activity analysis, the activity is primarily on an individual level (in contrast to the collective activity on a group level in activity theory above). The basic idea is then to study real activities on an individual level to learn how the individuals produce operating strategies to cope with their tasks. This is done in dealing with internal and external factors with great variability in specific contexts.

A number of highlighted aspects in the activity analysis approach made it suitable for this research, which aimed at gaining thorough understanding of what planners and schedulers actually do at work. These included the emphases on real work activities, the individual perspective, and the discrepancy between prescribed work and what the individual has to deal with in everyday work situations characterized by great variability. Next, the background to and general procedure within activity analysis will be reported as well as how this approach was applied in this research.

## **4.5 Activity analysis**

### **4.5.1 Origin of activity analysis**

The concept of activity is central for many French-speaking ergonomists in their approach to analyze work and change it (De Keyser, 1991). In France,

the analysis of work was first developed around the Second World War by researchers in psychotechnics and the training of adults (Daniellou, 2005). These researchers examined tests within their respective fields and found that they did not correspond to characteristics of real work tasks, which led to an interest in analyzing work in real situations and field observations. In the 1950s, the foundation for the development of ergonomics in French-speaking countries was laid by the work “L’analyse du travail” by Ombredane and Favergé (Daniellou, 2005). In this work, two major perspectives that must be distinguished in analysis of work were brought forward by Ombredane (1955): the *what* and the *how*, that is what the individual worker should do and how this is done. This is also described as the requirements of the task on the individual worker and his/her operational attitude and sequences to meet these requirements. During the following years there was a focus on the discrepancy between prescribed and real work, to understand the reasons behind the observed variability in work situations, and why individual workers could not follow the prescribed operations (Daniellou, 2005). Over the years, work that could not be directly observed, such as human processing of information, was included in the work analysis and there was a shift to speak about human “conduct” at work. In the first half of the 1970s, the notion of “activity” emerged among French-speaking ergonomists as a result of the earlier ideas about the *what* and the *how* as well as how the term “activity” was traditionally used in psychology and as developed in Soviet psychology (Daniellou, *ibid*). This laid the basis for the emphasized discrepancy between the task that should be carried out and the real activity, which is the human conduct to perform the task. As a result, French-speaking ergonomists, who intervene in response to a request from any organization, have the general hypothesis that “it is not possible to deal with issues of occupational health and productive efficacy simply by understanding it through the formal description of work in the terms used by the management or the formal procedures. It is the fine understanding of the difficulties that workers encounter in their activity and of the adjustments that they implement to deal with variability which make it possible to associate:

- factors determining activity (characteristics of workers, means of work and tasks);
- characteristics of the activity (operating modes implemented); and
- effects (in terms of health or development of skills) and results (in terms of productive efficiency).” (Daniellou, 2005, pp. 411-412)

Throughout the years activity analysis has been applied by both researchers and consultants in ergonomics, and there has been a strong link between these two groups (Daniellou, 2005). Conducted research within ergonomics

applying activity analysis has been categorized into two basic groups (Falzon, 1997):

- description of the activity of the individual whose work is being studied
- description of the activity performed by the ergonomist to change work

#### **4.5.2 General procedure in activity analysis**

As described above, the analyses of work activity assume that actual work tasks are partly prescribed and partly developed by the operators themselves. When there is a need to change a work system it is therefore of great importance to determine what is actually done as well as what is prescribed. Thereby a work situation may be created that allows latitude in ways of working (and thus suits more personality types). In general, activity analysis is applied in interventions initiated by a request from a company or any other type of organization, see Figure 4.1 for an overview of the general procedure in activity analysis. The request may come from different sources in the company and with objectives specified in ways that are more or less acceptable to the ergonomist (Guérin *et al.*, 2007). The two major types of requests are:

- those formulated at the beginning of a design project that will radically transform the work of the employees
- those directed towards issues within the organization's ongoing change

A basic issue in activity analysis is the analysis and reformulation of the initial request from the company. In this phase, it is important to gain understanding of the implicit elements of the request. These include understanding the context of the formulated problem, positioning the problem in the overall organizational context and perhaps revealing new problems. Questions that should be raised in this phase are furthermore (Daniellou, 1998; Guérin *et al.*, *ibid*):

- Who initiated the original request?
- What is at stake and for whom?
- Who are the stakeholders and are there any underlying conflicts?
- What is the subject of a request according to the organization?
- Why has the consultant or researcher been contacted?

This analysis of the request reveals contradictions and underlying conflicts, different views on and over-simplifications of problems, and different areas

in which the ergonomist may act in the intervention. Moreover, it aids the ergonomist in formulating a proposal that takes into account the different views put forward by different groups in the organization (Guérin *et al.*, 2007).

After the formal proposal for an intervention has been agreed upon, information is collected regarding the context and the organizational processes. This includes information about the economic and commercial context, the social and demographic context, production and its organization, rules and regulations, the geographical environment of the organization, the technical system, conditions for performing work etc. (Guérin *et al.*, *ibid*). This information is collected to get an understanding of what is supposed to take place. In this phase (see Figure 4.1), some initial hypotheses (level 1 hypotheses) may be made that can guide the ergonomist into choosing some particular work situations to analyze in detail. This choice may also be based on the following criteria (Guérin *et al.*, *ibid*):

- Choosing the situation where the operators complain the most
- Choosing the situations where the consequences of the problems are most serious for the organization
- Choosing the situations with most problems
- Choosing central situations that have strong effects up- and downstream
- Choosing situations that must be changed sooner or later

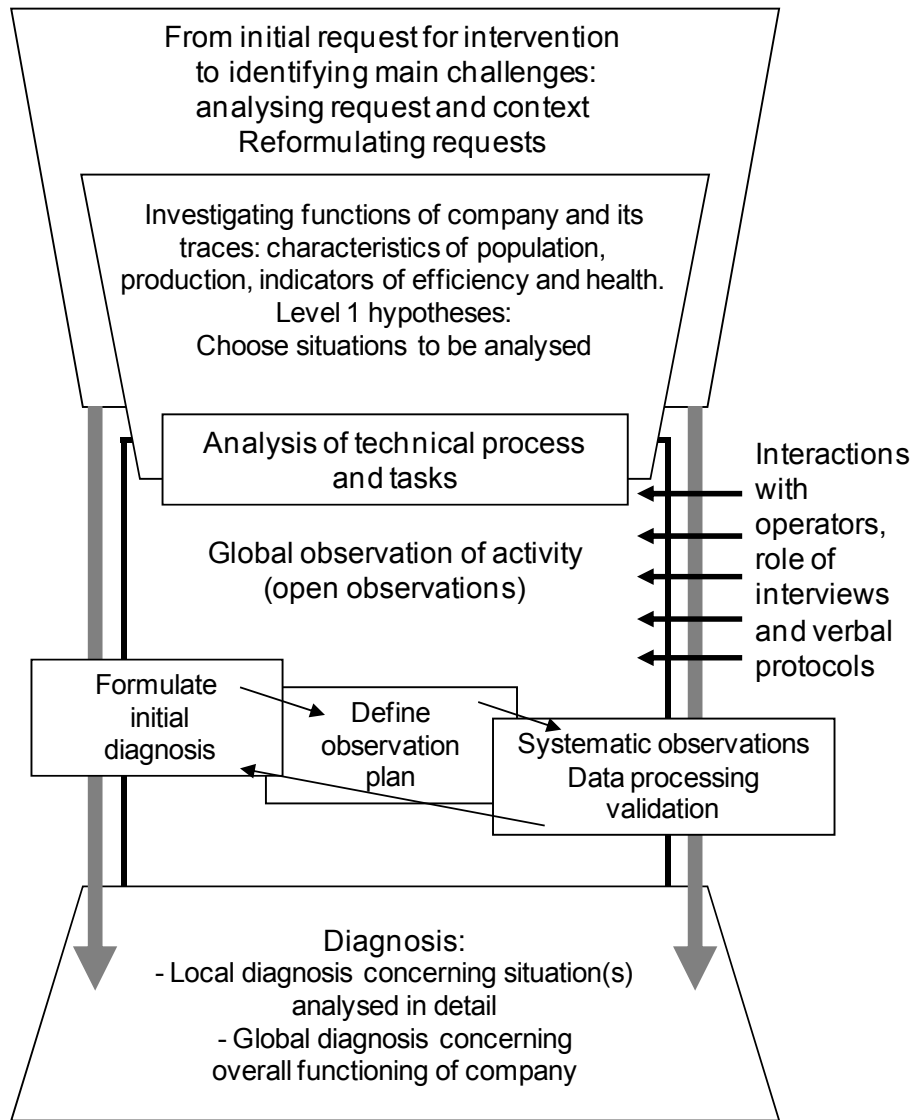


Figure 4.1 General procedure in activity analysis. Source: Redrawn from Guérin et al. (2007).

After initial contact with the employees concerned, open observations are conducted. The aim of these observations is to gain understanding of the technical process, the employees' tasks and the strategies adopted to fulfil these tasks. During the open observations it is important to keep in mind the initial factors behind the request. Based on these observations, a pre-diagnosis is made by relating the constraints in the work situation, the activities performed by the observed employees, and the outcome of these activities in terms of employee health and production performance (Guérin et al., *ibid*). These relationships then lead to the formulation of a pre-diagnosis (level 2 hypotheses), in which certain factors are regarded as influencing the employees to work in a certain way and thus explaining certain consequences. To validate, enrich and demonstrate these level 2 hypotheses, systematic observations are then conducted, see Figure 4.1. The observations constitute the cornerstone as data collection method in activity

analysis. The observations may focus on various aspects depending on the developed hypotheses. Some examples of observable features of work activities include (Guérin *et al.*, *ibid*):

- Movements from one place to another
- The direction of gaze
- Communication
- Postures
- Actions and information gathering
- The technical system and the physical environment
- People involved and distance between people
- The temporal scale

Based on the results of the systematic observations and information given by the employees, a local diagnosis, an ergonomics assessment of the work situation, is formulated. By highlighting the specific circumstances and difficulties in real work activities, the company is aided in identifying factors that could be changed. If the circumstances and difficulties identified at a local level are related to general aspects or policy, a global diagnosis is also formulated, and the company is then encouraged to deal with problems on a company level instead of only at a local level. Based on these diagnoses or assessments the ergonomist suggests possible directions for finding solutions to the encountered problems.

The phases in activity analysis as depicted in Figure 4.1 and as described here seem to be linear. In reality, results in any phase may lead to a transfer to earlier phases. For example, findings from observations in a work station may reveal new aspects of the request or the need to study also other work stations (Guérin *et al.*, *ibid*).

### **4.5.3 Activity analysis in this research about production planners and schedulers**

As described earlier, activity analysis was chosen as the method for the study of planning and scheduling work. This research project differed somewhat from the normal procedure within activity analysis as described above. First, the study was not initiated by a request from the companies involved in the study. Instead, the companies were initially offered to participate in the study. Second, the overall objective of the study was not to solve any specific problems that the companies perceived. The activity analysis was thus not the starting point for, nor was it part of, an ergonomics intervention.



Instead of undertaking an initial analysis of the company request, the companies were in this initial phase asked why they agreed to participate in the research project and what expectations they had of it. In the next phase, the functions of the company were investigated, including the scheduling task and the work context comprising technology, work process, roles and activities. Data about the prescribed scheduling task was collected in two phases, by acquiring knowledge of scheduling as initially described by the companies and as further described in the researchers' interviews with the staff. As the main overall aim was to gain further understanding of scheduling work in practice, no hypotheses were made regarding scheduling work or about any parts of scheduling work that should be observed in particular. The observations of real activities in scheduling work followed. Open observations were initially undertaken, not to formulate an initial diagnosis as in the general procedure of activity analysis, but to plan and prepare for systematic observations of the entire scheduling work activities. These observations are further described in section 4.8 "Methods for collecting data". Another distinction from the general activity analysis process was finally that no concluding diagnosis was made, but a number of different analyses of the data were made from different perspectives, see chapter 6.

## **4.6 Unit of analysis in the study of planning and scheduling work**

As stated before, the aim in this research was to gain deep understanding of planners' and schedulers' work in naturally occurring settings. As this was to be achieved by learning about the planners' and schedulers' values and experiences as expressed in their own words, it was natural to collect data primarily on an individual level. Data was thus collected with a focus on the individual planners and schedulers, but also on other individuals with whom the planners and schedulers collaborated.

As also stated before, throughout the study of the planners' and schedulers' work, a range of intertwined aspects and components emerged. To gain an overall picture of these aspects, the systems perspective including the subsystems of humans, technology and organization was adopted, see section 3.4. These three subsystems may be investigated from different perspectives. In this case, as earlier described, the human system was investigated from the following levels (as defined by Daniellou, 2001):

- the social level, emphasizing that every single individual is a member of several social groups with different cultures, which will partly determine his/her values and habits;

- the psychological level, where the human has a unique history, leading to a specific subjective processing of the situations he/she experiences; and to some extent
- the cognitive level, where the human is considered as an information processing system, including thought processes, representations, decision-making etc.

The technical system was divided and investigated from two viewpoints, the primary and the secondary technical system. The primary technical production system includes the production equipment that is devoted to maintaining the capability of the company. The main examples in this research were the entire woodworking machineries in the studied companies. This technical system was analyzed in different ways concerning technical limitations, problems, availability, reliability, etc. The secondary technical system comprises the system that assists the administration and procedures of the company but is not directly associated with the business as such (Wäfler, 2001). In this research, the secondary technical system consisted of the information system, including both hardware and software, which the schedulers used as decision support tools.

The organization, finally, was investigated in terms of how planning and scheduling work was organized, formally and informally (Westlander, 1999a), responsibilities and powers, hierarchical positions, business goals, rules, procedures, relations between organizational groups, etc.

## **4.7 Research procedure**

As stated previously, the author's interest in scheduling work emerged from earlier longitudinal studies of another white-collar group working close to production, namely production engineers (Berglund, 1998). Moving on to another white-collar group, production planners and schedulers, was of great interest along with the application of an enhanced method to study white-collar work: activity analysis. A methodological feature of activity analysis that was new to the author was the extensive use of observations of work carried out in practice. Similar to the earlier qualitative research it included data collection from the schedulers who were in focus as well as from other employees and management in the studied companies. This allowed for various subjective descriptions and multiple realities (Guba and Lincoln, 1981) to emerge and contribute to further knowledge about the schedulers' work and in what context it was performed.

The study of the production planners' and schedulers' work was realized within a research project initiated at Trätekt, the Swedish Institute for Wood Technology Research. The background to the project was that planning and scheduling was perceived as increasingly important, however problematic,

by a number of companies in Swedish woodworking industry. The planners and schedulers were facing complex decision making; a large quantity of decision-making software tools was available, but there was a breach to how their work was carried out in practice. The aim of the project was therefore to investigate the conditions that controlled the way in which planning and scheduling work was carried out in practice in the companies chosen for the study. By making these conditions known, they could be handled in appropriate ways to improve the companies' planning and scheduling process.

The research project officially ran between the years 1999-2001. During these years, the author's occupational situation changed from working at the university to work with industrial research at a research institute and further on to a combination of industrial research, teaching and consultant work. This research project was therefore carried out in parallel with industrial research, teaching and consultant work in other areas.

In the research project on scheduling work, two researchers (including the author) participated throughout the project. Data was collected during a period of one to six months in each company from December 1999 until November 2001. Researchers took main responsibility for data collection in two companies each (with the author having main responsibility for the parquet floor manufacturer and the house manufacturer). The first study was carried out in the sawmill. In this case, the methodological approach was developed, for instance by both researchers performing test observations and assessing individual notes to develop conformed data collection techniques.

The latter phases of this research also included international collaboration. The first contacts with other researchers in this area dawned in the year 2000, from when the author participated in yearly international workshops on Planning, Scheduling and Control in manufacturing which took place in different countries. The work of and collaboration in these first international workshops were later consolidated, intensified and further developed in the COST Action HOPS (Human and Organizational Factors in Industrial Planning and Scheduling), a research network funded by the European Science Foundation. The COST Action HOPS ([www.hops-research.org](http://www.hops-research.org)) ran during 2004-2008, and formed the basis for the cross-case analyses in this research.

What about theories used in the study of planners' and schedulers' work? Various theoretical perspectives were reviewed, selected, and used to view the problem area. Some of these theories served as a base for preliminary planning of the case studies; for instance, theories about work roles and the distinction between the official and the practised organization. Other

theories emerged as relevant during the progress of the studies; examples of those are theories about interpersonal influence, roles as viewed from a management perspective and the systems view “humans, technology and organization”. These different theories may seem dispersed; they were however considered relevant as few references were found regarding the problem area of this work.

## **4.8 Methods for collecting data**

As described earlier, a modified procedure for activity analysis was chosen as a method for the study of planning and scheduling work. The method included a detailed description of the mission, i.e. why the enterprise agreed to participate in the research project, the scheduling task, and the work context comprising technology, work process, roles and activities. Data collection was carried out in three stages, by acquiring knowledge of scheduling as initially described by the companies, as further described in the researchers' interviews with the staff, and scheduling activities as observed by the researchers.

Data was collected through discussions and initial open interviews with the scheduler, management and other employees whom the scheduler identified as crucial for his work. The interviews concerned production scheduling, the interviewees' own involvement in scheduling, or contacts with the scheduler. Documents, software support and the characteristics of the technical production system as well as the product demands were studied and described. The collected data served as the author's pre-understanding of scheduling work at the particular companies before carrying out the observations of scheduling activity in practice. Furthermore, it provided the authors with the dominant descriptions within the company of what was supposed to be carried out in scheduling work.

Each scheduler's work was observed during five entire working days although not in the same week. Observations took place each day of the week (a Monday, a Tuesday etc.) to allow for regular variations in work to be observed. During the observations, all notable work activities were recorded in terms of descriptions of tasks, time, people involved, use of aids, initiatives to activities taken, communication pattern, physical placement, etc. The observation protocol used (see Appendix A) was a minor development of the observation sheet developed by Crawford *et al.* (1999).

After the observations, a second set of interviews was carried out, in which the interviewees evaluated the state of scheduling practice in their company, their expectations on the scheduler, how their work was influenced by the scheduler, and how they influenced the work of the scheduler. This interview round was established to gain further information on the

schedulers' roles (according to Katz and Kahn, 1978) and to capture dependencies in the organizations. The reason for collecting data on the expectations held on the schedulers was that some of the expectations, as described by Biddle (1979), could be regarded as part of the schedulers' prescribed work. This interview round was performed according to an interview guide approach (Patton, 1990). The interviews consisted of open-ended questions with the terms in parenthesis serving as probes when the interviewees did not cover those elements in their answers; see the interview guide in appendix B. The interviewees selected for this second part were the studied scheduler in each company and those who during the observations were identified as having close contact with the scheduler. Some of those had been interviewed before the observations and some not. The number of interviews which were conducted after the observations and the interviewees' work position are listed in Table 4.2.

*Table 4.2 Interviews after the observations*

<b>Company</b>	<b>No of interviewees</b>	<b>Interviewees' position</b>
Sawmill	15	Scheduler, purchaser, marketing manager, CEO, production manager, planing scheduler, delivery officer, five operators and three forklift truck drivers
Parquet manufacturer	21	Scheduler, four production supervisors, four production group leaders, two forklift truck drivers, long distance truck driver, six customer helpdesk officers, quality coordinator, drying kiln foreman, purchaser
Furniture manufacturer	10	Scheduler, quality manager (in owner family), delivery officer, two foremen, purchaser, production manager, supervisor, two purchasers from the customer.
House manufacturer	19	Scheduler, foreman, two supervisors, industrial engineer, production manager, purchaser, material administrator, three delivery officers, two sales support officers, export officer, project coordinator, construction manager, three construction engineers

## 4.9 Data analysis

The empirical data was analyzed in a number of ways. The data from the initial interviews and documents was reported to provide an overview of each company's business activities and the ways scheduling was supposed to be performed. The data from the second set of interviews was transcribed into tables where the answers for each question were compared between interviewees and companies.

The data from the observations were analyzed qualitatively and quantified. For each case, observations were elaborated separately with the scheduler's

all work activities being described and categorized into main activities; see Table 4.3 for example of first transcription and categorization.

*Table 4.3 Example of a main activity and intervening activities at the parquet manufacturer*

<b>Main activity: Deleting already produced orders from the software system</b>	<b>Intervening activities: The scheduler changes from the main activity to deal with the intervening activity for some period of time and returns afterwards to the main activity</b>	
Start of main activity: 13:03	<i>Time</i>	<i>Short description</i>
Stop of main activity: 14:54	13:03	Forklift truck driver (1) enters and states what has actually been produced in the surface oiling line
<b>General description:</b>  The scheduler scans all orders in the scheduling software tool and deletes all production orders that have already been executed. Furthermore, he makes changes in delivery times for some orders where there are disturbances and those without alternative delivery times are put aside for further handling. Other departments are informed about these changes by mail or documents written along with making the changes. In this example the pressing line receives an explanation as well as customer service. In the latter case the changes are due to lack of incoming material and production disturbances.  The scheduler works in parallel with the scheduling software tool and own developed spreadsheets.  At the end of the main activity the scheduler has checked more than 400 orders.	13:07	Production leader (1) calls and informs about a disturbance due to rain in the packing line
	13:09	Production leader (2) calls and asks if he should mark that the articles should be oiled or not in the packing line
	13:15	Forklift truck driver (2) enters and seeks forklift truck driver (1) who often visits the scheduler
	13:21	Truck driver calls and asks if there is any delivery to another production plant this week
	13:31	Salesman calls with an inquiry
	13:38	Customer service officer (1) calls about certain production order that will be executed although not shown in the software system
	13:51	Economy department wants information about some articles
	14:04	Scheduler colleague enters and asks whether a certain parquet will be produced in a specific week
	14:11	Production foreman enters and asks about the production the following day in the glazing line
	14:15	Customer service officer (2) calls and asks where the scheduler's colleague is (who is not answering her phone)
	14:16	Scheduler colleague calls and informs that he is now dealing with the software problems that occurred last weekend
	14:21	Customer service officer (3) calls with a product inquiry
	14:33	Scheduler colleague calls out from his next door office and asks about a telephone number

To be able to make a cross case analysis (Yin, 1994) between the four companies, the main activities for each scheduler were grouped into generalized categories. These categories were divided into two groups,

dominating activities and context dependent activities. The *dominating activities* were those generally defined as being part of planners' and schedulers' task and activities:

- forecasting
- planning
- scheduling
- dispatching
- updating information system
- seeking information and overview

The *context dependent activities* included activities to which the studied schedulers devoted a great deal of time but which were specific to each company context. Examples of those were:

- development work
- upholding a communication node
- market related work
- travelling
- financial follow-up

Furthermore, all intervening activities where the schedulers suddenly changed from the main ongoing activities to other activities were listed and categorized into two types. The first type was defined as interrupting activities and consisted of activities that were included in the scheduler's normal tasks. The interrupting activities were initiated both by the schedulers themselves and by other people. The second type was disturbances which were activities not at all related to the scheduling task. See Table 4.4 for an example of quantified results, in this instance the number of different types of intervening activities in the parquet manufacturer case.

*Table 4.4 Number and types of intervening activities during five observed working days for the scheduler in the parquet manufacturer*

	<b>No. of intervening activities</b>
Interruptions others' initiative	238
Interruptions own initiative including contact	11
Interruptions own initiative without contact	7
Disturbances	12
Total number of interruptions	268

The data collection rendered extensive, rich data that may be analyzed from a variety of perspectives. Analyses that have been performed include both general descriptions of the schedulers' work and work situation (Berglund and Karlton, 2000) and highlights of specific observed phenomena such as the schedulers' handling of conflicts between market and manufacturing (Karlton and Berglund, 2002) or their influence on other employees' working conditions (Paper VIII). Furthermore, a quantification of the observed work activities was made to support argumentation about phenomena observed in scheduling work (Paper IV). Although quantification is not always accepted in qualitative research, it is an apparent method to establish that something is important. Reasons for quantifying may also be to get an overall picture of the data, to test or support a hypothesis, or to ensure that biases from the researcher do not prejudice the results (Merriam, 1988).

Specific theoretical perspectives were also applied in the analyses; role theory to analyze the expectations held on the schedulers (Paper III); a systems analysis including human, technological and organizational aspects on the schedulers' work (Paper I); theory on interpersonal influence to understand means which planners and schedulers use to exert influence (Paper VI) and operations management theory to model parts of the schedulers' work (Paper V). The latter two were carried out in cross-case analyses with British case studies, see further description below.

#### **4.10 Cross-case analysis**

As described earlier the author participated in an international research network which was formalized within the ESF funded COST Action HOPS. In this network, possibilities emerged for cross-case analysis with other case studies performed by other researchers. This collaboration rendered two major cross case comparisons with British case studies that had been carried out in other domains (Paper V and Paper VI).



In Paper V, a part of schedulers' work, the handling of production enquiries was modelled based on operations management theory. Although in each case different techniques were used to collect data, the data analysis process was carefully defined within the case study protocol to ensure comparability. That is, the derived process models, consisting of observed activities identified by a different researcher in each case, were generated using one agreed protocol without reference to each other. In this way the reliability of the analysis was ensured and final representations of the processes were generated in the same format to support the comparative analysis. The paper, including the analysis, is further described in section 6.5.

In Paper VI, a cross-case analysis was made regarding the way in which planners and schedulers exert influence across the commercial and manufacturing interfaces. The Swedish and British case studies were then analyzed individually and cross case (Yin, 1994) in relation to a synthesis of established theory on sources of power and influence. See further description of the paper in section 6.6.



## 5 The Swedish Case Companies

*In this section the Swedish case study companies are briefly described with respect to size, products and the scheduled part of the production system. Furthermore, the schedulers' backgrounds are described as well as the overall scheduling aim as described by the companies.*

### 5.1 Overview of the background of the schedulers and the Swedish case companies

The studied schedulers in the Swedish case companies worked with planning, scheduling and dispatching (see further Paper IV). As scheduling constituted the largest portion of their work, they are named schedulers in all descriptions regarding the Swedish cases. All schedulers had substantial shop floor work experience in their own and/or similar companies in the woodworking industry. The schedulers' work experience in the studied companies and number of schedulers are summarized in Table 5.1 below.

*Table 5.1 The schedulers' work experience and number of schedulers*

<b>Company</b>	<b>Work experience</b>	<b>No. of schedulers</b>
Sawmill	30 years at the sawmill	One scheduler
Parquet manufacturer	11 years in the parquet manufacturer	Two schedulers
Furniture manufacturer	24 years in the furniture manufacturer	One scheduler
House manufacturer	29 years in the house manufacturer	One scheduler

As described before, scheduling work was studied in four companies in the Swedish woodworking industry; a sawmill, a parquet manufacturer, a furniture manufacturer, and a house manufacturer. The companies represented different domains within the woodworking industry and are further described in subsequent sections. Their key characteristics are summarized in Table 5.2 below.

*Table 5.2 Overview of company characteristics in the Swedish case studies*

<b>Company</b>	<b>No of employees</b>	<b>Products</b>	<b>Scheduled production system</b>	<b>Scheduling aim</b>
Sawmill	42	Beams, tongue and groove boards, scaffold planks	Sawmill and drying kilns	Optimize the high value outcome of the sawing process regarding quality and volume
Parquet manufacturer	1400	Parquet floor	Production of hard surface of the parquet floor (pressing, formatting and surface treatment lines)	Find best possible fit between production capability and delivery demands
Furniture manufacturer	220	Bookshelves	Entire production	Control and manage the relation between forecast, order situation, schedule and actual deliveries
House manufacturer	370	Wooden houses	Drafting process, block production (pre-assembly at production site), parts delivery and house erection (final assembly at building site)	Capacity utilization and deliveries on time

## 5.2 The sawmill

The sawmill belonged to a larger sawmill group. It was organized in two sub-units. One was the sawmill with 42 employees, of whom five were white-collar workers, including the sawmill scheduler and the plant manager. The other unit was a secondary woodworking industry performing planing operations and also producing some of its own products such as cable drums and storage shelves. This unit had about 90 employees.

The sawmill produced about 110,000 m<sup>3</sup> sawn wood mainly for the international market. Products manufactured for the building and construction market were beams, tongue and groove boards, and scaffold planks. 40% of the company's production was exported to Japan, with a smaller quantity to Taiwan. The sawmill's primary focus on the Japanese market put new demands on the company, such as producing beams with very fine tolerances and specific shipping conditions.

The planning and scheduling work analyzed was that performed at the sawmill. The scheduler's main contribution was to optimize high value output from the sawing process achieving both volume and quality production. Further to this, it included achieving optimal fit between available timber supply and customer demand. In order to reach these goals the scheduler tried to influence supply, customer demand and the production process. The scheduler also took part in controlling the quality grading of produced high-value goods. Furthermore, the scheduler updated the scheduling software system several times every day. The company aimed to sell most of the sawmill production based on long-term contracts, typically agreed for a three-month period at a time. The company had its own marketing manager, drawing up the customer contracts. The customer then "called off" the required volume of product within the contract terms.

### **5.3 The parquet manufacturer**

The parquet manufacturer was a major parquet manufacturer on the world market with sales agents in many countries. Its weekly production was more than 100,000 m<sup>2</sup> of parquet. It had about 2,000 employees in different plants, most of which were situated in Sweden. This study was carried out in the main plant, which had about 1,400 employees, of whom 1,200 worked in production.

Scheduling involved the co-ordination of this production with that of the other plants. The production scheduling function belonged organizationally to production and consisted of four people, two of whom were involved with daily production and two who worked with the computerized scheduling system and development projects. The scheduler being observed in this study received orders from sales and entered job orders in the scheduling software system. Three main production flows were scheduled within the same premises and parts of production in two other premises. The scheduler's responsibility comprised finding the best possible fit between production capability and delivery demands.

## **5.4 The furniture manufacturer**

The furniture manufacturer was a family-owned company with 220 employees. It produced 1.3 million bookshelves each year, in different models for an international furniture retailer. This production constituted about 97% of company turnover. The company faced strong competition and tough pressure on cost, but it had at the time three-year agreements with the retailer. A large investment in an automated production line had recently been made, which was expected to increase productivity and production volumes considerably. Production set-ups were time-consuming so long production runs were preferred and sought.

The scheduler's contribution to the scheduling process was controlling and managing the balance between order requirements, the schedule and actual deliveries. This included recognising the current production capability, analyzing the order situation as well as the customer forecast. It further included establishing delivery feasibility and dates with the main customer. The scheduler also updated the scheduling software system and was responsible for the functionality of the system in the company.

## **5.5 The house manufacturer**

The house manufacturer produced wooden houses for the Swedish market. It had 370 employees. Two thirds of the employees were white-collar workers and the remaining blue-collar workers. The large proportion of white-collar workers was because of the large amount of design and administrative work associated with building and contracting management. About 90 % of the houses sold were delivered, erected and installed by a specific business at the building site. The main market was Sweden, but the company also delivered to other countries in northern Europe.

From the scheduler's point of view, there were two different processes to manage, single family houses sold to private customers and larger houses or groups of houses sold to individual external building contractors. The company was undergoing a change from delivering a standard house product to more customized houses. The company was therefore continually modifying its organization and production and delivery processes to improve its performance. The scheduler's tasks included making a master and a detailed schedule for each house produced, controlling the drafting procedures with respect to necessary scheduling steps, synchronizing three production units, and ordering and planning flows of material to the production units and building sites.

## 6 Overview of Appended Papers: Background, Results and Contribution

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*This chapter includes a précis of the appended papers in this thesis. The presentations comprise the background and objective of each study, on what theory and empirical material it was based, main results and contribution to knowledge development.*

### 6.1 Paper I: Human, technological and organizational aspects influencing the production scheduling process

#### 6.1.1 Background and empirical material

The data collection in the Swedish case studies rendered a vast amount of data that could be analyzed from different perspectives. In analyzing the material it became obvious that different data was related and thorough descriptions of scheduling work tended to be multi-faceted. One way to cope with this richness of data whilst still reaching an overall picture of scheduling work was to apply a systems perspective (von Bertalanffy, 1968; Checkland, 1981). There were a number of reasons for choosing an HTO (**H**umans, **T**echnology, **O**rganization) system perspective for the analysis in this paper: see a further description of the HTO-perspective in section 3.4. First, the HTO perspective (then referred to as MTO: Man, Technology, Organization) was established in Sweden as a meta-concept to analyze and develop further understanding of highly complex work activities, such as work on safety (Jacobsson Kecklund *et al.*, 1996). Second, the authors belonged to a research group at Linköping University that focused on an HTO system perspective for analyzing work. Third, earlier research on planning and scheduling had pointed out that it was influenced by technical, organizational and human aspects (MacCarthy and Wilson, 2001).

This paper was based on an analysis of data from all the Swedish case studies: the sawmill, the floor manufacturer, the furniture manufacturer and the house manufacturer. Data analyzed in this paper emanated from initial

unstructured interviews at the companies, observations of the schedulers' work activities during five working days, and 65 interviews carried out after the observations (see section 4.8). In all cases, the H-component was analyzed from a cognitive, psychological and social level. The T-component was regarded as consisting of two parts. The first was the *primary technical system* that includes the production equipment that is devoted to maintaining the capability of the company. This technical system can be described in different ways in relation to technical limitations, problems (both recurrent and stochastic), availability, and reliability. In regard to complex technical systems, the system may be considered as networks of linked relatively autonomous parts, which are to a large extent separately controlled and managed. The second part, the *secondary technical system* was a system that assists the administration and procedures of the company but is not directly associated with the value adding activities of the business (Wäfler, 2001). In this study, the secondary technical system consisted of the information system, hardware and software that schedulers use as decision support tools. Finally, the O-component comprised how the work was organized and structured, formally and informally (Westlander, 1999a), rules, procedures and cultural factors as well as relations between system components and subsystems.

### 6.1.2 Main results and contribution

The findings showed that the H-, T- and O-components were strongly interlinked aspects of scheduling. As this project had a focus on the scheduling work performed in practice and the schedulers' work role, the initial emphasis was on the H-component. The analysis revealed, however, the importance of analyzing and understanding the T- and O-component as well. The case evidence and analysis presented in this paper supported many of the previous studies made on scheduling in practice, in particular many aspects of the model of human scheduling presented in Jackson *et al.* (2004).

All three components in this study introduced conditions and limitations for the scheduling process which strongly suggested that all three components need to be addressed when aiming at improving scheduling processes. These three components, when jointly investigated, established the key issues that had impact on the scheduling work studied. It became clear that the scheduler was part of an HTO-system, both being affected by it and affecting it. Particular issues of note concerning the *human* contribution were:

- the importance of the scheduler's personal experience of the production system



- the need for the scheduler to understand marketing, sales and company strategies as well as production and in daily work manage incompatible goals
- the role of the scheduler as high-value information node
- the need for the scheduler to have good social skills
- the role of the scheduler as a problem-solver

This view complemented the more traditional one that good schedulers should be logical analysts, by adding that there were many other requirements placed on them due to context specific demands emerging from the real world environments.

*Technology* impacted the scheduling process as it set prerequisites in two key areas:

- the production system characteristics and its limitations at a detailed level in terms of capabilities, design failures and reliability
- the scheduling software system and its ability to provide sufficient data, control and decision support as well as to support other aspects of the scheduling task that in this study were largely ignored

The *organization* finally influenced the scheduling process through both formal and informal dimensions:

- the formal organization of the scheduling process, including formal meeting structures
- the scheduler's informal authority
- the scheduler's role to interconnect activities between different organizational groups
- the degree of proximity between employees (physical location and organizationally)

Further aspects of scheduling that may benefit from an HTO-analysis included distributed decision-making in the scheduling process as well as the scheduler's gaining control and coping with uncertainty. Furthermore, by taking a systems perspective like HTO into account from the beginning of any study it was possible to better establish and visualize a broad range of issues that contribute to the outcome of the work process. In this study, the HTO analysis rendered a holistic view of scheduling work and aspects that influenced the scheduling process and gave cues to further issues that could be followed up in deeper analyses of the material.

## **6.2 Paper II: Contextual conditions influencing the scheduler's work at a sawmill**

### **6.2.1 Background and empirical material**

As described earlier, a number of different analyses were made on the data collected in the woodworking industry. Several of these analyses pointed to the fact that scheduling work was strongly influenced by contextual factors (see for instance Paper IV), which also had been reported in other studies (McKay and Wiers, 1999; Jackson *et al.*, 2004). The idea behind this paper was therefore to make a more detailed analysis of the contextual factors in one of the Swedish cases, out of which the sawmill case was chosen to illustrate how contextual factors influence the scheduler's work. Based on the socio-technical ideas of interlinked technical and social systems, contextual conditions were viewed from two perspectives: a technical perspective and a social-psychological perspective (Klein, 1994). The technical perspective constituted contextual factors related to the technical system in the sawmill, the primary technical system including the production equipment etc., and the secondary technical system consisting of hardware and software in administrative systems and decision support tools (Wäfler, 2001). Regarding the social-psychological perspective, there is no absolute limit. The unit of analysis is therefore chosen by the investigator (Westlander, 1999a). It may be drawn for single job task, job content, work situation, organizational activities (activities as a whole, split up between different groups of personnel), the specific environment, or the general environment. In this research, the range of the context from a social-psychological perspective extended to the specific environment, including the scheduler's specific job tasks up to the market situation of the sawmill. The paper was based on data from initial interviews in the sawmill, five working days of observations of the scheduler's work and 15 interviews after the observations, see a further description in section 4.8.

### **6.2.2 Main results and contribution**

Apart from the objective of the paper as described above, this paper gave a more detailed description of the scheduler's work at a sawmill. It included the interaction with and influence from the technical system and production process as well as from the social system. The paper showed that there were contextual conditions related to constraints from the technical production system as well as from the technical scheduling tools used by the scheduler. These delimited the possible ways for the scheduler to perform his work and influenced how he interacted with other employees, thus influencing the social system. Examples of such contextual conditions were uncertainty in log supply and in production results of the drying kilns or incompatibility between different computer systems. Furthermore, this paper identified contextual conditions that were related to the social environment, consisting

of social interaction and often across functional boundaries. Here, the scheduler needed to handle different logics. These conditions were not always directly perceivable, but served as means for the scheduler to schedule production and thereby to control the technical system. It was therefore possible to assume that the scheduling process continuously develops under contextual conditions related to the interlinked technical and social systems. Finally, the study showed that the scheduler's thorough knowledge, experience and skills of both systems certainly had great influence on how the work tasks were performed in combining the technical and the social system in daily scheduling work.

## **6.3 Paper III: Schedulers' reality – expectations and dependencies**

### **6.3.1 Background and empirical material**

The idea of specifically enquiring about expectations on the scheduler and scheduling work in the second set of interviews was to gain further understanding about the schedulers' roles. This was based on Katz and Kahn's (1978) definition of roles as strongly related to expectations sent by others. The aim of this paper was to present and discuss preliminary findings regarding the expectations held by other employees concerning the schedulers' performance, and the dependencies between the schedulers and other employees. The paper was based on data from 36 interviews (see further description in section 4.8) in two of the Swedish case companies: the sawmill and the floor manufacturer. The results were primarily based on this second set of interviews. Extensive contextual data from the descriptions of the organizations and technical systems as well as from the structured observations of the schedulers' work activities were also used for the analysis.

### **6.3.2 Main results and contribution**

The results showed that the schedulers had to deal with many different categories of expectations from others within and outside the organization and serve in a variety of roles:

- **Information supplier:** The schedulers were expected to supply immediate, entirely correct and continuous information, although they lacked reliable data for it.
- **Continuous communicator:** The schedulers were expected to take responsibility for keeping up constant communications, which served as a basis for collaboration.
- **Efficient scheduler:** The schedulers were expected to perform efficient scheduling. This was defined by management as optimized

production in terms of production outcome and/or profitability. Many interviewees, however, included a number of other aspects facilitating their own work, adding that the schedulers should show consideration for prerequisites and consequences of their scheduling for other departments or groups of employees.

- **Change manager:** The schedulers were expected to be flexible and discuss changes when initiated from other employees or the market. They were at the same time, however, expected to keep agreed schedules or solutions.
- **Negotiator:** The schedulers were expected to find compromises and negotiate between groups in the company, including occasions when there were incompatible goals.
- **Problem solver:** The production schedulers were expected to solve problems in a more general sense. Apart from the areas earlier referred to, problem solving included handling of unexpected events, coordinating different production units, participating in production and product development, etc.
- **Context expert:** All activities carried out by the schedulers should be based on reality. The schedulers were expected to understand reality fully as it took shape in the workshop and other production premises as well as in the computer systems. As a consequence, the schedulers were expected to appear frequently on the production work floor.

A number of groups of employees expressed their dependencies on the schedulers. The production personnel stated that the schedulers controlled their work by issuing work orders and facilitating their work. Also the supervisors pointed out that they were dependent.

This paper also showed that there were mutual dependencies between the schedulers and other employees in the company. The schedulers depended on the production personnel and supervisors to receive complementary feedback about production status, as they could not rely solely on the scheduling software. Furthermore, they were dependent on the support from customer service in case of difficulties with certain production orders, and they depended on forklift truck-drivers to receive production feedback and to control production. At the same time, other employees in the company depended on the schedulers' work as the schedulers set prerequisites and limitations on their work, thereby influencing the working conditions of the production personnel, forklift truck-drivers and customer service. As the scheduler was considered to have a significant influence on production results, with which management was accredited, this was further identified as a management dependency on the scheduler.

These expectations on the schedulers and their mutual dependencies with other employees in the company added to the complexity of production scheduling. Understanding these human aspects of production scheduling might be considered as one critical success factor in developing efficient, flexible production units.

## **6.4 Paper IV: Schedulers' work content – a quantified analysis**

### **6.4.1 Background and empirical material**

The study of the schedulers' work in the Swedish woodworking industry rendered a great deal of qualitative data that could be analyzed from different perspectives. One possible analysis was to quantify the schedulers' work activities in terms of work content and conditions. Earlier research had for instance described the complexity of planners' and schedulers' tasks (Wiers and van der Schaaf, 1997), their management of goal conflicts (Higgins, 1996) and that the scheduling task could be divided into formal tasks, housekeeping tasks and compensation tasks (Crawford, 2000). A quantified analysis of the work content in the scheduling task had, however, not been undertaken. The objective of this paper was therefore to make a quantified analysis of the schedulers' actual work activities with the goal of gaining further insights in their work.

This paper was based on the study in all four Swedish case companies: the sawmill, the parquet manufacturer, the furniture manufacturer and the house manufacturer. The analysis made was solely based on the observation data from 20 days of observing the schedulers' work activities, but interpretation and contextual understanding of the observed activities were also based on studies of company documents and interviews (see section 4.8). The observation data was analyzed separately in each case by identifying and describing all main work activities for the scheduler. For each main activity all *intervening activities* were listed. These intervening activities were further analyzed and divided into *interrupting activities* or *disturbances*. The interrupting activities were in their turn divided into activities on the scheduler's own initiative or on others' initiative and whether they were performed with or without contacts with other people. The disturbances were defined as activities that were not at all related to the scheduling task. Finally, to allow for a cross-case analysis, all main activities were grouped into generalized categories.

### **6.4.2 Main results and contribution**

This paper clearly showed that the scheduling work was characterized by a large number of interruptions and disturbances, see Table 6.1. For example, in the floor manufacturer, the scheduler faced a large number of interruptions concerning sales and market issues. In the house

manufacturer, the scheduler himself initiated a large number of interruptions in his search for information and overview. In all companies, there were many interruptions related to requests about production status, order status, sudden problems, etc. Examples of disturbances were related to computer problems and various inquiries about names, addresses, materials, etc.

*Table 6.1 Interruptions (n) and disturbances (n) during five observed working days for each observed scheduler*

	<b>Sawmill (n)</b>	<b>Floor manufacturer (n)</b>	<b>Furniture manufacturer (n)*</b>	<b>House manufacturer (n)</b>
Interruptions others' initiative	50	238	34	88
Interruptions own initiative including contact	41	11	36	32
Interruptions own initiative without contact	1	7	4	28
Disturbances	28	12	25	24
Total no of interruptions	121	268	98	172

\*The scheduler at the furniture manufacturer was observed during four days in the company premises and one day visiting the customer.

In the analysis of how the schedulers' spent their working time, an analysis of the relative distribution was made to avoid any misunderstanding that the study could be used as any form of work study. After a calculation of the time spent on all main activities, these were categorized and divided into two groups. One was dominating activities which included activities that are generally defined as being part of schedulers' task and activities that were common among all the studied schedulers, see Table 6.2.

*Table 6.2 Schedulers' dominating activities*

	<b>Sawmill</b>	<b>Floor manufacturer</b>	<b>Furniture manufacturer*</b>	<b>House manufacturer</b>
Forecasting	2%		21%	
Planning				25%
Scheduling	22%	43%	18%	40%
Dispatching	6%			
Updating IS	27%	10%	17%	4%
Seeking information and overview	11%	14%	11%	4%
In total	68%	67%	67%	73%

The other was context dependent activities which included activities to which the different schedulers devoted a lot of their time, but was specific and related to their separate contexts. The content of those activities was dependent on the different schedulers' personal attributes like interest, experience, previous positions etc., how the scheduling was organized, and the system properties of the different companies. To this category, all minor activities (less than 8 %) were also added under the heading Miscellaneous to facilitate readability, see Table 6.3.

*Table 6.3 Schedulers' context dependent activities*

	<b>Sawmill</b>	<b>Floor manufacturer</b>	<b>Furniture manufacturer*</b>	<b>House manufacturer</b>
Development work	16%			
Communication node		14%		
Market related work			11%	
Travelling			16%	
Financial follow up				11%
Miscellaneous	16%	19%	6%	16%

\*The scheduler at the furniture manufacturer was observed during four days in the company premises and one day visiting the customer. This makes the figures on context dependent activities larger than expected average and consequently dominating activities less than expected average.

A difficulty in separating the schedulers' activities into general categories was that the activities were in some cases performed integrated. For example, in the sawmill the scheduler's high percentage of updating IS includes both updating with production results and with sales, which was

done exclusively by this scheduler. Difficulty in separating activities was also experienced between scheduling and dispatching in the floor manufacturer and between planning and scheduling at the house manufacturer.

Interestingly the dominating activities occupied about two thirds of each scheduler's work although they worked in entirely different contexts. These were activities that can be expected in most companies, either based on the definition of the scheduling task or from studying previous research. This paper also showed, however, that less expected context dependent activities constituted as much as one third of the schedulers' work. These work activities were less recognized by management and in theoretical framework about production scheduling. A quantification of their work activities might here serve as a strong argument for management to increase their understanding about schedulers' work roles and an input for organizational redesign. Furthermore, it could be concluded that interruptions and disturbances constituted a considerable part of the schedulers' work content. The interruptions and disturbances, sometimes searched for by the scheduler and sometimes avoided, served different purposes and caused a working situation that was characterized by fragmentation. As interruptions and disturbances could not be foreseen, they often caused high workloads and stress. From this point of view the task of the schedulers could be regarded as a service task in an industrial context.

## **6.5 Paper V: Production planning aligning customer requests with production capability**

### **6.5.1 Background and empirical material**

The idea behind this paper was to develop an alternative way to describe planning and scheduling work by modelling the work activities in the interface towards production and the commercial departments (market and sales). The schedulers' work in these interfaces within this study had been reported earlier by Karlton and Berglund (2002) in a description of how the schedulers needed to manage goal conflicts in their daily work practice. In this study, the handling of production enquiries was highlighted. This constituted one part of the schedulers' work interfacing production and the commercial side. The hypothesis was that the planners and schedulers here performed some type of trans-specialist role (Postrel, 2002). The overall objective of this paper was therefore to develop a model to represent front-end business processes that align customer requirements and business capabilities in manufacturing business. This was to be achieved with special focus on production enquiries and the role which planners and schedulers play in this respect.

The theoretical base for this paper included earlier research on individuals with cross functional expertise performing trans-specialist roles (Postrel,



*ibid*), objects and ends analysis (Carlile, 2002) to understand different logics and agendas in different functions, and communication mechanisms deployed across functional boundaries (Carlile, 2004). In a literature review it was identified that significant research findings had been made in the understanding of product enquiry handling within the field of product development where interactions between sales and engineering need to be handled. The idea was therefore to investigate the equivalence of such processes to production enquiry handling. This was scrutinized through cross case comparison of the processes that handle product and production enquiries. The product enquiry case was a British instrumentation manufacturer and the production enquiry case the Swedish parquet floor manufacturer. The latter case was based on data from five days of observations of the scheduler's work and 21 interviews (see further description in section 4.8).

Different techniques were used to collect data in each case and the observed activities were identified by a different researcher. The data analysis process, nonetheless, was carefully defined within the case study protocol to ensure comparability. That is, the derived process models were generated using one agreed protocol without reference to each other. In this way the final representations of the processes were generated in the same format to support the comparative analysis.

The analysis steps included:

- Representation of the processes as a 'role activity diagram' (Cheung and Bal, 1998);
- Comparison of the role activity diagram activities (including assessment of terminology vs. meaning between the cases);
- Development of an *alignment process diagram* for each case that described each element in the process, its sequence and ownership;
- Development of a generic model that combined elements of the process identified for both processes in the form of a process diagram.

### **6.5.2 Main results and contribution**

The comparison between the product and the production enquiry process showed strong similarities in the alignment processes. Here, the results from the study of the production enquiry process at the parquet manufacturer are presented. Handling production inquiries was observed as a frequently recurring activity for the parquet floor scheduler. The scheduler's activities in handling production enquiries are described in Table 6.4 and the role activity diagram is depicted in Figure 6.1.

*Table 6.4 Key activities and functional roles in the production enquiry process at the parquet manufacturer*

<b>Activity</b>	<b>Description of activity</b>	<b>Category</b>	<b>Functional role</b>
Check customer enquiry	Check if customer enquiry fits into expected volume of products in stock for the desired delivery date		Customer service representative
<b>Assess</b> production <b>capability</b>	Based on own thorough knowledge about production status, PSC-tool and authority make a first assessment of production capability that guides decision-making about how to handle the customer enquiry	A Assess	Scheduler
<b>Filter</b> production enquiries	Filter out enquiries that the scheduler can deal with himself and direct the remaining to specific production leaders depending on type of customer enquiry	B Filter	Scheduler
<b>Problem solve</b> without referral	Reject the enquiry or modify it without reference to production	C Assess	Scheduler
<b>Translate</b> enquiry	Interpret customer enquiry and translate it into a form relevant to production	D Translate	Scheduler
<b>Route</b> enquiry	Route interpreted enquiry to relevant production representative	E Route	Scheduler
<b>Assess</b> production <b>capability</b>	Assess production capability related to issues presented by scheduler such as overtime, alternative running of production etc.		Production leaders
<b>Suggest alternatives</b> to customer order	Find or schedule for alternative delivery date or suggest alternative product with requested delivery date to customer	F Transform	Scheduler
<b>Translate</b> production reply	Translate production response to acceptance, rejection or alternative solution to customer enquiry	G Translate	Scheduler
<b>Negotiate</b> between marketing/sales and production	Negotiate with both marketing/sales and production regarding the possibility to fulfil production inquiries or regarding the scheduler's suggested alternatives	Negotiate	Scheduler

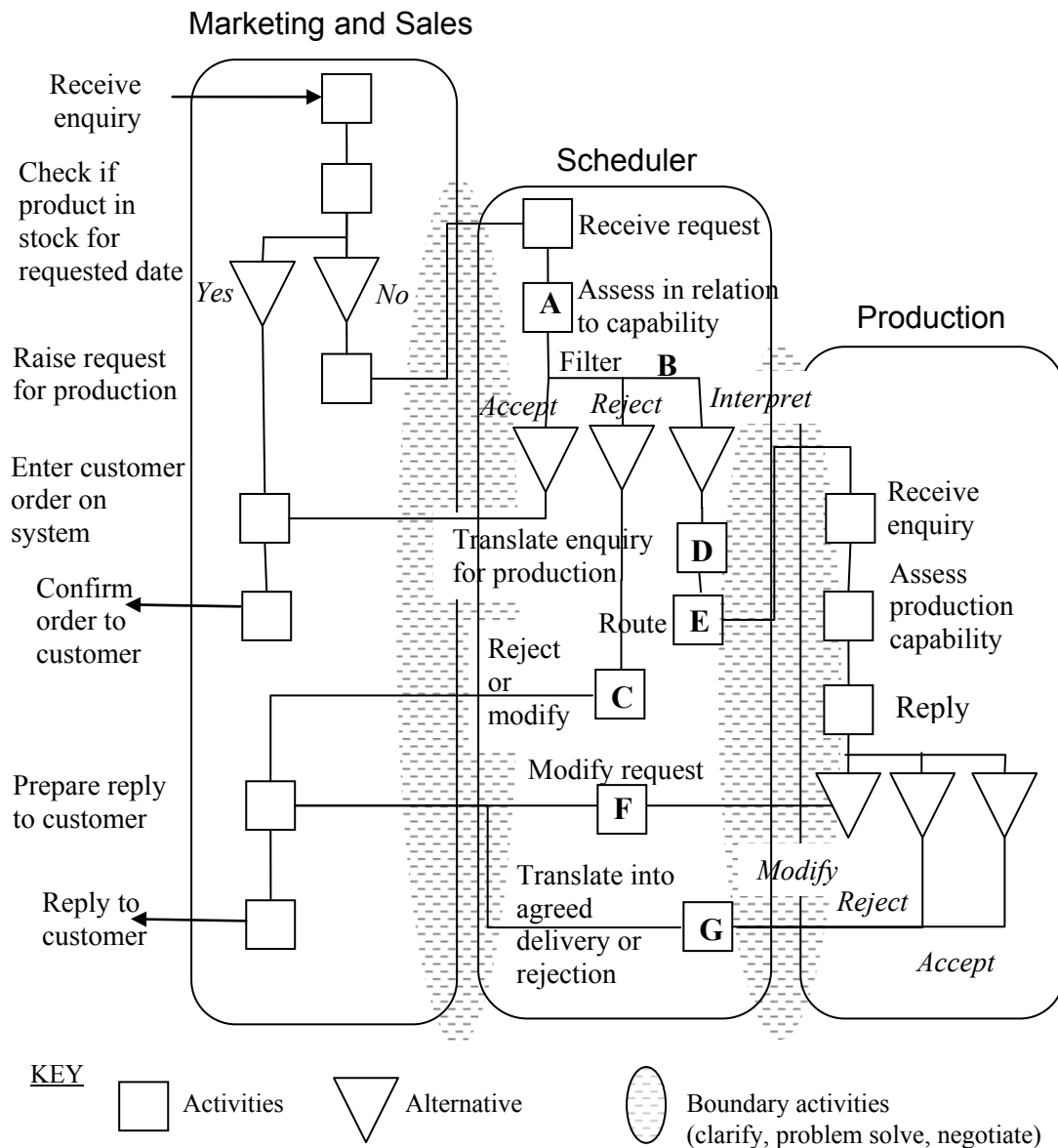


Figure 6.1 Role Activity Diagram for production enquiry at the parquet manufacturer.

Some of the scheduler's activities were autonomous and performed solely within the alignment function while other activities occurred at the interfaces towards marketing and sales or production, described here as boundary activities.

The autonomous activities were:

- *Translate* – translating the enquiry information into a form that made sense to people in the other functions – this occurred in both directions; converting customer information into a form relevant to the capability function and vice versa

- *Assess* – assessing the enquiry in relation to its feasibility
- *Filter* – filtering enquiries to ensure only feasible requests were taken further. This included seeking revisions to the enquiry to support its acceptance
- *Route* – where the enquiry was directed to relevant personnel and processes
- *Transfer* – where a response was purely transferred from the capability function to customer interface function
- *Transform* – where a response from the capability function needed to be further developed and the alignment function applied additional information and/or its own expertise to develop the response

The boundary activities that were performed in joint work processes with representatives from marketing and sales or production were:

- *Clarify* - clarifying where additional information might be sought and anomalies dealt with
- *Problem solve* - jointly problem solving where adjustments to the product or plan needed to be analyzed and ‘best solutions’ determined
- *Negotiate* – negotiating with others, to fulfil the request where accommodations and/or trade-offs were necessary.

Based on the results from the British product enquiry case and the Swedish production enquiry case at the parquet manufacturer, a simple common model was developed that showed the process elements and positioned the roles in the process, see Figure 6.2. In this model the business functions involved in the process were described as customer facing, alignment or enterprise capability functions. In the case of planners and schedulers, the customer facing function referred to marketing and/or sales and the enterprise capability function was production.

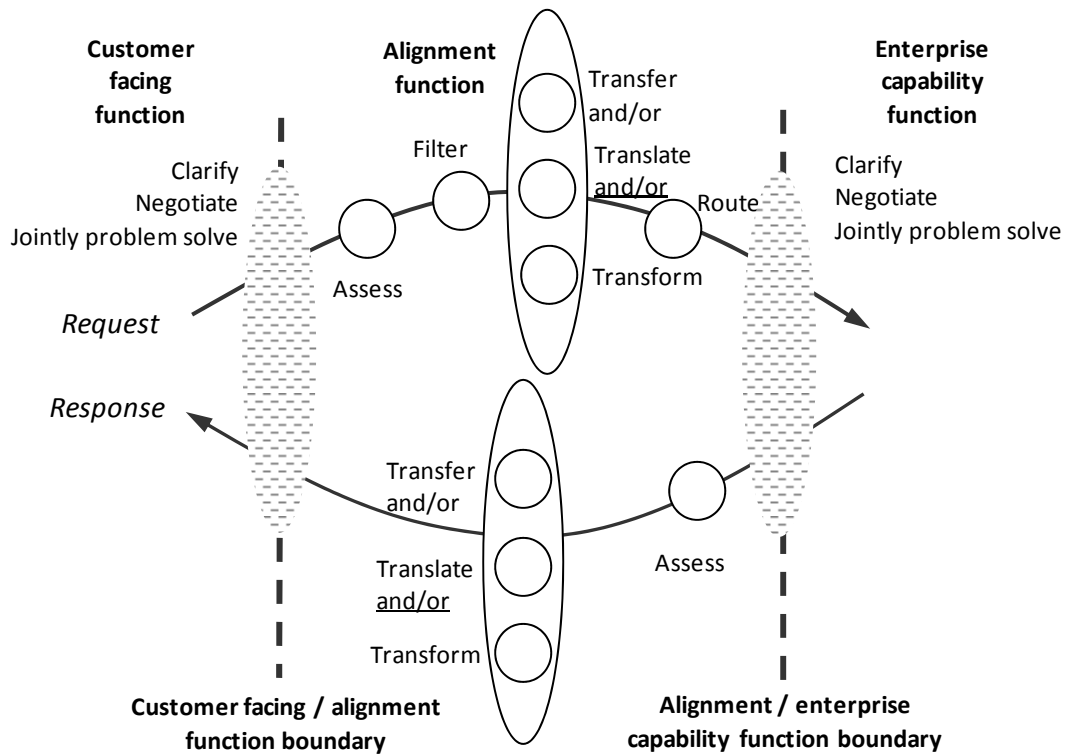


Figure 6.2 Model of the customer request alignment process.

The derived model provided a simplified representation of an alignment process, in which the planners and schedulers serve in an alignment role. It could be used to support a range of research enquiries on these processes. In particular it could be used:

- to analyze more complex processes, to identify what distinguishes them and the impact of specific factors on process requirements;
- as a framework from which to study and improve other facets of the process, for example:
  - knowledge transfer and sharing;
  - skills requirements of those in the alignment function;
  - information system requirements;
  - effective organization structures to support alignment processes;
  - interdependences between different functional groups.

## **6.6 Paper VI: The influence of production planners and schedulers at manufacturing and commercial interfaces**

### **6.6.1 Background and empirical material**

The fact that the schedulers lacked formal authority, but in practice exerted strong influence was identified in the Swedish case companies (see for example Paper I). An interesting issue was how this was done in daily work and what further knowledge could be achieved from such an investigation. In this work, the starting point was the conflict between manufacturing and the commercial side of the business (e.g. Crittenden et al., 1993) and that studies had identified production planning and scheduling as providing a bridge between manufacturing and commercial departments (Parente, 1998). Interfacing with both the commercial and manufacturing functions, which have incompatible goals, it was assumed that planners and schedulers would need to influence others using various forms of power (Pfeffer, 1981). This paper therefore set out to investigate the work and role of planners and schedulers in relation to how they influence manufacturing and commercial employees at these key manufacturing and commercial interfaces.

There are different power bases from which interpersonal influence may be exerted. The investigation of the planners' and schedulers' behaviours was mainly based on Handy's (1993) power bases as sources for interpersonal influence. These were in their turn derived from French and Raven (1959) and provided the following power categories (as earlier described in section 3.2):

- Resource power
- Position power
- Expert power
- Personal power
- Physical or coercive power
- Negative power

The paper was based on the case studies in the sawmill and the parquet manufacturer in the Swedish woodworking industry in a cross-case analysis with two British cases, a DIY manufacturer and a steel manufacturer. In each case data was collected from observations of activities and interviews with employees in planning/scheduling, manufacturing and commercial departments. The data concerned the tasks influenced, who influenced whom, why influence was required, where (in relation to fora) and when it

occurred, which form it took (related to categories identified in literature), and how it was applied.

### 6.6.2 Main results and contribution

A number of power bases were identified in the different cases, see Table 6.5 below.

*Table 6.5 Sources of influence at production (prod) and commercial (com) interfaces*

Source of influence	Sawmill		Parquet floor manufacturer		DIY product manufacturer		Steel manufacturer	
	Prod	Com	Prod	Com	Prod	Com	Prod	Com
Resource power	–	–	–	–	–	–	–	X
Position power:								
• Formal (line) authority	–	–	–	–	–	–	–	–
• Access to information	X	X	X	X	X	–	X	X
• Access to networks	X	X	X	X	–	–	X	X
• Right to organize	X	–	X	–	X	–	X	–
Expert power	X	X	X	X	X	–	X	X
Personal power	X	X	X	X	X	–	X	X
Physical power	–	–	–	–	–	–	–	–
Negative power	–	–	–	–	–	–	–	–

From the cross case comparison the following was found:

- The right to organize occurred at the production interface in all cases; the planners and schedulers being responsible for instructions and plans.
- Position power based on access to information and to networks was prevalent at both commercial and production interfaces; an exception was in the DIY product manufacturer.
- Expert power was identified at all interfaces; an exception was in the DIY product manufacturer.
- Only in one case was resource power utilized, though in an indirect form.
- Physical power and negative power were not observed in any of the cases.

For each case a number of propositions were developed which were checked regarding relevance in all cases. In Table 6.6 these propositions are listed along with reference to the cases in which they were supported.

*Table 6.6 Propositions and cases of application (Sa = Sawmill; F = Floor manufacturer; DIY = DIY manufacturer; St = Steel manufacturer)*

Proposition	Company
1. The scheduler is a social actor performing a co-ordinating role between sales and marketing and manufacturing.	Sa, F, DIY, St
2. A combination of expert power and personal power provides the scheduler with perceived personal integrity that helps him smooth out difficulties and conflicts.	Sa, F, DIY, St
3. Long work experience gives legitimacy to the scheduler's suggestions and contributes to both expert power and personal power.	Sa, F, DIY, St
4. The scheduler does not have formal authority but aspects of position power such as access to networks, people with power, and information as well as the right to organize (in relation to production) are evident.	Sa, F, DIY, St
5. Based on the scheduler's access to key arenas, valuable information is gained and used to influence others.	Sa, F, DIY, St
6. Information power is gained not just from formal participation in meetings but informal interaction with employees from commercial and production.	Sa, F, DIY, St
7. Personal power supports negotiations with manufacturing and commercial.	Sa, F, DIY, St
8. Position power based on the right to organize is effective in this organization as it has a hierarchical structure where autonomous roles have been clearly established;	DIY
9. The need to influence can be minimised where the company ethos and goals are shared;	DIY
10. A customer focused ethos may legitimize the dominance of commercial over planning resulting in the over-ruling of planning expertise.	DIY
11. Ownership and control of information and expert knowledge create the need for a judge-adviser relationship and dependency of senior managers on their adviser.	St
12. By influencing the agendas and communicated objectives of senior managers the planner can legitimise his plans throughout the organization.	St
13. Where multiple players vie for production the planner may be able to influence others on the basis of perceived resource power	St
14. Planners can consciously actively develop and maintain their sources of power; these in turn can be used to reinforce each other.	Sa, F, St

The empirical research demonstrated that the planners and schedulers in daily work exerted strong influence on other employees in manufacturing



and commercial departments. In particular it showed the informal power bases from which planners and schedulers commonly act. They did not hold legitimate power as expressed in the formal organization; instead individuals drew on a vast repertoire of reinforcing sources of power to influence others. Their influence emanated mainly from their access to and control of information and their ability to apply their expertise to interpret this information and examine the impact of decisions made across different areas of the business. Here, access to company agendas and influential arenas was key. Often forms of influence were seen to be consciously developed and maintained. It was also shown that personal power related to social skills was significant.

This understanding has value in a number of practical applications that include assessing the skills requirements of planners and schedulers, and establishing how best to induct and train them. Also it could be used to establish how an organization might be adapted to better fit the integration needs of commercial and manufacturing using planning and scheduling as an intermediary. This is of particular value as it represents one aspect that should be considered when establishing appropriate ways of achieving effective and responsive order fulfilment.

These findings contributed to increased knowledge on how planners and schedulers influence manufacturing and the commercial departments. The findings could be used to support further research in this area, in particular research that addresses ways of improving joint decision making, the selection and training of key planners and schedulers, and the utilization of expert knowledge.

## **6.7 Paper VII: The unsung contribution of production planners and schedulers at production and sales interfaces**

### **6.7.1 Background and empirical material**

As less research has been undertaken on planning, scheduling and control (PSC) in relation to the sales and production interfaces at an operational level, the aim of this paper was to contribute to the body of knowledge in this area. This was attained by taking a number of different perspectives drawn from various theoretical domains such as operations management, organizational behaviour and work science in a compilation and combinational analysis of the research that had been carried out by the authors within this area. The paper was intended to serve as a book chapter.

This paper was based on data (mainly 65 interviews and 20 days of observation, see section 4.8) from the four Swedish case companies: the sawmill, the parquet manufacturer, the furniture manufacturer, and the

house manufacturer as well as on data from two British cases: a DIY product manufacturer and a steel manufacturer.

### 6.7.2 Main results and contribution

As described above, this paper served as a compilation of the authors' earlier work that was related to the planners' and schedulers' work towards the commercial and production interfaces. Some of these results are also reported in more detail in other papers in this thesis. The paper included the following areas:

- *Complexities in everyday PSC practice* – illustrated what planners and schedulers encounter in everyday work and how they respond, starting with general PSC practice and then moving on to illustrate the types of issues that are dealt with in relation to the sales and production interfaces. The latter was especially highlighted in examples of how schedulers need to handle the different logics of production and sales departments.
- *Planners and schedulers aligning customer demands with the production capability of the enterprise* – described the model that represents the alignment process undertaken when customer requests are aligned to the capability of the business through the effective handling of production enquiries. (This is described in detail in Paper V.)
- *Planners' and schedulers' influence at the sales and production interfaces* – described the ways in which planners and schedulers influence others. (This is described in detail in Paper VI).
- *Planners' and schedulers' knowledge use and decision making at key PSC interfaces* – looked at the knowledge contributed by planners and schedulers and how their and others' distributed knowledge is drawn together and used to enable decision making and problem solving at key interfaces and across work groups.

The main contribution of this paper was the development of a more comprehensive and multifaceted view of planners' and schedulers' work in relation to the commercial and production interfaces. It showed how they balance between the business production capability and customer demands in complex and dynamic environments where functional objectives differ, trade-offs need to be made, negotiation may be required, and there is often a dearth of current information.

The paper also identified some practical implications, where the developed model for the alignment process could be used to support managerial decisions on PSC people, processes and organizational design:

- Managers can use it as a framework against which they can examine their own business processes, to help them recognize and visualize elements of the alignment process.
- The model can help managers to differentiate autonomous and boundary elements, highlighting the latter in which social and influencing skills, and possession of cross domain knowledge may be crucial.
- From the analysis of the model in their specific case, managers can appreciate the nature of the process and make decisions on planner and scheduler selection, training and induction. Furthermore, they can consider whether necessary competences are in place and the extent to which organization ethos, design and processes support planners and schedulers.
- Analyses of sources of power, and the forms of influence that planners and schedulers employ as well as their knowledge use and sharing, can aid managerial decision making on operational practice and organization design.

## **6.8 Paper VIII: Schedulers' work activities and decision making influencing working conditions of other employees**

### **6.8.1 Background and empirical material**

Production scheduling work includes frequent decision-making concerning what manufacturing personnel should do or produce, how much, when, and how much time and resources they can spend performing their work. The coordination character of the work also gives schedulers strong links to other people in the organization such as sales and marketing personnel, since schedulers have great impact on what information and what promises can be given to customers.

Schedulers and the way scheduling is performed will thus have a direct influence on the working conditions for a large number of employees. This fact is often indicated, by the very definition of scheduling, which implies that the schedule should reduce the decision latitude for single members of the organization and coordinate efforts towards common goals. Few studies though, have explicitly analyzed how, for whom and in what respects the schedulers actually influence working conditions of other employees. The objective of this paper was therefore to investigate the links between how schedulers perform their work and the working conditions of other employees.

The theoretical base for defining working conditions included desirable psychological demands that individuals may put on their work content as proposed by Thorsrud and Emery (1970) within the socio-technical school of thinking. These demands include a minimum of variation, ability to learn, ability to make decisions, a certain degree of human understanding, etc.

Furthermore, the psychological demand/decision latitude model (Karasek, 1979) was used, which defines different job characteristics depending on levels of psychological demands and individual decision latitude. Hackman and Oldham's (1980) model was further used, and it describes how favourable job characteristics may form work motivation and effective performance, as opposed to negative work characteristics that may cause strain.

The paper was based on data (mainly 65 interviews and 20 days of observation, see section 4.8) from the four Swedish case companies: the sawmill, the parquet manufacturer, the furniture manufacturer, and the house manufacturer.

### **6.8.2 Main results and contribution**

Based on the theoretical background and the interview data, five characteristics describing the relations between the schedulers' work and the working conditions of other employees were identified:

- *Scheduling feasibility* – special demands that individuals had on the schedule or scheduler in order to optimize their own work.
- *Information* – expectations on the schedulers to supply rich information, often extended above prescribed level.
- *Workload* – how the schedulers were perceived or experienced to directly influence the workload of others.
- *Prerequisites* – when schedulers' work was directly used as a basis for further scheduling or tasks such as purchasing, furnishing information to customers etc.
- *Means of influence* – how other employees could affect the schedule.

The results indicated that the schedulers had a direct impact on the working conditions of many personnel categories in the companies. Apart from production workers, there were frequent examples of when the schedulers directly influenced the work of various levels of production management, forklift truck-drivers, customer service officers, customer project engineers, marketing personnel, etc. In the two smallest companies, the sawmill and the furniture manufacturer, even the CEOs regarded their own performance as directly dependent on the work of the scheduler concerning some issues.

Schedulers' work, as illustrated in this study, affected different aspects of working conditions for various categories of personnel. These aspects, which mainly relate to facilitating the working conditions for different categories of personnel, included the feasibility of the schedule, the furnished information, and the workload imposed. Schedulers' control had a clear influence on the desirable psychological job demands for other employees, on their decision latitude, and the schedulers could promote work motivation, general job satisfaction, and work effectiveness by the way they perform their job. Another interesting finding was the high proportion of employees believing that they could influence the schedule. It violated the definition of scheduling, to reduce the individual decision latitude, and it violated the expressed opinion by the employees that the schedule should stick to the rules agreed. At the same time, nevertheless, it supported the employees' general need for decision latitude and autonomy.



## 7 Discussion

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*This chapter contains the final discussion of this research, highlighting some of its main findings and with focus on the research questions posed initially in this thesis. Some methodological issues are also discussed. Specific findings from the study of the schedulers' work in the Swedish woodworking industry are discussed. Furthermore, general findings from the cross-case analyses with the British cases and concerning both planners and schedulers are discussed.*

In this thesis it is argued that planning and scheduling work is far more than creating a plan according to optimization models and/or executing a developed plan. At the start of this research, the author had the assumption that planners and schedulers do not only apply a developed plan which has been created by them or retrieved from a software support tool. As will be discussed here, the planners and schedulers rather have to construct and re-construct their plans. For this, firstly and as shown in the case studies, information is needed from both up-streams and down-streams departments; information that is beyond what can be found in the computerized support systems. As will be discussed also in this chapter, this information is found by using tentacles in continually searching for hints and pieces of information in everyday work. Secondly, it is essential to build personal relations beyond what is expected in the formal organization and with others from different functional groups within and sometimes outside the company. These findings are highlighted from the different angles defined by the research issues. Thirdly, the process of constructing and re-constructing the plan is also built on negotiations and facilitation. As shown in the case studies, negotiations are needed between different groups, incompatible goals, and conflicting constraints. At the same time, however, facilitation is required. This facilitation, which will be discussed, is directed towards others in servicing them in different ways in their work. Being dependent on the results of others' work, however, the planners and schedulers thereby facilitate their own work. In the following text, these and other main issues will be brought forward and discussed in the light of the research questions identified initially in this thesis.

## **7.1 What tasks, activities and roles are inherent in planning and scheduling work?**

This study shows that planning and scheduling work is characterized by high demands for flexibility, a need to deal with a high degree of uncertainty, and consisting of problem solving and multiple parallel tasks. These findings are evidence that planning and scheduling work is highly demanding cognitive work, and the findings support those made in earlier research from other industries (McKay *et al.*, 1992; Crawford, 2000; Bazet, 2002b; Jackson *et al.*, 2004). Further evidence of the high cognitive workload is the large amount of interruptions and disturbances found in the schedulers' work content in the woodworking industry. The interruptions and disturbances, sometimes searched for by the scheduler and sometimes avoided, serve different purposes and cause a working situation that is characterized by fragmentation. As the occasions when interruptions and disturbances happen cannot be foreseen, they will often cause high workload and stress.

To fulfil the role as problem solver, this study showed that schedulers especially need thorough detailed knowledge of the functioning of the production system. In the woodworking industry, this knowledge had been developed for all schedulers through personal experience from working in production. Due to this personal experience, the schedulers gained legitimacy from "bottom-up" experience and had many strong links with employees in the production departments.

The study also showed that planning and scheduling work is strongly characterized by social factors. It supports earlier studies (Crawford, 2000) and demonstrates the importance of the schedulers' frequent personal contacts with different groups of personnel and departments in the organization. In fact, the schedulers act as informal coordinators, that is as nodes through which information is spread and contacts between people are coordinated in the organization. The need to negotiate between incompatible goals, the expectations on schedulers to show social concern about consequences of the schedule for the employees, as well as the schedulers' dependency on others' willingness to help out in acute situations, are all examples of the strong demands placed on the schedulers' social abilities.

A complicating aspect in scheduling work in this study was to control the high degree of uncertainty, which has also been reported in other research (MacKay *et al.*, 1989; McKay and Wiers, 1999). Uncertainty was in this study emerging both from inside and outside of the company. The schedulers in the woodworking industry had high expectations placed on them to provide information to others in the organization; information that in some cases was more detailed than that obtained from the scheduling software system.



Necessary information therefore had to be sought by other means. As described before, this was in many cases achieved through visual inspection of production and stock and informal conversations. The schedulers put a lot of effort into gathering information about the past, present and the anticipated future state of the system. Walking around the facility and the conscious building of social networks within and outside the company were examples of measures used to support these activities.

The range of expectations discussed above shows that the schedulers in the woodworking industry had a complex role in their respective organization. Using Biddle's (1979) terms, few of these expectations were overtly expressed, none written. Examples of expectations that were part of the dominating view of what the schedulers should achieve in the companies, and therefore could be regarded as overtly expressed, included those related to the scheduling aim such as optimizing the high value outcome of the sawing process or finding the best possible fit between production capability and delivery demands. Other expectations, which were partly covertly held were brought forward in the interviews and included the expectations on the schedulers to be problem solvers, serve as information centre, be both flexible and maintain agreements, show social concern in scheduling work etc. Though these were only partly expressed, the schedulers were fully aware of these expectations, and why these may be considered as part of their prescribed task and role in the companies.

The inability of the systems to provide the type of information that the schedulers needed had resulted in development of spreadsheets, which might be viewed either as workarounds or as powerful flexible aids to scheduling that complement the scheduling software system. These spreadsheets may also be regarded as boundary objects, which are used across organizational functions as objects that may contribute to knowledge development (Carlile, 2002).

Furthermore, in dealing with the scheduling software system there were many examples of situations that required human interaction and support to sustain a scheduling process capable of achieving its set goals. The scheduling software systems in the companies studied could not fully support the schedulers in their tasks and did not comply with the design criteria in terms of information presentation, integration with the task, and providing relevant feedback. The scheduling software system also acts as a decision support system. Nonetheless, the available systems were criticized for providing insufficient decision support for the scheduling task. This deficiency has also been identified in earlier research on scheduling, in which data availability and accuracy, dealing with complexity, performance measurement, organizational embedding, and interaction with the human scheduler were inadequate (Wiers, 1997a; Jackson *et al.*, 2004).

The analysis of schedulers' work in the woodworking industry revealed that the studied schedulers' tasks lead to a number of activities. Some of these activities are such that can be expected in most companies, either based on the definition of the scheduling task or from studying previous research. In the woodworking cases these activities were categorized into forecasting, planning, scheduling, dispatching, updating the information system and seeking information and overview. About two thirds of the schedulers' activities were in this category. The remaining activities, as much as about one third, were found to be dependent on the schedulers' individual attributes as well as the context in which they work. Context related conditions may emanate from the production process or the need to deal with different logics in daily work, as in the case of the sawmill scheduler who had to deal with the logic of production, log supply and marketing and delivery. These activities vary from company to company and are generally not expected in scheduling work. In this respect, planning and scheduling work may be regarded as an important service function in the studied companies. Another less expected aspect of planning and scheduling work was the strong impact of dealing with the commercial side in daily work, also with matters of a negotiation and problem-solving nature. This aspect, planning and scheduling work in the interface between manufacturing and the commercial side, will be further discussed in the following section.

### **7.2 What does production planning and scheduling work imply with respect to the commercial and manufacturing interfaces?**

The observations and interviews showed that planners and schedulers play a crucial role as a link between manufacturing and the commercial side. In this research, one part of planning and scheduling work was highlighted in particular, the alignment process performed by planners and schedulers when handling an enquiry for production of certain goods or orders to see if it fits within the company's production capability. Within this alignment process planners and schedulers perform a number of activities. Some of these activities are performed within their own function, in this research named autonomous activities, and some are performed across functional interfaces, here called boundary activities. The autonomous activities include among other activities translating the enquiry information into a form that makes sense to people in the other functions, assessing the enquiry in relation to its feasibility, and transforming for example the response from production (adding information so the response fits the needs of the commercial side). The boundary activities are carried out at the interface towards the commercial side or manufacturing. They include clarifying the enquiry to manufacturing or the response to the commercial side, negotiating when necessary and problem solving where adjustments to the

plan need to be analyzed and “best solutions” determined. Both the examples of the autonomous activities as well as the boundary activities require a great deal from the planner or scheduler. He/she needs to have good information access to sources from both manufacturing and the commercial side. The manufacturing side is expected, but good collaboration with the commercial side is also required. Thorough knowledge about both manufacturing and the commercial side and their different logics (Carballeda, 1999) is also required. This is essential in order to be able to negotiate, translate or transform an enquiry or response. By this, the planners and schedulers can also act as a representative for one area in contact with the other, filter out what production enquiries should be passed on to manufacturing, and interpret the real meaning of the enquiry from the commercial side into issues that are at stake in manufacturing and translate back their response into issues of interest to the commercial side. This suggests that the planners and schedulers possess cross functional expertise enabling them to perform a trans-specialist role (Carlile, 2004). These activities are furthermore all examples that contribute to the complexity of the planners’ and schedulers’ roles as they need to be involved in subsystems, each of which has its own priorities and subcultures (compare Katz and Kahn, 1978).

Viewing the organization as a system of roles (Katz and Kahn, *ibid*), the alignment role between manufacturing and the commercial side is suggested as one of the roles of the planners and schedulers. Are the studied organizational system roles integrated, do its roles fit well together (Biddle, 1979)? In this study, the planners and schedulers succeed in performing the alignment role and serve in a linking role towards different work roles within both manufacturing and the commercial side. This could be regarded as a success and evidence of an integrated role. At the same time, this alignment role is not fully acknowledged in the companies and recognized by the companies’ agendas. By doing that, it would be possible for instance to find ways of improving joint decision making at the interfaces, the selection and training of key planners and schedulers, and the utilization of planners’ and schedulers’ expert knowledge. All of this is essential to achieving responsive order fulfilment.

As described in this thesis, the planners’ and schedulers’ work consists of a number of activities, such as negotiating or finding compromises in the alignment of manufacturing and the commercial side, problem solving or ensuring that a developed schedule will be finally executed. To be able to perform their tasks in daily work, the planners and schedulers sometimes need to exert influence on other individuals and groups within the organization.

### **7.3 By what means do planners and schedulers exert influence in the organization?**

As described before, this research shows that planners and schedulers in daily work exert strong influence on others in the organization. This is done more or less consciously, is necessary to fulfil their work tasks, and is exerted in many different forms. As the planners and schedulers did not have any formal authority, this was exerted by the use of other means. Some of these sources of influence emanated from power bases (French and Raven, 1959) related to their formal work position, and others were related to personality features.

Regarding the power bases related to formal work position, access to information and access to networks were used a great deal by both planners and schedulers in this study. In many cases the planners and schedulers were strongly linked to a number of different groups in the companies, including management and specific support groups such as quality control. They had access to vital arenas and participated in a large number of formalized meetings. At these meetings valuable firsthand information was gained and the planners and schedulers could participate in crucial decision-making regarding major issues. This information could later be used to influence others and in negotiations. These formal meeting arenas are examples of places for “cold adjustments” (Carballeda, 1999), where problems could be solved with representatives for different functions. The established meeting structure is furthermore part of the formal organization and quite easily retrieved in an initial presentation of the way in which the work in a company is organized. It is important to note that information power is gained not just from formal participation in meetings but also from informal interaction with employees from different functions. As the planners and schedulers had extensive contacts with a number of people within and outside the organization this was also a major source of information power, especially as they consciously searched for updated information during all these interactions.

Another identified source of influence related to position power (French and Raven, 1959) was the right to organize. It occurred at the manufacturing interface in all the cases, as the planners and schedulers were responsible for plans and schedules and thereby instructed employees and to some extent management in manufacturing.

As described earlier, the planners and schedulers were involved in intense social interactions related to a wide range of issues. In these interactions, “hot adjustments” (Carballeda, *ibid*) were identified, for instance in deviation of formal rules in order to solve immediate problems but also in

manipulation of the scheduling system in order to force other users in the system to make final decisions about preliminary established orders.

The planners and schedulers also exerted influence based on expert power and personal power (French and Raven, 1959), which were more related to their personal features. Both power bases were identified towards manufacturing and the commercial side. As described earlier expert power emanates from an individual possessing expert knowledge that is needed and acknowledged by others (Handy, 1993). This was certainly the case for the planners and schedulers. For the planners and schedulers, expert power was derived from being recognized for having the knowledge needed to understand the implications of decisions made and how to manage them. This was very different from having access to information and was firmly based on experience. Long service experience and associated knowledge provided planners and schedulers with expert power and strong legitimacy. This was apparent in the woodworking industry and also observed in the British steel product manufacturer. In the woodworking trade, the experience formed a personal knowledge base from which to carry out scheduling tasks. The schedulers' legitimacy with others was also based on the schedulers' ability to understand the production process, its limits and under what conditions work was executed.

Expert power is the power base that is socially most accepted (Handy, 1993). Another power base which is directly related to social interactions is personal power. It emanates from an individual's personality (Handy, *ibid*) and the individuals are characterized by eloquence, ability to listen and quick comprehension (Pfeffer, 1981). These social skills were evident in all studied cases. The personal power supported contacts with a wide range of groups within and outside the companies, contacts where the planners and schedulers needed to pay attention to the different logics in the organization and adapt in order to fulfil their work tasks. This occurred towards different groups within manufacturing, in the commercial departments, or towards management. In the floor manufacturer, the scheduler even described explicitly how he used humour as a conscious means to cheer up and befriend customer helpdesk representatives to ensure their support when it was needed.

The use of power bases in planning and scheduling is an essential part to fulfil the tasks. What is required of the individual planners and schedulers? Some power bases are related to organizational position and will come naturally during work activities. Other requirements such as expert knowledge to gain legitimacy and social skills are less achievable. Expert knowledge comes with time and experience. It is however possible to include facts about the practice of planning and scheduling work in training and educational schemes. Training on site could also include some periods

in different parts of production as well as in the commercial departments to learn more about their logics, ways of working, and how they regard their interface towards planning and scheduling. One important issue is to acknowledge further the role and contribution of planning and scheduling within and disseminate information about these processes within real world practice as well as research.

### **7.4 What aspects of planners' and schedulers' work contribute to and influence business operations and the work of other employees in the company?**

One focus of this research was to explain planners' and schedulers' significance to business operations and other employees' work in the company. This research showed how planners and schedulers in practice perform far more than assumed tasks such as optimizing through logical analyses and compensating for inadequacies in planning and scheduling systems. As has been discussed before, they also serve as problem solvers in a number of domains through their expert knowledge as well as constitute efficient information nodes (also identified by Crawford, 2000). These parts of planning and scheduling work are further examples where they contribute to other employees' work and overall business operations. Related to their service as information nodes are their numerous interactions with different groups within and outside the companies. There were several examples of others' dependency on the schedulers in the woodworking industry. In production, operators put forward that they were dependent on the schedulers as they issued work orders and facilitated their work. Production supervisors described their dependency on the schedulers as he furnished information and set overall production goals. The commercial departments similarly reported their dependencies on the scheduler in furnishing them with relevant information to customers, information that was not available in the MPC-system. Also management considered the scheduler to be important for their work, as management received credits or criticism depending on the production results, on which the scheduler was considered to have significant influence.

The planners' and schedulers' work had a major impact on overall production capability in their way of searching alternative production solutions to obtain maximum production. This work may be expected work by planners and schedulers (Hill, 2005). Less expected is that their work also included taking the commercial consequences into account, therefore suggesting alternative goods for customer enquiries and encouraging the commercial department to sell more of certain products. Adding their alignment role, which was described in this research, the planners and

schedulers contribute to business operations in bridging the gap between manufacturing and the commercial side. This is done partly in “smoothing the system” and negotiations, but also in handling production enquiries. The latter is an example of the planners’ and schedulers’ contribution to overall company performance and impact on the company responsiveness.

The findings in this thesis are evidence that human contribution in planning and scheduling is necessary to achieve set objectives in the companies. There is thus reason to question the possibility to automate planning and scheduling. So where are logical optimization and mathematical models in daily planning and scheduling? Integrated in the planners’ and schedulers’ software tools, they contribute by supporting their decision-making. At the same time, this research shows that a number of contextual factors strongly affect what is possible to achieve in practice. Planning and scheduling work is therefore characterized by situated actions (Suchman, 1987) as well as naturalistic decision-making (Klein Associates, 1987; Guinery, 2006) where mathematical optimization is replaced by compromises, negotiations and feasibility.

The strong dependencies on the schedulers reported from other employees and management in the woodworking industry influenced the work activities of the others. These influences set some basic preconditions for their work and could both facilitate and delimitate the work of other employees, thereby influencing others’ working conditions. The schedulers were well aware of this and were in their turn dependent on the other employees to achieve their own work objectives. The aspects of scheduling work that directly influenced the working conditions of others included the schedulers’ supply of information and that they showed concern for the feasibility of the schedule and workload imposed. Depending on the schedulers’ attitudes towards others and the developed schedules, the schedulers influenced the decision latitude of others and could indirectly promote job satisfaction and work effectiveness. This subtle interdependence between the schedulers and other employees and the schedulers’ influence on others’ working conditions have scarcely been developed in earlier research.

The schedulers could be regarded as facilitators in the HTO (Humans, Technology, Organization) system in each of the studied companies in the woodworking industry. They facilitate others’ work in continuous personal interactions, they serve the technical scheduling software system and they align different organizational functions. Facilitation occurs when the scheduler’s behaviour affects another individual’s behaviour by means of environmental manipulation; that is when the scheduler’s behaviour increases the probability of another’s behaviour (Biddle, 1979). Where the scheduler’s behaviour decreases the probability of another individual’s

behaviour, there is hindrance (Biddle, *ibid*). The schedulers in the woodworking industry seem to be skilled in balancing their behaviours towards facilitation. Their work facilitates others' work and influences working conditions and business performance.

As initially mentioned in this chapter, this thesis argues that the facilitating work is performed by the schedulers using tentacles; tentacles that actively search for information, hints and possible solutions for a wide range of daily challenges and problems. These tentacles extend into different groups of operators in production and management. They are used in developing and re-constructing the plans, schedules, and work orders in order to discern what is feasible with respect to the technical system, while at the same time showing social concern for people involved in the work system. These tentacles are also necessary in dealing with the variety of logics, languages, and values that exist among different groups in the companies (within production itself or between production and the commercial side). These tentacles constitute a suitable tool to reach good understanding of what is at stake in each of these groups. In combination with expert knowledge and developed social skills the schedulers may contribute both to good operations performance and suitable working conditions.

### **7.5 Discussion about methodological approach**

This thesis has focused on how planning and scheduling work is performed in daily practice. There are numerous ideas on how these processes should be improved and optimized (e.g. Wang and Wu, 2003; Mourani *et al.*, 2008). This research sought to give a complementary view of these processes, from the individual planners and schedulers who perform daily work activities within them.

One important aspect in the research approach was to distinguish between the formal and practised side of the organization (Westlander, 1999a; Guérin *et al.*, 2007) and here specifically the planning and scheduling processes. Organizational charts may be regarded as an illustration of management's ideas of how the business operations should function. These ideas are also fairly easy to describe explicitly. As we have seen, practice is often much more complex, with specific constraints and great variability. The author's assumption is that real work activities must also be investigated. It is in the practised work activities that we reach the actual performance of the work system. To reach full potential of any suggestions for improvements, the actual work, the informal structure of the process and under what conditions it is performed should be taken into account. Some specific findings from the study of planning and scheduling in practice was a multifaceted picture of the roles and contributions of planners and schedulers, how they in practice align between manufacturing and the



commercial side, and a more thorough view of how they exert control without having the formal authority to do so. These are all important aspects of the informal side of the organization.

The use of activity analysis (Guérin *et al.*, 2007) to study scheduling work in practice resulted in very rich data, from which it is possible to make analysis from various theoretical perspectives, out of which some were presented in this thesis. With a combination of structured observations and interviews as main data sources, activity analysis resulted in very detailed data about a variety of issues. This resulted in a multifaceted picture and an enhanced understanding of planning and scheduling, which is a type of white-collar work that is not easily described. At the same time, however, the richness of data brought forward the challenge to describe the content of the white-collar work in a comprehensive way. As in other qualitative methods, activity analysis, as used in this study, proved to be quite time-consuming. This was especially the case during the phase of data analysis. The author, nonetheless, regards activity analysis as a suitable method to investigate the essence of and nuances in white-collar work in general.

A challenge perceived in the use of the methodology was to distinguish clearly between prescribed work and real work activities. During the data collection, three pictures emerged instead: prescribed work as initially presented by for instance management; work as further described in initial interviews with the schedulers and their colleagues; and finally, the real work activities. Work as further described could not be fully positioned in any of the initial groups. Another challenge was the scarce descriptions of the prescribed work within the studied companies. There were no written statements about prescribed work. Instead, it proved to be suitable to approach also the prescribed work by relating it to role theory (Katz and Kahn, 1978; Biddle, 1979) and investigate the expectations held on the schedulers from a broad range of stakeholders within and outside the studied companies. This approach to learn about prescribed work is complementary to earlier descriptions within activity analysis of what prescribed work comprises.

The gap between prescribed work (the formal side) and actual work (the practised side) could be considered as a knowledge lacuna within the studied organizations. The outcome of an activity analysis could here facilitate knowledge development by management or other stakeholders and serve as important input to organizational development, thus having a direct practical application. Related to the identification of the gap between prescribed work and actual work is the idea of distinguishing between what is expected work and what is not expected. As presented in this research, approximately one third of the studied work was non-expected as planning and scheduling work, but strongly related to the context in each company

and the schedulers' personal attributes. Some components of this work could have been presented during the interviews. The quantification, however, which was possible to make of the observation data, strongly supports any argument in favour of a change of the work content for the schedulers. The same applies to support argumentation for a change of the working conditions for the schedulers, by bringing forward the vast amount of interruptions and disturbances that occur in their daily work. These emerged strongly in the observation data and could also easily be illustrated in reports of the findings.

As described above, the data collection rendered extensive data. This was analyzed from different perspectives. There was interplay between analyses of empirical data and development of the theoretical framework. Here, the author's earlier research of white-collar work served as an important source of inspiration in the use of role theory to approach planning and scheduling work. The choice of theoretical framework was continually developed. Analysis of the data from any specific perspective often revealed an opportunity to examine the data from another viewpoint. One theoretical perspective that proved to embrace a broad range of issues that contributed to the outcome of the scheduling process was the system perspective of Humans, Technology and Organization (Rollenhagen, 1997; Westlander, 1999b). By taking the HTO components into account from the beginning of any study, it will render a multifaceted view of any specific work that is to be investigated. The HTO perspective may also be used as a tool for analysis of extensive data, a tool that will support the development of a comprehensive view of the work that is focused. In this research, the HTO analysis contributed to this comprehensive view, from which ideas for further analyses were developed.

As stated before, case studies are often criticized in that they provide little basis for scientific generalization (Yin, 1994). To deal with this issue, this research has sought to generalize the case study findings to some broader theory, that is analytical generalization (Yin, *ibid*). In this case, examples of theories used include role theory as well as theories about sources of power and the formal and informal side of the organization. Detailed descriptions of the specific cases were also sought to facilitate reader or user generalization, so that readers may draw their own conclusions about the possibility to generalize the findings presented in this thesis to other situations or cases (Wilson, 1979; Walker, 1980). Finally, the findings from the Swedish woodworking industry cases were generalized in cross-case analyses (Yin, 1994) with two cases carried out in other domains in Britain. Each case was first analyzed in its own right (Eisenhardt, 1989) in relation to theory and then evaluated cross-case. Through this, the findings were further validated to apply also to other domains.

This research was carried out within ergonomics and human factors, a discipline concerned with the interaction among humans and other elements of a system, here the work system of planners and schedulers, to support human well-being and overall system performance. Both human well-being and health have since long been focused in Sweden, while overall system performance has been added during later years. To gain thorough understanding of system performance, deep insights of the work content and in what context it is carried out is essential. As argued before, it is not the formal structure of an organization, number of tools or other supportive equipment that will generate the final outcome in performance. This is only achieved by understanding what takes place in practice, for instance what supportive tools or working methods which are actually integrated in daily work. In this respect, ergonomics and human factors may contribute with expert knowledge about working life issues, well established methods for how to understand work practice, and in designing work systems that support both human wellbeing and good system performance.



## 8 Conclusions, Contribution and Future Research

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*This final chapter consists of closing comments about this research. The conclusions are presented as well as its contribution to the prior body of knowledge. Finally, some avenues for future research are identified.*

### 8.1 Conclusions

This research was conducted with the overall objective of gaining further understanding of planners' and schedulers' work within the manufacturing industry, to elucidate how their work situation is formed, and explain their significance to other employees' work and activities in the company.

Regarding the *tasks, activities and roles* that are inherent in planning and scheduling work, the findings from the Swedish examples in the woodworking industry revealed that the schedulers' tasks lead to a number of activities. Two thirds of these activities are what can be expected as a result of the scheduling task. These activities include forecasting, planning, scheduling, dispatching, updating the information system and seeking information and overview. The remaining third constitutes activities that are dependent on the schedulers' individual attributes as well as the context in which they work. Context related conditions may emanate from the production process, the scheduling software system and its ability to provide sufficient data and control, or the need to deal with different logics in daily work. These activities vary from company to company and are generally not expected in scheduling work.

The planners and schedulers have *multifaceted roles*. This research showed how planners and schedulers in practice perform far more than assumed tasks such as optimizing through logical analyses and compensating for inadequacies in planning and scheduling systems. They also serve as problem solvers in a number of domains through their expert knowledge and constitute efficient information nodes, thereby supporting earlier research. In this respect, planning and scheduling work may be considered as an important *service function* in the studied companies. Furthermore, they

have an *alignment role* between different organizational groups. The alignment role is specifically remarkable in planners and schedulers dealing with production enquiries which need to be aligned with production capability.

This research shows that planners and schedulers play an essential role as a *link between the manufacturing and the commercial sides*. Some of their autonomous activities are performed within their own function. These autonomous activities include translating the enquiry information into a form that makes sense to people in the other functions, assessing the enquiry in relation to its feasibility, and transforming the response from production. The boundary activities are carried out at the interface towards the commercial side or manufacturing. These include clarifying the enquiry to manufacturing or the response to the commercial side, negotiating when necessary and problem solving where adjustments to the plan need to be analyzed and “best solutions” determined. For this, thorough knowledge about both manufacturing and the commercial side and their different logics is required. Through their possession of cross functional expertise, the planners and schedulers perform a trans-specialist role, acting as a representative for one area in contact with the other, filtering out what production enquiries should be passed on to manufacturing, and interpreting the real meaning of the enquiry from the commercial side into issues that are at stake in manufacturing and *vice versa*. The planners’ and schedulers’ alignment role between the manufacturing and the commercial sides shows that they need to manage both information and personnel relations with great skill.

Planners and schedulers in daily work exert *strong influence* on others in the manufacturing and commercial departments. This is done more or less consciously and is necessary to fulfil their work tasks. They do not hold legitimate power as expressed in the formal organization; instead individuals draw on a vast repertoire of reinforcing sources of power to influence others. Their influence emanates mainly from their access to and control of information and their ability to apply their expertise to interpret this information and examine the impact of decisions made across different areas of the business. Here, access to company agendas and influential arenas is essential. For the planners and schedulers, expert power was derived from being recognized for having the knowledge needed to understand the implications of decisions made and how to manage them. This was very different from having access to information and was firmly based on experience. Long service experience and associated knowledge provided planners and schedulers with expert power and strong legitimacy. It was also shown that personal power related to social skills is significant. These skills supported contacts with a wide range of groups within and outside the companies, contacts where the planners and schedulers needed

to pay attention to the different logics in the organization and adapt in order to fulfil their work tasks.

The findings in this thesis are evidence that *human contribution* in planning and scheduling is necessary to achieve set objectives in the companies. There is thus reason to question automation of planning and scheduling. The planners' and schedulers' work had a major impact on overall production capability in searching for alternative production solutions to obtain maximum production. In addition to that, the planners and schedulers contribute to business operations in bridging the gap between manufacturing and the commercial side. Especially in their handling production enquiries, they have an impact on company responsiveness. Furthermore, the schedulers could be regarded as facilitators in the HTO (Humans, Technology, Organization) system in each of the studied companies. They facilitate others' work in continuous personal interactions, they serve the technical scheduling software system, and they align different organizational functions.

This thesis argues that the facilitating work is performed by the schedulers *using tentacles*; tentacles that actively search for information, hints and possible solutions for a wide range of daily challenges and problems. These tentacles extend into different groups of operators in production and management. They are used in developing plans, schedules, and work orders in order to discern what is feasible with respect to the technical system, while at the same time showing social concern for people involved in the work system. These tentacles are necessary in dealing with a variety of logics, languages, and values that exist among different groups in the companies. These tentacles constitute a suitable tool to reach good understanding of what is at stake in each of these groups. In combination with expert knowledge and developed social skills, the planners and schedulers make a significant contribution to good operations performance. Furthermore, the schedulers influence the decision latitude of other employees and may indirectly promote job satisfaction, thus contributing to the development of appropriate *working conditions for others* in the company.

## 8.2 Research contribution

As stated earlier, this research supports earlier reported findings regarding the planners' and schedulers' work as problem solvers, information nodes and that their work is characterized by a high degree of uncertainty, fragmentation and a great deal of rework due to variability in real world environments. Further findings of this research add a complementary view to earlier studies in the research stream of human and organizational aspects in planning and scheduling. These contributions include:

- This research has contributed to a deeper understanding of planning and scheduling by proposing a method that in a structured way addressed the human aspects in planning and scheduling from a theoretical perspective. This perspective focuses on the distinction between task and activity as well as the formal versus informal side of the work. A further complement to earlier research is to regard the schedulers' roles from a theoretical perspective that focuses on expectations.
- The integration of the concept of expectation from role theory into activity analysis for analyzing and understanding the implicit part of the prescribed task was proposed and assessed as suitable in this study of schedulers' work.
- The need for planners and schedulers to understand marketing, sales and company strategies as well as production and in daily work handle incompatible goals has been mentioned in earlier research, but was here developed into a model of how this may take place at an operational level especially in the manufacturing and commercial interfaces.
- The informal power bases from which planners and schedulers commonly act were described, which has value both in research to understand the planning and scheduling processes in real world environments as well as in practical applications such as assessing the skills requirements of planners and schedulers or organizational design to achieve effective and responsive order fulfilment.
- The planners' and schedulers' role in aligning different actors and stakeholders in the organization was highlighted from a systems perspective including both human and organizational aspects. This alignment function has a significant influence on company performance.
- Finally, the interdependence between schedulers and others in the organization was highlighted including the schedulers' influence of others' working conditions, which has been scarcely reported in earlier research.

### **8.3 Future research**

During the course of this research some avenues for future research were identified, for which new studies are recommended:

- Further knowledge on how to support planners and schedulers in their dealing with uncertainty and gaining control may be retrieved by



focusing these issues from an HTO (Human, Technology, Organization) perspective.

- Follow-up studies of the schedulers' alignment role in an organizational design perspective may serve as a basis for improved decision-making and increased order responsiveness.
- Further research on the need and use of power bases used by planners and schedulers and the implications on how to deal with power asymmetries in the organization as well as selection and training of planners and schedulers.
- Research and development of planning and scheduling tools for better adaptation to the needs of the planners and schedulers.
- Further in-depth studies of the schedulers' influence on other employees' working conditions in terms of the schedulers' awareness of this influence and consequences of this influence.

To conclude, as the planners and schedulers strongly influence others' work and company performance, further research about planning and scheduling work in practice is needed. This research is essential to develop their roles and the organizational design, and to improve the planning and scheduling process. This new knowledge is furthermore important to improve the training of planners and schedulers.



## References

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- Arbnor, I. and Bjerke, B. (1997). Methodology for Creating Business Knowledge, 2<sup>nd</sup> ed., Thousand Oaks: Sage Publications
- Ashforth, B.E. and Mael, F. (1989). Social Identity Theory and the Organization, *Academy of Management Review*, 14(1), 20-39
- Bazet, I. (2002a). Le plan ou la prescription de l'engagement. In Actes du XXXVII<sup>ème</sup> Congrès de la Société d'Ergonomie de Langue Française, Aix-en-Provence, 161-166 (In French)
- Bazet, I. (2002b). Le travail de planification, Thèse de Doctorat de Sociologie, Université Toulouse Le Mirail (In French)
- Berglund, M. (1998). On White-Collar Work Close to Production, Licentiate Thesis, LiU-Tek-Lic-1998:53, Linköping University
- Berglund, M. (2000). Transfer of Production Planning and Scheduling from Staff to Production Personnel in a Complex Maintenance Company. In Proceedings of the XIV<sup>th</sup> Triennial Congress of the International Ergonomics Association and 44<sup>th</sup> Annual Meeting of the Human Factors and Ergonomics Society, Santa Monica: Human Factors and Ergonomics Society
- Berglund, M. and Karlton, J. (2000). Production planning and scheduling for whom? An analysis of two woodworking industries, CMTO Research Papers No. 2000:09, Linköping University
- Biddle, B.J. (1979). Role Theory. Expectations, Identities, and Behaviors, New York: Academic Press
- Bolman, L.G. and Deal, T.E. (1991). Reframing Organizations. Artistry, Choice and Leadership, San Francisco, CA: Jossey Bass
- Buxey, G. (1989). Production scheduling: Practice and theory, *European Journal of Operational Research*, 39, 17-31
- Carballeda, G. (1999). La contribution des ergonomes à l'analyse et à la transformation de l'organisation du travail: l'exemple d'une intervention relative à la maintenance dans une industrie de processus continu,

- Collection Thèses & Mémoires, Laboratoire d'Ergonomie des Systèmes Complexes, Université Victor Segalen Bordeaux 2 – ISPED (In French)
- Carlile, P.R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development, *Organization Science*, 13(4), 442-455
- Carlile, P.R. (2004), Transferring, translating, and transforming: an integrative framework for managing knowledge across boundaries, *Organization Science*, 15(5), 555-568
- Chaiklin, S. and Lave, J. (1993). Understanding practice. Perspectives on activity and context, Cambridge: Cambridge University Press
- Checkland, P. (1981). Systems Thinking. Systems Practice, Chichester: John Wiley & Sons
- Cheung, Y. and Bal, J. (1998). Process analysis techniques and tools for business improvements, *Business Process Management Journal*, 4(4), 274-290
- Churchman, C.W. (1968). The systems approach, New York: Dell Publishing Co., Inc.
- Clare, D.A. and Sanford, D.G. (1984). Cooperation and Conflict Between Industrial Sales and Production, *Industrial Marketing Management*, 13(3), 163-169
- Corlett, E.N. and Clark, C. (1995). The Ergonomics of Workspaces and Machines: A Design Manual (2<sup>nd</sup> ed.), London: Taylor and Francis
- Crawford, S. (2000). A field study of schedulers in industry: understanding their work, practices and performance, Ph.D. thesis, University of Nottingham
- Crawford, S., MacCarthy, B.L., Wilson, J.R. and Vernon, C. (1999). Investigating the work of industrial schedulers through field study, *Cognition, Technology & Work*, 1, 63-77
- Crawford, S. and Wiers, V.C.S. (2001). From Anecdotes to Theory: A Review of Existing Knowledge on Human Factors of Planning and Scheduling. In B.L. MacCarthy and J.R. Wilson (Eds.), Human Performance in Planning and Scheduling, London: Taylor & Francis, 15-43
- Crittenden, V.L. (1992). Close the marketing/manufacturing gap, *Sloan Management Review*, Spring, 41-52
- Crittenden, V.L., Gardiner, L.R. and Stam, A. (1993). Reducing Conflict between Marketing and Manufacturing, *Industrial Marketing Management*, 22, 299-309

- Cronbach, L.J. (1975). Beyond the two disciplines of scientific psychology, *American Psychologist*, 30, 116-127
- Dabhikar, M. (2005). Mot hållbara produktionsystem! In L. Bengtsson, C. Berggren and J. Lind (Eds.), *Alternativ till outsourcing* (Eng: Alternative to outsourcing), Malmö: Liber AB, 71-84 (In Swedish)
- Daniellou, F. (1998). Seminar on activity analysis, Linköping University, Linköping, Sweden, February 23-25
- Daniellou, F. (2001). Epistemological issues about ergonomics and human factors. In *International Encyclopedia of Ergonomics and Human Factors* Vol. 2, London and New York: Taylor & Francis, 43-46
- Daniellou, F. (2005). The French-speaking ergonomists' approach to work activity: cross-influences of field intervention and conceptual models, *Theoretical Issues in Ergonomics Science*, 6(5), 409-427
- Daniellou, F. and Rabardel, P. (2005). Activity-oriented approaches to ergonomics: some traditions and communities, *Theoretical Issues in Ergonomics Science*, 6(5), 353-357
- Davenport, T.H. (1998). Putting the Enterprise into the Enterprise System, *Harvard Business Review*, 76(4), 121-133
- De Keyser, V. (1991). Work analysis in French language ergonomics: Origins and current research trends, *Ergonomics*, 34, 653-669
- Denzin, N.K. (1978). The research act: A theoretical introduction to sociological methods (2<sup>nd</sup> ed.), New York: McGraw-Hill
- Eisenhardt, K.M. (1989). Building theories from case study research, *Academy of Management Review*, 14(4), 532-550
- Eklund, J. (2003). An extended framework for humans, technology and organization in interaction, *Proceedings of Human Factors in Organizational Design and Management – VII*, 47-54
- Engeström, Y. (1990). Learning, working and imagining. Twelve studies in activity theory, Helsinki: Orienta-Konsultit Oy
- Etzioni, A. (1966). Moderna organisationer. Stockholm: Aldus (In Swedish)
- Falzon, P. (1997). La construction des connaissances en ergonomie: éléments d'épistémologie. In *Recherche Pratique Formation en Ergonomie. Evolutions et interactions dans le context social, économique et technique*, Actes du XXXII<sup>ème</sup> Congrès de la Société d'Ergonomie de Langue Française, Lyon, 641-654 (In French)
- Falzon, P. (2004). Nature, objectifs et connaissances de l'ergonomie. In P. Falzon (Ed.), *Ergonomie*, Paris: Presses universitaires de France (In French)

- Fielding, N. and Fielding, J. (1986). *Linking Data*, Beverly Hills: Sage Publications, Inc.
- Forslin, J. (1990). Produktionsteknik och arbetsmiljö. In L. Lennerlöf (Ed.) *Människan i arbetslivet*, Chapter 8, Stockholm: Allmänna Förlaget (In Swedish)
- Fransoo, J.C. and Wiers, V.C.S (2008). An empirical investigation of the neglect of MRP information by production planners, *Production Planning & Control*, 19(8), 781-787
- French, J.R.P. Jr., and Raven, B.H. (1959). The bases of social power. In D. Cartwright (Ed.), *Studies in social power*, Ann Arbor, MI: Institute for Social Research, 150-167
- Glaser, B. and Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*, New York: Aldine Publishing Company
- Gonzalez, M.E., Quesada, G., Mueller, R. and Mora-Monge, C.A. (2004). QFD strategy house: an innovative tool for linking marketing and manufacturing strategies, *Marketing Intelligence & Planning*, 22(3), 335-348
- Guba, E.G. and Lincoln, Y.S. (1981). *Effective Evaluation*, San Fransisco: Jossey-Bass Inc., Publishers
- Guérin, F., Laville, A., Daniellou, F., Duraffourg, J. and Kerguelen, A. (2007). *Understanding and transforming work. The practice of ergonomics*, Lyon: ANACT
- Guinery, J. (2006). *Knowledge integration in production planning, scheduling and control*, Ph.D. thesis, Nottingham University
- Gunasekaran, A., Tirtiroglu, E. and Wolstencraft, W. (2002). Gap between production and marketing functions: a case study, *Management Decision*, 40(5), 428-435
- Hackman, J. R. and Oldham, G. R. (1980). *Work Redesign*, Reading: Addison Wesley
- Handy, C.B. (1993). *Understanding organisations*, 3<sup>rd</sup> ed., Harmondsworth: Penguin Business Library
- HFES (1995-2009). HFES (Human Factors and Ergonomics Society), [www.hfes.org](http://www.hfes.org), retrieved 26-01-2009
- Higgins, P. (1996). Interaction in hybrid intelligent scheduling, *International Journal of Human Factors in Manufacturing*, 6(3), 185-203
- Higgins, P. (2001). Architecture and interface aspects of scheduling decision support. In B.L. MacCarthy and J.R. Wilson (Eds.), *Human*

- performance in planning and scheduling, London: Taylor & Francis, 245-281
- Hill T. (1997). Manufacturing strategy - keeping it relevant by addressing the needs of the market, *Integrated Manufacturing Systems*, 8(5), 257-264
- Hill, T. (2005). Operations Management (2<sup>nd</sup> ed.), Basingstoke: Palgrave Macmillan
- IEA (2000). IEA (International Ergonomics Association), [www.iea.cc](http://www.iea.cc), retrieved 26-01-2009
- Jackson, S., Wilson, J.R. and MacCarthy, B.L. (2004). A new model of scheduling in manufacturing: tasks, roles, and monitoring, *Human Factors*, 46(3), 533-550
- Jacobsson Kecklund, L., Edland, A., Wedin, P. and Svenson, O. (1996). Safety barrier function analysis in a process industry: A nuclear power application, *International Journal of Industrial Ergonomics*, 17, 275-284
- Kalpic, B. and Bernus, P. (2002). Business process modelling in industry – the powerful tool in enterprise management, *Computers in Industry*, 47, 299-318
- Karasek, R. A. (1979). Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign, *Administrative Science Quarterly*, 24(2), 285-308
- Karlton, J. (2007). On Stage. Acting for development of businesses and ergonomics in woodworking SMEs, Dissertation No. 1123, Linköping University
- Karlton, J. and Berglund, M. (2002). Production scheduling in practice – a study of managing goal conflicts. In Proceedings of the 9<sup>th</sup> International Conference European Operations Management Association, Copenhagen, Denmark
- Katz, D. and Kahn, R. (1978). The social psychology of organizations, New York: John Wiley & Sons
- Kirwan, B. and Ainsworth, L.K. (1992). A guide to task analysis, London: Taylor & Francis
- Klein, L. (1994). Sociotechnical/organizational design. In W. Karwowski and G. Salvendy (Eds.), *Organization and Management of Advanced Manufacturing*, New York: John Wiley & Sons
- Klein Associates (1989). Naturalistic Decision Making (NDM) Workshop organized by Klein Associates, Dayton, OH, USA, September 25-27
- Konijnendijk, P.A. (1993). Dependence and conflict between production and sales, *Industrial Marketing Management*, 22(3), 161-167

- Lawrence and Lorsch (1967). *Organization and environment: managing differentiation and integration*, Boston: Harvard Business School Press
- Leplat, J. (1990). Relations between task and activity: elements for elaborating a framework for error analysis. *Ergonomics*, 33 (10/11), 1389-1402
- Leplat, J. (1992). L'analyse psychologique du travail. In J. Leplat (Ed.) *L'analyse du travail en psychologie ergonomique*, Toulouse: OCTARES Éditions, 23-39 (In French)
- Leplat, J. and Hoc, J.-M. (1992). Tâche et activité dans l'analyse psychologique des situations. In J. Leplat (Ed.) *L'analyse du travail en psychologie ergonomique*, Toulouse: OCTARES Éditions, 47-59 (In French)
- Lompré, N. and de Terssac, G. (1995). Pratiques organisationnelles dans les ensembles productifs: essai d'interprétation. In *Ergonomie et production industrielle. L'homme dans les nouvelles organisations*, Actes du XXXe Congrès de la Société d'Ergonomie de Langue Française, Biarritz, 253-262 (In French)
- MacCarthy, B.L. (2006). Organisational, systems and human issues in planning, scheduling and control. In J. Herrmann (Ed.) *Handbook of Production Scheduling*, International Series in Operations Research and Management Science, New York: Springer publications, 59-90
- MacCarthy, B.L. and Liu, J. (1993). Addressing the gap in scheduling research: a review of optimization and heuristic methods in production scheduling, *International Journal of Production Research*, 31(1), 59-79
- MacCarthy, B.L. and Wilson, J.R. (2001). *Human performance in planning and scheduling*, London: Taylor & Francis
- MacCarthy, B.L., Wilson, J.R. and Crawford, S. (2001). Human performance in industrial scheduling: a framework for understanding, *Human Factors and Ergonomics in Manufacturing*, 11(4), 299-320
- Magne Holme, I. and Krohn Solvang, B. (1991). *Forskningsmetodik. Om kvalitativa och kvantitativa metoder*, Lund: Studentlitteratur (In Swedish)
- McKay, K.N. and Black, G.W. (2007). The evolution of a production planning system: A 10-year case study, *Computers in Industry*, 58, 756-771
- McKay, K.N., Buzacott, J.A. and Safayeni, F.R. (1989). The scheduler's knowledge of uncertainty: the missing link. In J. Browne (Ed.) *Knowledge Based Production Management Systems*, New York: Elsevier Science, 171-189



- McKay, K.N., Buzacott, J.A., Charness, N. and Safayeni, F.R. (1992). The scheduler's predictive expertise: An interdisciplinary perspective. In G.I. Doudikis and R.J. Paul (Eds.), *Artificial intelligence in operational research*, Basingstoke: Macmillan, 139-150
- McKay, K.N. and Wiers, V.C.S. (1999). Unifying the theory and practice of scheduling, *Journal of Manufacturing Systems*, 18(4), 241-255
- McKay, K.N. and Wiers, V.C.S. (2001). Decision Support for Production Scheduling Tasks in Shops with Much Uncertainty and Little Autonomous Flexibility. In B.L. MacCarthy and J.R. Wilson (Eds.) *Human Performance in Planning and Scheduling*, London: Taylor & Francis, 165-177
- McKay, K.N. and Wiers, V.C.S. (2003). Planning, scheduling and dispatching tasks in production control, *Cognition, Technology & Work*, 5, 82-93
- Meredith, J. (1998). Building operations management theory through case and field research, *Journal of Operations Management*, 16(4), 439-452
- Merriam, S.B. (1988). *Case Study Research in Education. A Qualitative Approach*, San Francisco: Jossey-Bass Inc., Publishers
- Mintzberg, H. (1983). *Power In and Around Organization*, Englewood Cliffs, NJ: Prentice-Hall
- Monk, E. and Wagner, B. (2008). *Concepts in enterprise resource planning* (3<sup>rd</sup> ed.), Boston: Course Technology Cengage Learning
- Mourani, I., Hennequin, S. and Xie, X. (2008). Simulation-based optimization of a single-stage failure-prone manufacturing system with transportation delay, *International Journal of Production Economics*, 112, 26-36
- Mukhopadhyay, S.K. and Gupta, A.V. (1998). Interfaces for resolving marketing, manufacturing and design conflicts, *European Journal of Marketing*, 32(1/2), 101-124
- Murrell, K.F.H. (1965). *Ergonomics – Man in his working environment*, London: Chapman and Hall
- Nakamura, N. and Salvendy, G. (1994). Human planner and scheduler. In G. Salvendy and W. Karwowski (Eds.), *Design of work and development of personnel in advanced manufacturing*, New York: John Wiley & Sons, 331-354
- Nilsson, T. (1992). *White-collar Employees Close to the Production Process. Companies and Work in Transition*, Swedish Union of Clerical and Technical Employees in Industry (SIF), Stockholm

- Norros, L. (2004). Acting under uncertainty. The core-task analysis in ecological study of work, VTT Publications 546, Espoo: Otamedia Oy
- O'Leary-Kelly, S.W. and Flores, B.E. (2002). The integration of manufacturing and marketing/sales decisions: impact on organizational performance, *Journal of Operations Management*, 20(3), 221-240
- Olhager, J. (2000). Produktionsekonomi, Lund: Studentlitteratur (In Swedish)
- Ombredane, A. (1955). Introduction. In A. Ombredane and J.-M. Faverge (Eds.), *L'analyse du travail*, Paris: PUF, 1-18. Reprinted in Leplat, J. (1992). *L'analyse du Travail en Psychologie Ergonomique*, Toulouse: Octares Editions (In French)
- Ould, M.A. (1995). Business Processes – Modelling and Analysis for Reengineering and Improvement, New York: John Wiley & Sons
- Parente, D. H. (1998). Across the manufacturing-marketing interface. Classification of significant research, *International Journal of Operations & Production Management*, 18, 1205-1222
- Pasmore, W. (1988). Designing effective organizations: the sociotechnical perspective, New York: Wiley
- Patel, R. and Tebelius, U. (1987). Grundbok i forskningsmetodik, Lund: Studentlitteratur (In Swedish)
- Patton, M.Q. (1980). Qualitative Evaluation Methods, Beverly Hills: Sage Publications Inc.
- Patton, M.Q. (1990). Qualitative Evaluation and Research Methods (2<sup>nd</sup> ed.), Newbury Park: Sage
- Pfeffer, J. (1981). Power in organizations, Cambridge, MA: Ballinger
- Porras, J.I. and Robertson, P.J. (1992). Organizational development: theory, practice and research. In M.D. Dunette and L.M. Hough (Eds.), *Handbook of Industrial and Organizational Psychology*, Volume 3 (2<sup>nd</sup> ed.) Palo Alto: Consulting Psychologists Press, 719-822
- Postrel, S. (2002). Islands of shared knowledge: specialization and mutual understanding in problem-solving teams, *Organization Science*, 14(3), 303-320
- Rasmussen, J. (1994). Taxonomy for work analysis. In G. Salvendy and W. Karwowski (Eds.), *Design of work and development of personnel in advanced manufacturing*, New York: John Wiley and Sons
- Rollenhagen, C. (1997). MTO – en introduktion, Sambandet Människa, Teknik och Organization, Lund: Studentlitteratur (In Swedish)

- Rollenhagen, C. (2003). Att utreda olycksfall, Teori och praktik, Lund: Studentlitteratur (In Swedish)
- Sanderson, P.M. (1991). Towards the model human scheduler, *International Journal of Human Factors in Engineering*, 1, 195-219
- Scherer, E. (1998). The Reality of Shop Floor Control – Approaches to Systems Innovation. In E. Scherer (Ed.), Shop Floor control – From Deterministic Models towards Agile Operations Management, Berlin: Springer Verlag, 3-26
- Shapiro, B.P. (1977). Can marketing and manufacturing coexist?, *Harvard Business Review*, September-October, 104-114
- Shepherd, A. and Stammers, R.B. (2005). Task analysis. In J.R. Wilson and N. Corlett (Eds.), Evaluation of human work (3<sup>rd</sup> ed.), Boca Raton: Taylor & Francis, 129-157
- Skinner, W. (1969). Manufacturing - missing link in corporate strategy, *Harvard Business Review*, May-June, 136-145
- Slack, N. and Lewis, M. (2002). Operations Strategy, London: Prentice Hall
- Spencer, M. and Cox, J.F. (1994). Sales and manufacturing coordination in repetitive manufacturing: Characteristics and problems, *International Journal of Production Economics*, 37(1), 73-81
- Stake R.E. (1978). The case study method in social inquiry, *Educational Researcher*, 7, 5-8
- Starrin, B., Larsson, G., Dahlgren, L. and Styrborn, S. (1991). Från upptäckt till presentation, Lund: Studentlitteratur (In Swedish)
- Stoop, P.M. and Wiers, V.C.S. (1996). The complexity of scheduling in practice, *International Journal of Operations and Production Management*, 16(10), 37-53
- Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R. and Samson, D. (2002). Effective case research in operations management: a process perspective, *Journal of Operations Management*, 20, 419-433
- Suchman, L. (1987). Plans and situated actions. The problem of human machine communication, Cambridge: Cambridge University Press
- Swamidass, P.M., Baines, T. and Darlow, N. (2001). The role of manufacturing and marketing managers in strategy development, *International Journal of Operations and Production Management*, 21(7), 933-948
- Swedish Standard (1983). SS 01 82 10, Ergonomic principles in the design of work systems

- Terssac, G. de and Lompré, N. (1995). Pratiques organisationnelles dans les ensembles productifs, essai d'interprétation. In J.C. Sperandio (Ed.), *L'ergonomie face aux changements technologiques et organisationnels du travail humain*, Toulouse: Octarès Editions, 51-66 (In French)
- Terssac, G. de, Lompré, N., Erschler, J. and Huguet, M.J. (1993). La renégociation des contraintes, Presentation at Ergonomie – CARS, Toulouse 18-19 Nov. 1993 (In French)
- Thorsrud, E. and Emery, F. E. (1970). Mot en ny Bedriftsorganisasjon - Eksperimenter i industrielt demokrati, Oslo: Tanum Forlag (In Norwegian)
- Vicente, K. (1999). *Cognitive Work Analysis. Toward Safe, Productive, and Healthy Computer-Based Work*, Mahwah: Lawrence Erlbaum Associates, Publishers
- Vollman, T.E., Berry, W.L. and Whybark, D.C. (1997). *Manufacturing planning and control systems* (4<sup>th</sup> ed.), New York: McGraw-Hill
- Vollman, T.E., Berry, W.L., Whybark, D.C. and Jacobs, F.R. (2005). *Manufacturing planning & control for supply chain management* (5<sup>th</sup> ed.), New York: McGraw-Hill
- Voss, C., Tsakriktsis, N. and Frohlich, M. (2002). Case research in operations management, *International Journal of Operations and Production Management*, 22, 195-219
- von Bertalanffy, L. (1968). *General system theory. Foundations, development, applications*, New York: George Braziller
- Walker, R. (1980). The conduct of educational case studies: Ethics, theory and procedures. In W.B. Dockerrell and D. Hamilton (Eds.), *Rethinking educational research*, London: Hodder & Stoughton
- Wallén, K. (1996). *Vetenskapsteori och forskningsmetodik*, Lund: Studentlitteratur (In Swedish)
- Wang, H.-F. and Wu, K.-Y. (2003). Modeling and analysis for multi-period, multi-product and multi-resource production scheduling, *Journal of Intelligent Manufacturing*, 14(3-4), 297-309
- Westlander, G. (1999a). *People at Work. Investigating social-psychological contexts*, Lund: Studentlitteratur
- Westlander, G. (1999b). Fokus på människan i forskning om verksamhetsutveckling. In J. Ahlin (Ed.), *Forskningsperspektiven*, NUTEK, 20-33 (In Swedish)
- Whybark, D.C. (1994). Marketing's influence on manufacturing practices, *International Journal of Production Economics*, 37(1), 41-50

- Wiers, V.C.S. (1996). A quantitative field study of the decision behavior of four shop floor schedulers, *Production Planning & Control*, 7, 383-392
- Wiers, V.C.S. (1997a). A review of the applicability of OR and AI Scheduling Techniques in Practice, *OMEGA – International Journal of Management Science*, 25(2), 145-153
- Wiers, V.C.S. (1997b). Human-Computer Interaction in Production Scheduling: Analysis and Design of Decision Support Systems for Production Scheduling Tasks, PhD thesis, Eindhoven University of Technology
- Wiers, V.C.S. and van der Schaaf, T.W. (1997). A framework for decision support in production scheduling tasks, *Production Planning & Control*, 8(6), 533-544
- Wilson, J.R. (2005). Methods in the understanding of human factors. In J.R. Wilson and N. Corlett (Eds.), *Evaluation of human work* (3<sup>rd</sup> ed.), Boca Raton: Taylor & Francis, 1-31
- Wilson, J.R. and Morrisroe, G. (2005). Systems analysis and design. In J.R. Wilson and N. Corlett (Eds.), *Evaluation of human work*, (3<sup>rd</sup> ed.), Boca Raton: Taylor & Francis, 240-279
- Wilson, S. (1979). Explorations of the usefulness of case study evaluations, *Evaluation Quarterly*, 3(3), 446-459
- Wäfler, T. (2001). Planning and scheduling in secondary work systems. In B.L. MacCarthy and J.R. Wilson (Eds.), *Human Performance in Planning and Scheduling*, London: Taylor & Francis, 411-447
- Yin, R.K. (1994). *Case Study Research Design and Methods*, Applied Social Research Methods Series Volume 5 (2<sup>nd</sup> ed.), London: Sage publications



## Observation Protocol

Observation protocol, planning and scheduling work

[illegible]

S = disturbance, B = decision made, P = planned, E = own initiative, A = other's initiative





## **Interview Guide**

Follow-up questions to people, whom in the observations were identified as having close contact with the scheduler

1. Describe what you regard as good production planning and scheduling.
2. What expectations do you have on the scheduler's work?
3. In what way are you influenced by the scheduler's work? (relationship, dependency)
4. In what way do you influence the scheduler's work? (relationship, dependency)
5. How do you perceive that the production scheduling is performed at your company? (assessment and reason)
6. What possibilities for improvements are there? Further comments?