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IT Support for Flight Technicians:

An Exploratory Study

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Abstract

This paper reports an interpretive case study conducted at three different airports in Sweden and Norway during 1999. The focus of the study has been to establish an understanding of the work practice of flight technicians and the use of IT support tools for aircraft maintenance. By use of observations, interviews and document reviews, we found three main issues. First, there is a gap between the education of flight technicians and their production work. Second, flight maintenance is time critical, which makes on-site educational efforts difficult. Third, the diversity of computer systems used by flight technicians hinder efficient and productive maintenance, as well as restrain a recent trend towards mobility of IT support tools.

Keywords: Aircraft Maintenance, IT-support, Interpretive Case Study

Introduction

Maintenance has always been a matter of great importance in several areas. This is especially true within a commercial airline, where aircraft maintenance constitutes a large, costly, crucial and hence highly important part of the daily activities. Every time an aircraft arrives at an airport, it requires attention from a host of service personnel. Apart from loading and unloading cargo and fuelling the craft for the next take-off, a skilled and authorized flight technician needs to declare the craft airworthy for the departure. In addition to these constant go/no-go decisions and other minor daily checks, all craft are maintained in a more thorough way on a regular basis. In general, these extensive checks are carried out at the specific airline's key airport, were craft are maintained in a hangar setting for several days and even weeks. All aircraft maintenance work involves complex trouble-shooting and profound knowledge about the many specialized systems that are in use in aircraft of different types.

All maintenance work on aircraft must be carried out by authorized and certified flight technicians. The work performed is essential to the flight industry since the daily operation is highly dependent on airworthy aircraft. Obviously, this makes the technicians an important part of a commercial airline, and hence their work is a key factor to the entire flight industry.

Many of today's organizations use IT to support their employers' work related activities. This is also the case within the flight industry were IT is used widely to support work in general and the work of the flight technicians in particular. Today, for instance, all aircraft manuals are stored on CD-ROMs, and a considerable part of the advanced training systems that are used for training the technicians are computer-based. Hence, IT-

support seems important for the flight industry and has already been implemented and put to use in many different areas for different purposes.

In addition to the already mentioned digital manuals and the numerous computer-based training systems already present within aircraft maintenance, we believe that there are other ways in which IT can be used to support the flight technicians. Hence, the purpose of this paper is to investigate if IT-support could also be used:

- for educational purposes at each flight technician's own regional airport, and
- as a mobile device used for maintenance on-site and on time.

To do so, we need to identify issues, problems and obstacles as well as possible windows of opportunities for a successful development and implementation of such IT-support in the day-to-day work of the flight technicians within a specific organization, which is also the main scope of the paper. In order to develop such IT-supports, we believe it is of great importance to form a thorough comprehension of the work practice in which the flight technicians operate and to understand the every-day activities they are engaged in (Suchman, 1987; Star & Strauss, 1999; Strauss, 1993). Their situation and their actions must be studied carefully in order to develop appropriate and well-suited IT-support. Consequently, it is of great importance to be familiar with the work carried out at different airports and to try to develop an understanding of the work practice in which flight maintenance takes place.

The aim of this paper is to try to give an understanding of the work carried out by flight technicians at Alvik, Arlanda and Gardermoen Airport. It describes the work practice carried out during both day- and nightshifts at these three very different airports. The empirical material presented here becomes a prerequisite for further discussion about advanced training of flight technicians and the possibilities to distribute parts of that training to the regional airports. It also fundamental for further discussions about how IT can support flight technicians doing actual maintenance work on different aircraft.

Research method

This study has been carried out at Scandinavian Airlines System, SAS, which is a consortium consisting of the three national airlines, SAS Danmark A/S, SAS Norge ASA and SAS Sverige AB. The business concept is to offer the Scandinavian market a broad and profitable range of airline based services, focusing particularly on business travel. Today, SAS is able—through co-operation with Star Alliance, regional partners and British Midland, Spanair and airBaltic, all three of which are partly owned by SAS—to offer more than 8,000 departures daily to over 800 destinations in 114 countries. During 1998, SAS flew 21.7 million passengers to 101 destinations in 31 countries. The same year SAS had more than 1,000 daily departures and the average number of employees was 27,071. Today, the SAS fleet consists of 177 aircraft of which the MD80s are the most common.

Interpretive Case Study

The study can be classified as an interpretive case study (Klein & Meyers, 1999; Walsham, 1995; Orlikowski & Baroudi, 1989) in which the work practice of the flight technicians at SAS has been thoroughly observed and analyzed. The observations cover the work practice at three different airports—Alvik, Arlanda and Gardermoen—in order

to reflect similarities as well as differences in the work practice of flight technicians. This means that our field study describes the situation and current practice at three different sites within the same organization.

Our observations were carried out as participant observations, which helped us in our understanding of the very complex work setting of flight technicians. As observers we aimed at getting an inside view of the work by being a temporary member of the field for a shorter period of time (Walsham, 1995; Van Maanen, 1979). These observed field data in combination with semi-structured interviews worked as our primary source of information. In the interviews, we discussed topics and questions that had arisen in earlier observations. As a complement to observations and interviews with the technicians, we also used documentation as a source of information. The types of documents used were primarily the Maintenance Operations Manual (MOM), and other documents regarding the education system of flight technicians. We also read technical manuals to get an understanding of the nature of the manuals that are in use. Besides this documentation, we were also introduced to administrative documentation. These different sources of information gave an understanding of the way in which the technicians work in the offices as well as in the field.

As participant observers, we took notes during all observations and also continually asked questions and discussed different topics. Since the work carried out by the technicians is of a complex nature, one of them was also asked to "think aloud" while working on an aircraft. Our notes were then analyzed and used as input in later interviews. The interviews and project meetings were all tape-recorded so that they could be discussed and analyzed in the further work. These recordings provide a full description of what was said and through analyzing the discussions, we were able to access the interpretations that the technicians had regarding their work and their situation (Walsham, 1995).

Research Sites

In order to cover the work practice in an organization as big as SAS we found it important to conduct our observations at different sites. This approach would give an understanding of both similarities and differences and because of that generate results that can be applied in all parts of the organization. As mentioned in the introduction, SAS is a consortium consisting of three national airlines. The head quarters of the company are placed in Stockholm, Oslo and Copenhagen and this is where most of the activities take place and where most of the SAS staff is employed. Besides these larger airports, there are many regional airports in all of the three countries. In Sweden, regional airports can be found in for example Umeå, Kristianstad, Luleå and Malmö.

With the aim to cover the work practice of the flight technicians at SAS, we chose to perform our observations at three different sites within the organization. This would give an understanding of the work in different countries as well as the work practice at airports of different size in Sweden. In Sweden, we initially studied the technicians at Alvik Airport in Umeå. Alvik is one regional airport where seven flight technicians work and were mainly domestic flights arrive and depart. In order to reflect upon differences and similarities between the one smaller regional airport and a bigger one, we chose to continue our studies at Arlanda Airport in Stockholm. Arlanda is the largest airport in Sweden and seemed a natural place to conduct this study since many flight technicians both work and are educated there. The SAS headquarters are also situated at Arlanda, a fact that further strengthened our reasons for choosing the airport as one object to study.

Finally, we chose Gardermoen Airport in Oslo since it is a key airport as well, but situated in another country.

By studying a mixture of airports with different characteristics, we are convinced that the study will generate relevant results for technicians at both regional and international airports. We were also able to use our initial understandings from the study at Alvik as input to further observations at Arlanda and Gardermoen. Initially, much of our work was concerned with understanding the work practice of the flight technicians at a general level. At Alvik we studied the type of work carried out, in what way the technicians used the manuals and how the work was documented. As the study went on, the gained knowledge could be used in order to question the routines and maintenance work in a more detailed way. In this way, we moved from an initial understanding at a general level to a more detailed knowledge in which the work of the technicians was more critically examined.

By way of introduction, observations were carried out at Alvik Airport in Umeå. We followed, questioned and observed the work carried out by two of the seven flight technicians that run the everyday work of controlling and maintaining the SAS aircraft fleet in Umeå. Flight technicians at Alvik Airport work in twelve-hour shifts and always unaccompanied which makes their situation exceptional since they must be able to handle all work in connection with the craft as well as administrative efforts and the documentation work. Their only contact with other technicians is by using phone or fax.

We made participatory observations that were followed by semi-structured interviews with the technicians studied. During the interviews which lasted for about one hour, different topics and questions that had arisen during our earlier observations were discussed. Since the technicians at Alvik always work alone they have an equal competence. All of them must be able to handle every routine in relation to the craft as well as all administrative routines in the office in relation to documentation. Due to this situation, we could have chosen any of the flight technicians for an interview, but we chose the technicians earlier observed in work since we already had established very good contact with them and because of their knowledge about our work and us.

At Arlanda Airport, the situation is different in many ways compared to that of Alvik. Arlanda is the prime airport in Sweden and the place where most of SAS activities take place. All craft in need of heavy maintenance are sent to Arlanda, and since the airport is frequently operated by many foreign companies it is a continuous activity and maintenance work is carried out at several aircraft at the same time. This implies that the technicians at Arlanda work in teams and that technicians with different skills work together in order to maintain as many aircraft types as possible. The technicians are either working in the hangar with heavy maintenance work, or at the airport were minor controls are made before take off, as in Umeå. The technicians in one of the hangars at Arlanda were studied during the intensive hours in the morning. A lot of coordination work was carried out and heavy maintenance took place in order to get craft from Sweden and Denmark airworthy. The technicians working at the airport were also studied during a shorter visit. In all, the technicians at Arlanda have been studied for 6 hours, and two shorter visits have been made in order to ask questions and discuss their work practice. We also made interviews with two technicians in a leading position. These interviews helped us in our understanding of the hierarchy of the technicians at Arlanda and how the maintenance work is organized at the biggest airport in Sweden. Except for the observations and the visits in connection with the interviews, we also visited Arlanda twice for shorter project meetings. These meetings were held at SAS Flight Academy in Stockholm, the head quarter of all maintenance training and where the advanced training

of flight technicians is situated. At these occasions, we met the director of all maintenance training and some of the instructors that work with advanced education for flight technicians.

At Oslo's pristine airport Gardermoen, work is also very different from that of Alvik Airport. Akin to Arlanda, Gardermoen is one of SAS key airports which means that craft are not only declared airworthy or not, but also served, checked and repaired on a regular basis. This means that work is conceptually separated into two categories, one that resembles work at Alvik Airport, where craft are received, checked, fuelled and sent off, and one that deals with both unexpected heavy repair work as well as planned activities such as pre-scheduled checks and aircraft component checks and repair.

During this session, we focused on work in two locations – Heavy Maintenance and Traffic Related Maintenance – which both belong in the latter of the categories mentioned above. Work was followed during two days, in all approximately 14 hours divided equally between the two days. During the observational studies, notes were taken and the studied technicians were questioned extensively about the activities in which they were involved. In addition, when working on a task, each technician observed was asked to 'think aloud', i.e. to explicitly state each of the actions that he carried out. This allowed for a detailed understanding of some aspects of the kind of work that took place, where the problem areas usually occurred and the technicians' different strategies for solving them. We found this strategy especially well suited in order to grasp the use of different computer systems that constitute important tools for flight technicians in order for them to carry out their work, at the same time as we found that poor design, diversity among the applications and their lack of mobility seems to hinder the activities that most flight technicians regard as their work practice.

During the session at Gardermoen in Oslo, we also conducted semi-structured interviews with the director of maintenance training in Oslo, with two members of the computer support personnel at Gardermoen Technical Base and with one representing SAS Data, the division within SAS that deals with issues of computing. The length of these interviews ranged from about one to two hours each.

Research design

In order to get an understanding of the typical work of a flight technician, our exploration of the flight technicians work environment has been carried out as an interpretive case study (Klein & Meyers, 1999; Walsham, 1995). The aim has been to focus on the unique characteristics of the work situation of flight technicians at Alvik, Arlanda and Gardermoen Airport. To allow for such understanding, we make use of three sources of empirical data. First, to grasp the work practice, the complexity of the setting in which the flight technicians work and the role of IT support used, we carried out participant observations at all the three research sites. Discussions that took place during the observations, as well as comments, impressions and presumed or apparent work practices were documented by note taking. Second, we made several interviews and engaged in a number of project meetings that were all recorded for further reviewing, discussion and analysis. Third, to allow for an understanding of the hierarchy within the organization, the numerous regulations that each flight technician has to understand and work routines as suggested by the book, we have reviewed a substantial amount of documentation. Some of the document review took place at the actual research sites, while we copied most material for more thorough analysis off site. A summary of the different data sources is found in figure 1.

We believe that the triangular form the data sources yield gives us a better chance of perceiving the actual work practice of the flight technicians. For instance, the observations allow us to perceive a) if work is carried out in the way SAS prescribes in the documentation, and b) if work is carried out in the way the flight technicians themselves state during the interviews. The documentation allows us to understand some parts of the work practice, e.g. the complex pattern of regulations as well as the hierarchy within the maintenance organization, which is obvious from neither the interviews nor the observations. The interviews allow for detailed explanations of the work routines and opinions about the work being carried out from the perspective of the individual flight technician, a perspective missing both in the formal documentation and to some extent also missing in the observations where focus is more on the activity of work itself than on the individual.

Figure 1. A summary of the different data sources used during the study

	Site 1 Alvik Airport	Site 2 Arlanda Airport	Site 2 Gardermoen Airport	Off site
Participant observation				
Quantity (days)	3	2	2	—
Length (total, in hours)	32	6	14	—
Interviews				
Quantity	2	4	3	—
Length (total, in hours)	3	6	5	—
Documentation review				
Extensive reviewing	Yes	Yes	—	Yes
Minor reviewing	—	—	Yes	—
Project meetings				
Quantity	1	2	—	—
Length (hours, total)	1	10	—	—

At research site 1, Alvik Airport, we made participatory observations for 32 hours, which were followed by semi-structured interviews with the technicians studied. During the interviews, which lasted for about one hour, different topics and questions that arose during our earlier observations were discussed.

At research site 2, Arlanda, the technicians have been studied for 6 hours. Two shorter visits have been made in order to ask questions, perceive and discuss their work practice. We also made interviews with two technicians in leading positions. These interviews helped us in our understanding of the hierarchy of the technicians at Arlanda and how the maintenance work is organized at the largest airport in Sweden. Except for the observations and the visits in connection with the interviews, we have also visited Arlanda twice for shorter project meetings, which were held at SAS Flight Academy in Stockholm. Here we met the director of SAS Maintenance Training as well as some of the instructors that work with advanced education of flight technicians.

At research site 3, Gardermoen Airport, we focused on work practice in two locations with a particular emphasize on understanding the role of IT support: Heavy Maintenance and Traffic Related Maintenance. Work was followed during two days, in all 14 hours divided equally between the two days and the two locations. During the observational studies, notes were taken and the studied technicians were questioned

extensively about the activities in which they were involved.

Alvik Airport, Umeå

Alvik Airport is in Swedish standards a comparatively large airport located in Umeå in the north of Sweden. It is mainly used for domestic travels with most of its flights destinated to Stockholm Arlanda, but there are also departures for charter trips and more distant destinations. At the airport there are seven flight technicians employed to take care of all the maintenance work. This paper presents a case study in which the everyday practice at Alvik airport is studied. The observations were made during both day and night shifts in May 1999.

Every-day-work at Alvik airport

As a fundamental activity at SAS, maintenance work is carried out during days as well as nights. This means that the technicians work in shifts in order to cover all hours a day and to meet the increasing demand for maintenance work due to heavy traffic in the flight industry.

At Alvik Airport, the technicians work in twelve-hour shifts. The day shift begins at 5 a.m. and is succeeded by the evening shift that starts at 5 p.m. During the shift, the flight technician works alone and consequently has to be able to run all everyday activities by himself. The work consists of a number of activities of which receiving arriving aircraft, controlling them and give authorization for further flight are the most common and most important ones. Besides the activities that are in direct connection with the aircraft, the technician is also responsible for taking care of administrative work and to handle incoming information such as changes to the manuals.

The day shift is characterized by very intensive work. Many aircraft arrive during the early hours in the morning and all of them have to be checked, fueled and approved for further flight. At these short stops it is the technicians responsibility to make sure that everything is in order and that the aircraft can be sent away for further flight without any remarks. To be able to guarantee this, the technician performs an overall check that includes a control of the engines, the wings and the undercarriage. The landing lights are also examined as well as any specific issue brought up by the pilot or the other crew. What is special about the situation at Alvik Airport is that the arriving aircraft are of different types, for example MD80, Fokker and Boeing 747, and since the technician works alone he has to be familiar with a great number of different types of aircraft. He must also be able to make fast decisions since time is a crucial factor for success in the flight industry where the competition for the customers is very hard. This requires both significant knowledge and the possibility of getting information fast.

Beside minor controls that are made as soon as an aircraft arrives, the technician is also responsible for more extensive controls of the aircraft. Such controls are carried out at regular intervals, for example every second day or during the nights when the aircraft are not in use. In these controls the aircraft are examined in a more detailed way. All lights are checked as well as the oil pressure, the engines and the tires. If any part has to be repaired or replaced that is made during these controls. Since Alvik Airport is a minor airport with only one technician per shift only minor repairing is carried out. If there are many components to change or if the aircraft is in need of heavy maintenance work, it is sent to Arlanda or to some of the bigger SAS airports such as Oslo or

Copenhagen. The craft is then put into a hangar and can be intensively maintained by several technicians at the same time, something that would be impossible at Alvik where the technician works alone. In addition to the actual checking of the aircraft, all these controls are thoroughly documented and reported in an agreed upon and structured way. This extensive documentation makes it possible to follow the history of every aircraft owned and used by SAS. Recurrent remarks can be traced and it is also possible to see at what airport and of which technician the aircraft has been repaired.

After a very intense morning with heavy traffic, the afternoon is a bit calmer which gives the technician time to take lunch and go through information and documentation. Although the arrivals and departures of aircraft are not as many as in the morning, the technician must always be prepared to leave the office or interrupt his lunch if anything happens. This means that there are no scheduled breaks in the shifts and therefore the technician must adapt very much to the current situation.

At 5 p.m. the day shift ends and the night shift begins. This is the only time where the technicians can meet and exchange information since there is a scheduled time for discussion and information exchange between 5 p.m. to 5.12 p.m.

The work with receiving and departing aircraft continues during the evening and is taken care of by the technician working the night shift. The evening is relatively calm and is not characterized by the stress felt during the morning. The major happening of the night is the aircraft that arrives at 9 p.m. which is towed to the post-terminal nearby. At the terminal all of the aircraft's chairs are taken out and replaced with containers filled with post. The aircraft then takes off for Arlanda after being controlled and approved. After this, an atmosphere of silence becomes present. No aircraft arrive and almost no communication is heard on the radio. This is the only time when the technician can relax and enjoy the company of the employees at *Luftfartsverket* who work about the same shifts as the technicians do. There is time to talk, have a coffee and just relax until the aircraft returns at 2 am to be rebuilt as a regular aircraft so that it can be used in traffic again next morning. After the chairs have been replaced, the craft is transported from the post-terminal back to the airport where a major check is performed and where the craft is fueled so that everything is prepared for its departure the next morning. When this is completed, the night-shift ends and the technician have only to document what has happened during the night and wait for the technician to relieve him.

Discussion

After doing participant observations and being part of the work at Alvik Airport, many impressions are left to be analyzed since the flight industry in general and the work of flight technicians in particular is of very complex and specialized nature. However, a few qualities showed to characterize the situation at Alvik Airport.

First, an early impression is that the technicians studied are very positive to their work and seem to adapt very easily to these special circumstances. Incoming information and changes to the manuals are taken as something natural and something that is only to adapt to since the safety regulations are very strict in the flight industry.

Second, using computers in the everyday practice is a matter of course and something that has been the rule for many years. In general, the attitude towards computer-based work is positive since handling different technical artifacts is what the technicians actually do. Technology is their main interest and computers can be seen as one part of that interest which makes the adaptation to new routines and new applications a minor problem than can be the case in an organization where computers are looked

upon as “not belonging to the actual work”. However, there have been situations when computer-based programs have been rejected even though the general attitude seems to be open and positive. Earlier education systems intended to support the technicians in their administrative work was never fully accepted or used at Alvik Airport. One of the technicians interviewed argues that the reason to this is the unfriendly and badly designed interface of the application and the unnatural and complicated way in which the commands have to be used. There were also technical difficulties in getting the application to work properly, something that naturally influenced the attitude towards it in a negative way.

> “…we tried it at Arlanda, but didn’t get it to work here. It was probably something with the computers, something wrong in the application” (flight technician, 990705).

In spite of this, the general impression is that the flight technicians observed are very flexible and positive to changes in their work. Since everything they do must be digitally documented in a standardized way, computers are seen as part of their everyday practice. Today, all stations have access to administrative programs in which all remarks on craft and all maintenance work performed is documented. The experience of computer-based applications in the education program also contributes to the positive attitude towards computers that we found. The computers at Alvik are used mainly for administrative work and for documentation and very rarely in educational purposes.

The technicians also show to be used to handle information. They are used to continuous changes since the manuals are constantly updated due to new laws and changes in requirements. Incoming information is handled in a direct manner since it is of great importance that nothing is left without notice. Therefore, the manuals are revised as soon as the information reaches the technician so that the others can take part of the manual and be sure that it is always accurate. To be able to keep the manuals constantly updated it is of great importance to get accurate information in an easy way.

Besides these characteristics, the flight technicians also seem to be very loyal towards their company and most of the technicians at Alvik Airport have been working at SAS for a considerable time. This means that they are well aware of the company and its goals, and also that they have been part of the advanced training system in SAS for a very long time which make them an important source of information when discussing their work practice and changes in the advanced education system. Their experience of the existing education program is also of importance when discussing future changes such as a distribution of parts of the education.

Arlanda Airport, Stockholm

Arlanda Airport is the largest airport in Sweden and the place where most of the SAS activities take place. The airport is heavily used by both Swedish and foreign airline companies and it is the place where major controls and more extensive maintenance work is carried out. Hundreds of technicians work at the airport in order to maintain all craft that arrive and depart, and craft that are intentionally sent to Arlanda for heavy maintenance for longer periods. The technicians working at Arlanda Airport are divided into two groups were one group is responsible for the arriving craft and their further take-off, and the other group is working in the hangars with light and heavy maintenance on

craft that are sent to Arlanda for specific reparations. Since there are many different types of aircraft, the technicians at Arlanda have very different competence and what certificate they have may vary. The situation is therefore in many ways different from that of Alvik where the technicians have the same skill and operate alone during the shift. At Arlanda, technicians work in teams and the maintenance work they perform is of a specialized character. The technicians are also part of a hierarchy, since their competences vary and since not all of them are certified for operating all craft that arrive. In our studies, we have observed the work of advanced technicians doing maintenance work on SAS aircraft in the hangars. We have also observed the work carried out by the docking bay in order to get an understanding for the work performed by the group of technicians that is responsible for arrivals and departures. The work practice at Arlanda is outlined on basis of several observations and interviews that took place in September 1999.

Every-day work at Arlanda Airport

The organization of the maintenance work at Arlanda is in many aspects different from that of Alvik in Umeå. This is due to the character of the airport. Arlanda is the largest airport in Sweden and therefore the place where most of SAS activities take place. Besides all Scandinavian aircraft, it is also used by foreign companies, which makes the air traffic very intense. Besides the every-day work of the technicians, there are many other services to provide. One example is the incoming craft that are intentionally sent to Arlanda for maintenance work. They can be in need of such heavy maintenance that is impossible to take care of by the technicians at the smaller airports, or it can be craft of a specific type to which the only competence for handling is to be found at Arlanda.

The technicians work either by the docking bays or in the hangars. The technicians by the docking bays perform the same controls and minor maintenance work as those at Alvik in Umeå. The most important is to see that the craft is airworthy by controlling the engine, the lights and to fuel the craft so that it can take off for further flight. Our observations show many similarities with as those carried out in Umeå since most of the work performed is the same. Though, one big difference is that the flight technicians at Arlanda Airport is in constant contact with other technicians since many activities are going on at the same time and it takes a lot of people to handle the work. During the short breaks, the technicians can talk, exchange ideas and discuss their work. They are also in contact with other categories of people since much work at the airport is about coordinating people, craft and skills.

The heavy maintenance work is carried out in the hangars where flight technicians work in teams to get the craft back in daily operation. The craft that are maintained are often put in the hangar for several days where they are thoroughly repaired and controlled. For example, this is where the engines are changed or where skilled technicians operate on special components inside the craft. The technicians in the hangars view themselves as the ones carrying out the heavy work and their status is high among other technicians. In the hangars, the craft are put for several days and the same team can operate on the craft for a longer period. The work they do can be of varying character depending on the type of the craft and for what it is in need. This means that their work is more unpredictable in some sense since the work depends on what happens to the craft.

Besides the technicians by the docking bays and the technicians in the hangars, there is also technical staff in the offices at the hangars. The technicians working here often share their time between maintenance work and administrative and coordination work. Their performance is of great importance to SAS and the daily operation since

most of the coordination work and planning is carried out here. Except for scheduling all SAS technicians at Arlanda, they are also responsible for what team and what hangar is to be used for heavy maintenance of incoming craft. As in Umeå the airport is manned 24 hours a day and much of the activities take place in the early morning hours when night shift technicians leave the hangar and the day shift personnel arrives. All day shifts begin with a short meeting where different technical personnel report on the previous night. Often there have been incidents that are of crucial importance for the day shift technicians to know about so this meeting is very important for further work. The meeting is also a very good starting-point of the day since most people are then dispersed and may not see each other for the rest of the shift.

Discussion

An early impression when studying the technicians at Arlanda is their friendship and the exhilarated atmosphere. This is most obvious in the hangars where the teams of technicians know each other very well and seem to know what to do even without asking. The possibility to meet other categories of people and to work close to other technicians make the situation very stimulating and exciting and information can be spread very fast and in an easy manner.

In addition, they are very used to handle information in an efficient and direct manner since it is of great importance that nothing is left aside or not noticed. Like the technicians in Umeå incoming information are handled directly and if it concerns the manuals it is of high priority. This ability is noticed among all technicians studied, but especially among the technicians in the offices where most of the coordination work is carried out. The environment at Arlanda is very intense and characterized by incoming information, telephone signals, faxes that must be taken care of and people that have questions. Despite this constant pressure, the technicians seem to be positive to their work and it is obvious that aircraft and the technique around them is the main interest of these people. New types of aircraft are discussed and every technician seems to have a favorite type of aircraft on which to work.

When it comes to computer-based information the attitude depends on what category of technicians that are asked. For those handling the administrative work and all coordination work the computer-based information is only one part of all information but the most important one. The computers are looked upon as something natural in the every-day practice and the programs are necessary to track and evaluate all work carried out. Using computers is therefore one part of their work and has been so for a very long time. The technicians at Arlanda also have access to the SAS Intranet, which is being developed in order to, support the distribution of information. The Intranet provides possibilities to read manuals and bulletins and it also provides mail and other services necessary to the technicians. This makes their work easier in that they can find relevant information in an easy way. The intranet can also work as a communication tool for all technicians in the organization (Damsgaard & Scheepers, 1997).

The technicians in the hangars and at the airports use the computers indirect for reading the computer-based manuals but not for direct use in their work. When information is needed, the most common way is to get a printout of that particular part of interest. This makes the computers a complement but not crucial to their work and the study show that these technicians very seldom use the intranet for retrieval of information. Although, the use of computers is common to all technicians and especially in their education they are presented to a lot of computer-based information. Many of the

advanced training systems are computer-based, and in order to learn how to use the administrative systems, a computer-based training module is used for all technicians.

What is obvious at Arlanda is the constant use of many different systems. Different computer-based systems are used to document maintenance work, contact other technicians and to order particular components. This makes to work situation very complex and it is obvious that in order to be efficient, a careful knowledge of how the systems interrelate is necessary.

Gardermoen Airport, Oslo

Gardermoen airport constitutes the largest and most significant airport in Norway. It is the base for SAS domestic flights within Norway, as well as many international flights as Gardermoen is also being used extensively by other airlines as well, apart from SAS. Its runway is also the lift off for many Norwegian based charter tourism trips. All in all, that makes Gardermoen a fairly large international airport with several take-offs and landings each hour both day and night. In addition, as hosting both domestic, international and charter flights, Gardermoen is visited by a large number of different craft, ranging from very small to very large. The SAS flight technician organization is divided into three divisions, one that works by the docking bays receiving and releasing craft, one that does checks and repair work on the craft, called Light Maintenance or Traffic Related Maintenance, and one called on Heavy Maintenance, where components of planes are checked and repaired. Work in Heavy Maintenance and Traffic Related Maintenance was the focus of this part of the study, where the work practice of the technician and their use of supporting computer systems constituted the main area of interest. This section focuses on the work practice of flight technicians in Heavy Maintenance and Traffic Related Maintenance, with special emphasize on the use of IT-support tools. This part of the study was conducted in November 1999.

Every-day work at Gardermoen Airport

Much of the work in the first location studied, that of Heavy Maintenance, circles round planned activities. This includes mainly the extensive checks of all craft with regular intermission, where the individual craft is entirely taken apart and inspected for errors. During these so called D-checks – which all aircraft undergo at an interval of about 6 to 8 years somewhat dependent on the type of craft and its age – it is not unusual to find more than 2000 errors, each of which needs to be explicitly documented and handled separately by a certified technician. This list is added to a compulsory list that consists of more than a thousand items of different entities that needs to be seen to even if no particular inaccuracy exists. These lists of things to check have been compiled by the manufacturer of the aircraft, controlling governmental bodies and SAS TK Engineering, a division within SAS that handles technical questions, compile manuals and decide upon work processes. These extensive checks usually take about three weeks to complete, and during this time many hundred technicians with special competence work on a particular set of components from the aircraft.

The Heavy Maintenance department is in itself divided into five sub-divisions that focus on a particular type of systems of a craft. A responsible manager, who is also a technician, controls the work in each of these sub-divisions. Directly under the manager are three senior technicians that are responsible of assigning the right tasks to the rest of

the staff, usually addressed by the term skilled workers.

All of the errors and checks that need to be carried out by the Heavy Maintenance division are carefully documented. Each separate task, consisting of what is to be done, what kind of certificate is needed to do the work and which parts of documentation that needs to be considered, is written down on to a special job card, which by the help of the senior technicians are handed out to the skilled workers. The job card is one of three types: it may be a routine check that is imposed by the craft manufacturer or the controlling governmental bodies. The job card may also be an action decided upon by SAS TK Engineering, often in the form of the adding of new systems or changes in existing systems. In addition, the job card may consist of an error or inaccuracy found during the initial complete check-up. The skilled worker receives the job card and carries out the check or repair work of the component in question, which may include the ordering of spare parts. When the work is done, the skilled worker uses a barcode on the job card to report that this particular task is carried out, and the worker is assigned another task. However, in order for the component to be declared as repaired or checked, it is requires that dedicated control personnel checks the component repaired by the skilled workers and declares the job complete. Some components, such as the engines, must also undergo extensive functional testing before it may be put back into the craft.

The workplace setting in Heavy Maintenance resembles typical industrial production. There are several desks that are dedicated to different types of components. There are also several standard desktop computers that technicians use to document what they are doing, reading manuals, sending e-mails and so on. All computers are connected to a network, where most documentation and information about the different craft and their components are gathered. However, many workers seem to prefer to use CD-ROM versions of these tools, apparently because of the sometimes rather slow response from the network. Most computers in use are based on Microsoft Windows 3.11, but computers with better performance and Microsoft Windows NT 4.0 are currently replacing these. The workers use a diverse set of applications to carry out their daily activities.

Work in the Traffic Related Maintenance, or Light Maintenance, is structured in a similar way. However, here the flight technicians do not work with a single component as in heavy maintenance, but rather they work on the craft as a whole an a hangar setting. TRM too do planned activities, such as minor changes to craft and also take care of craft that have been declared not airworthy. However, in TRM work is generally not as thorough as in Heavy Maintenance, but they do carry out some rather complex checks and repair work. Besides working in the hangar, if problems occur with craft by the docking bays close to the runway that the technicians there cannot solve, staff from TRM are equipped with two van-sized cars that they may use to go there if help is needed, in order to solve the problem and get the craft airworthy. One of the cars is specialized towards heavier maintenance, and one is dedicated to avionics, which includes instrumentation, electrical systems and radio systems.

These cars are equipped with a set of useful tools. Besides the tools used for mending the airplane itself, the cars are also equipped with a VHF radio to communicate with other technicians and others on the runway. To further assist the technician during the work by the docking bays, the cars are equipped with a laptop computer, a printer and different sets of CD-ROMs with aircraft documentation. However, the computers in these cars are not connected to the network that the other computers in use are. The technicians look at these cars as something that improve their working conditions, since they use to be forced to first go from the hangar to the aircraft by the docking bay, check what was

wrong with it, return to the hangar, find the right information for the perceived task using desktop computers, print out the right pages and then drive back out the docking bays. With the use of these cars, a technician can bring all the information needed out to craft on the runway or to the docking bays, and print the right pages from the manual when the problem is close at hand.

TRM also use what they call ‘computer tables’ to carry out their work in the hangar. Depending on the size of the currently held aircraft, or the number of craft that are currently stationed in the hangar, work does not take place in exactly the same location from one day to another. This would make the use of stationary desktop computers quite obtrusive, because it would be difficult to find a location where they would be both nearby as well as not in the way. To solve this situation TRM uses the computer tables. These consist of a desktop computer with keyboard and mouse, a printer to print job cards and telex-messages and a telephone. The tables are equipped with wheels that allow them to be mobile in the sense that they do not have to have a fixed position within the hangar. Though, to allow the computer tables to be hooked on to the network, there are certain spots – which resembles floor drains – within the hangar that allows for a fiber optical connection to the network. One problem is that the rugged setting inside the hangar often makes the thin fiber cable that connects the computer tables to the networks the subject of mishandle, and consequently these expensive cables break frequently. Even though the location spots restrain the mobility, they allow the tables, as opposed to the cars used by TRM, to be connected to the network. The SAS Technical Base computer group, called OSLTZ, is currently evaluating a wireless network solution that is based on radio frequencies, which would allow the computer tables to be much less restrained than today, and perhaps even make it possible for the cars to be online at all times.

Discussion

Especially in the case of TRM, there is an apparent tendency towards mobility in the use of computer equipment. Both the cars used to go to the runway and to the docking bays as well as the computer tables are evidence of this. What should be noticed is the fact that in the case of the computer table, mobility is limited to allow for a network connection, while in the case of the cars, mobility is not restrained, but for the price of not having it connected to the network. A wireless network would solve this problem to some extent, making the computer tables able to be placed anywhere within the hangar, and the cars could be online anywhere on the runway or by the docking bays. However, there are several problems involved in having a radio-based wireless LAN in this environment. Not only are there questions that concern the possibility of interference of aircraft instruments, but also the hangar itself is not ideal for radio transmissions, with a huge amount of metallic equipment and surfaces. There may be a severe amount of echoes from these surfaces that may cause the width of the actual bandwidth to drop dramatically when used in this setting.

Perceived Issues

The gap between production and education

Today, all education of flight technicians is situated at SAS Flight Academy in Stockholm. To be able to gather the technicians who also are very important in everyday routines at the regional airports it is common to organize the courses as a compact set of theory that is worked through in a couple of days. Most common is to begin the course with repetition of the aircraft types that the technicians are already certified for operating, then repeat the administrative routines that are to be used in all documentation work and finally to start the training on a new aircraft type or component. This arrangement makes the courses very compressed and intense with a significant theory to work through under a limited couple of days.

This is hardly the situation in the everyday practice at smaller regional airports, for example Alvik in Umeå, where the technicians always work alone and use the manuals in a more ad hoc way. Consequently, there is a prevalent opinion that the education of today in an imperfect way represent the ordinary activities in every-day production, and that the education cannot be experienced as an integrated part of the work practice. The technicians are taken away from their ordinary context every time they are to be educated, and the knowledge they acquire at SAS Flight Academy and at Arlanda Airport cannot be used in their own situation in a direct manner. The situation is further complicated by the fact that the technicians in Umeå may have to wait a considerable time before they can apply the skills acquired at courses since not all aircraft types arrive at Alvik Airport.

This means that a gap between the education and ordinary production is experienced. The technicians at Alvik Airport feel that the knowledge they acquire is sometimes hard to apply in daily routines at the regional airports. An education of a more situation-based character would be preferable so that theory could be mixed with practice in a more natural way. This would make possible the feeling of education as an integrated part of every-day work instead of something outside the real work practice.

After studying the way in which the technicians use the computer systems and the computer-based information, it is obvious that the distribution of parts of education is possible. This is due to the positive attitude and the ease in which computers are used by the technicians. One possible solution would be to use the intranet, something common in many organizations of today. To integrate education in a system that is used on daily basis would increase the feeling of education as an integrated part of the work (Damsgaard & Scheepers, 1997). It would also make possible an education of a more situation-based character since theory and practical work would be performed directly in the every-day environment.

The time factor

In the flight industry, being on time is crucial. To keep customers and to make people choose SAS among other companies it is of great importance to keep the timetables and not accept any delays. The work of flight technicians can be seen as one part in a chain of work that can never be stopped since all parts are dependent on each other.

At Alvik this means that the technician must always be at hand and ready to

operate in case something happens. Problems occur when people get sick or when somebody has to go away for a longer period. This is also the case at the larger airports since the technicians are crucial in all maintenance work carried out.

Therefore, longer courses at Arlanda can be experienced as a problem since they require that parts of the technical staff must be taken out of production for several days or even weeks. At Alvik Airport, the work carried out in shifts by seven men must then be taken care of only by six, and since the airport has to be manned every hour of the day it would be of great value to be able to do parts of the education at the local station. The attitude to this type of training is generally positive with a strain of curiosity, but according to the technicians studied, it would require scheduled time especially put aside for training. This is due to the situation today in which it can be hard to locate time for education and hard to concentrate when you know that you might be interrupted. To be able to study and practice your skills it is of great importance that education is viewed as something belonging to work and therefore put time aside for this in the ordinary schedule.

Another important aspect is the time it takes technicians to retrieve information. Today, important information and manuals are scanned on CD-roms. This solution is by some technicians experienced as insufficient since there is no possibility to search the extensive text in a fast way. To get time to search through heavy manuals can be hard and it can also be very trying in a situation where a misjudgment would have disastrous consequences. In future development, it would be of great interest to analyze how information could be retrieved using a wearable computer system.

The diversity of computer systems

A wireless network such as the one being heeded at Gardermoen Airport for use in Traffic Related Maintenance solves some problems in connection with the prospect of making IT support tools mobile, to better accommodate the work practice of the flight technicians, but is not in itself sufficient to provide a useful basis for such system. There is a far greater issue than for which a particular network technology provides an answer, and its core is the diversity of the computer systems that the flight technicians must use in order to carry out their work. Each flight technician makes use of a host of different systems that can be divided into three categories: First, they use a number of different computer systems to handle manuals, job cards, trouble shooting and checklists. This first group of systems may be perceived as the backbone of flight maintenance. Second, there is a specific system to handle the ordering of spare parts. Third, each flight technicians also use a mix of standard desktop applications, such as time scheduling applications, e-mail clients and web browsers.

As for the first and second category, flight technicians use a system called MOPS, which constitute the core for specification, handling and documentation of job cards and planning, and another system called MOVEX for the ordering of spare parts. These systems, which are conceptually connected, are not integrated and not even based on the same platform, which makes the use of them intricate. One flight technician, when asked directly, stated that these two systems are both problematic to use, and his opinion was that they do not provide good and usable interfaces for the users and are generally difficult to learn for inexperienced users. While the wide range of different systems and interfaces do not seem to produce usable support tools in general, it may be considered particularly troublesome in this setting, given that the flight technicians interviewed stated that they do not consider themselves computer literate, and that they do not feel

comfortable using the computer systems presented to them.

The actual documentation of the aircraft from the different manufacturers – which in SAS' case often mean Boeing – come in at least three media: in books or folders, which now are becoming obsolete and can not be used for maintenance; on microfilm, which too seems to be on the verge of extinction; and stored digitally on computer servers or CD-ROMs. The latter medium is currently taking over unconditionally even though the digital information provided does have its weaknesses. There are primarily two different applications that are used to view the documentation of the aircraft being attended at Gardermoen. These two are not in any way integrated with the MOPS system or with the MOVEX system, even though the conceptual connection seems definite. One system, KODAK, for reviewing documentation and manuals of the aircraft McDonnell Douglas MD-80 and DC-9 is based on scanned pictures of the pages in the folder-based manuals. These pages then constitute of pictures that are reviewed one by one, and hence the content is not searchable except from a minor and poorly designed indexing function, which makes the KODAK solution difficult to use.

This system also causes frustration during the observations. A technician had found what appeared to be cracks on a window on a craft already on the runway and ready to take off, full with passengers and cargo. If what he saw was indeed cracks, the craft must not be declared airworthy. However, if these were not in fact cracks but merely scratches, the plane could be declared airworthy and the window maintained later. What are cracks and what are scratches may not be based on arbitrary judgments, the exact depths and sizes of what are to be considered cracks and what are scratches are listed in the documentation of the aircraft. The flight technician needed this piece of information fast because of several factors. Every minute a plane is delayed, SAS loses huge amounts of money because of passengers that risk missing connecting flights, a consequence that may seem tolerable but may in fact ripple to have a severe total effect. Also, the craft are generally used extensively with tight schedules, and a delay may cause repeated delays on several flights throughout the day. Moreover, the different airlines are given slot times to allow for take off and landing. If a plane is not ready to take off during its assigned slot time, it may be difficult receive a new one contiguously – something that is especially true with large airports – which may cause the delay to be even greater. The flight technician in need of this piece of information was not able to find it rapidly, apparently because the system responds quite slowly, even when run off a local CD-ROM, and because of the non-existing searching abilities. In fact, just the search for the right page in the documentation took 10 to 15 minutes and required two technicians.

The second application used for reviewing aircraft documentation is called JEPPESEN, and is used for the aircraft Boeing 737 and 767. This system does not use pictures only, but instead uses a mix of pictures, text and links that resembles a hypertext-based system. This system has searching functions and seems to cause much less frustration than the KODAK system.

During the study, we found that numerous IT support tools, including telephones, VHF radios and different computer-based support systems support the work of flight technicians in many ways. However, we also found that poor design, diversity among applications and interfaces, and especially the lack of mobility seems to hinder the activities that most flight technicians regard as their work practice.

Conclusions

This paper has reported an interpretive case study of flight technicians within SAS, conducted at three different airports, Alvik Airport and Arlanda Airport, Sweden, and Gardermoen Airport, Norway. The main intention has been to establish an understanding of the work practice and the variety of IT support used in this setting. To achieve such understanding, our interpretive case study makes use of three data sources in order to capture different aspects of what it is to be a flight technician, and what range of IT support they use. These sources are interviews with flight technicians and managers, participant observations of flight technicians carrying out their work and document reviews.

Based on the empirical case study we have suggested and explored three problem areas. First, there seems to be a gap between the education of flight maintenance personnel and the activities carried out during production work. Second, production work in flight maintenance is time critical. Within this rigid time schedule, it seems difficult to create the time necessary for educational activities. Third, there is a diversity of computer systems used for production work. Very different types of systems, used for different purposes but conceptually related, provide difficult to use and hence non-productive IT-support tools for flight maintenance. While the overall tendency is towards an increased use of IT support within flight maintenance, and recently also towards mobility of IT use, the diversity and complexity of the currently used applications constitute an important and problematic barrier for the introduction of new computer-based systems for flight maintenance.

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