Introducing CAD to a Big Corporation

Volker Müller

Zentrum für Graphische Datenverarbeitung e.V.
Wilhelminenstraße 7
6100 Darmstadt, Germany

The report presents the ongoing activity of introducing CAD to the entire range of facilities planning and management of the Frankfurt Airport Corporation. It addresses issues of organizing the shift from conventional to computer supported planning and facilities management; the problems of training professionals with various background in the use of new tools; aspects of data validity; regulation of data exchange; and customization of software to the needs of special tasks within the corporation. The report is based on about four years of project runtime. The preparation of the project started in fall 1988. The project proper started in June 1989. It is entering its last year. Up to now about 120 persons have been trained to use CAD.

Keywords: CAD introduction, corporation setting, adult education, data integrity, data security, data exchange, linkage between geometric and alphanumeric data, customized systems.

1 The Project "Introducing CAD to the Frankfurt Airport Corporation"

The Frankfurt Airport Corporation (FAG) runs one of the largest European airports. It has about 12,000 employees. At the airport, the entire workforce is about 55,000 people. The airport itself generates work for about 150,000 people in the region. The corporation is divided in six divisions. Most planning and facilities management activities are located in the technical division. However, all other divisions are involved with aspects of these activities, as well (Figure 1).

The continuing growth of the airport necessitates the introduction of contemporary techniques to facilities management. This means computer support. Of course, the corporation has used computers in a variety of areas for a few decades already. Airport operation, flight control, flight information, and business applications have been computer supported. The step towards computer-supported facilities planning and management, however, has been taken with the integration of all correlated activities in mind. Therefore, all computer support in these fields is conceived as being centered around the facilities, especially properties and buildings. Available data are mostly surveying and planning documents.

U. Flemming and S. Van Wyk (eds.), ***CAAD Futures '93****, pp. 497-512.*

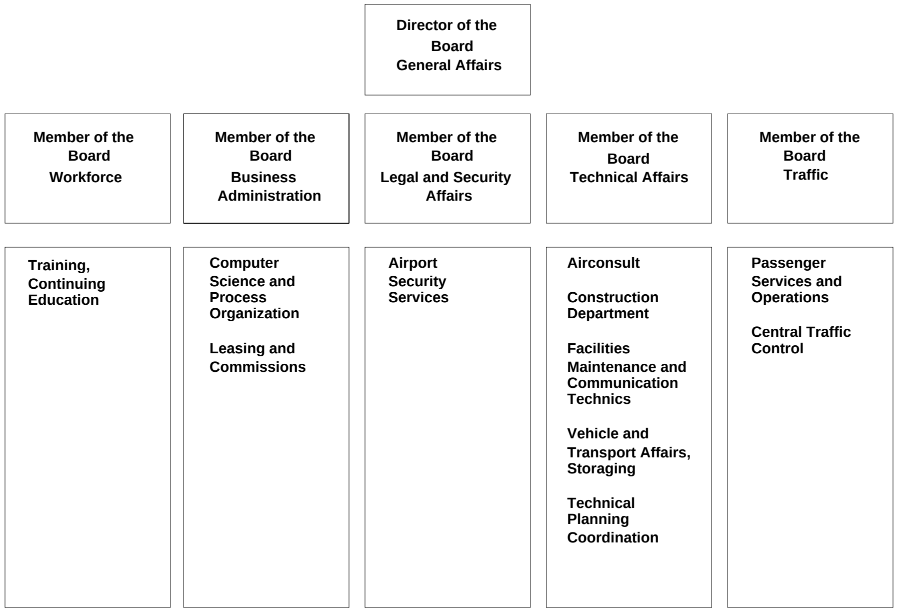

Figure 1. Divisions of the FAG; listed departments are those that are mainly involved with facilities planning and management.

2 Facilities Planning and Management Data and Software

The decision process about the CAD system was a project in its own right. Besides the airport, four major CAD system producers participated in the complex process. In this context the decision rationale can only be outlined. The data and the software were one focus of the considerations because they influence the performance of the system and the necessary amount of user training and support. The former, of course, has an impact on user satisfaction and productivity.

The pertinent data of facilities planning and management documents are geometric data. They are partially linked to alphanumeric data because geometric data by themselves cannot represent all information that needs to be documented for comprehensive facilities planning and management. Provided that an exchange of data should be possible among all participating departments, it was suggested that one data format be used. A general solution (one application handling all data, Figure 2a) was considered impractical because it could be expected to show low performance and was not readily available anyway. The alternative was to accept a division of tasks in different specialized applications that drew on a common database (Figure 2b).

The decision was made that rather than sharing one comprehensive geometric and alphanumeric database by several expert systems there would be one shared geometric database handled by a basic geometric modelling system. Specialized add-on software packages managed their own specific alphanumeric data (Figure 2c).

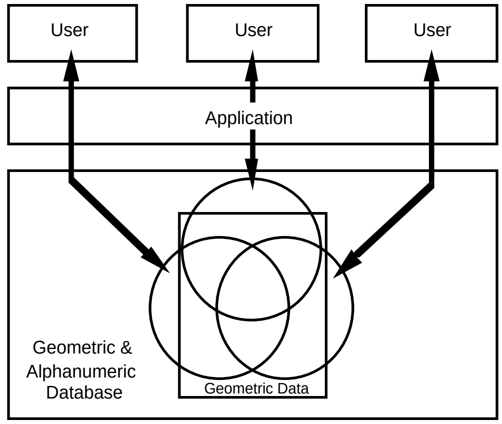

Figure 2a. Sharing a common database through one general application.

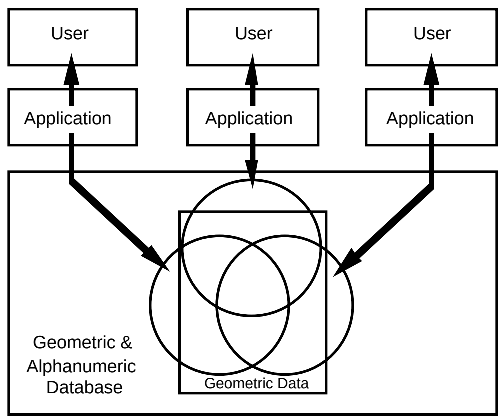

Figure 2b. Sharing a common database through different applications.

Reasons for this decision were on the one hand the availability of according systems, on the other hand the expected difficulties in handling one gigantic mixed database with the known effects on performance. In consequence, a proprietary basic modelling package was chosen. It provides the base for specialized applications in the different professional fields. The shared geometric data are accessible by all users through the basic modelling software. The specific alphanumeric data can only be accessed by the users who work with the respective add-on expert systems (Figure 3).

The other main criteria for the choice of a specific CAD system were the range of professional areas supported by the system in conjunction with proprietary and third party add-ons; the availability on the German market; the availability of software support; the availability of hardware support depending on the required platforms; the availability on consultant knowledge about introducing CAD in general and especially the specific CAD system; the possibility of networking for fast and easy data exchange; the possibility of additional customization. The system of choice then was Intergraph's MicroStation 32.

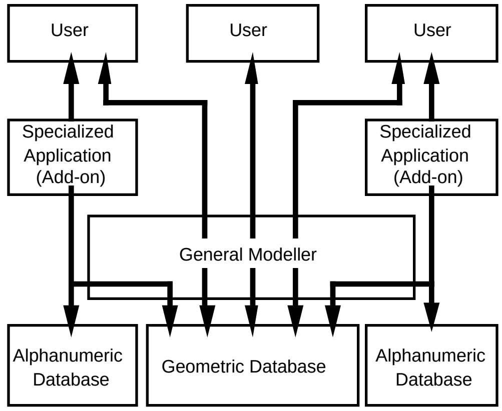

Figure 2c. Sharing one geometric database while using different add-on applications with specific alphanumeric databases.

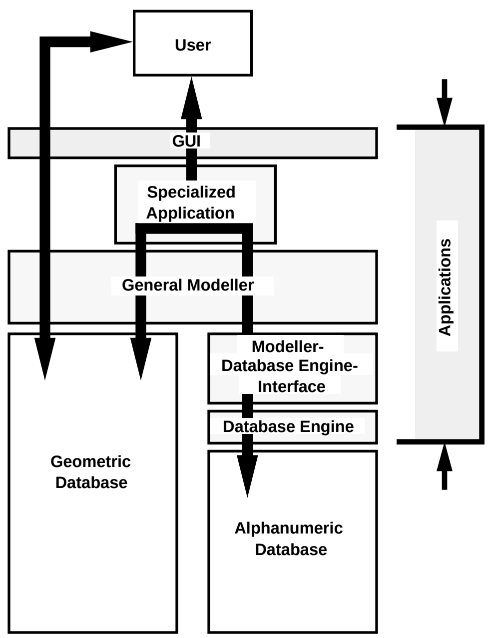

Figure 3. Connection between geometric and alphanumeric data.

3 Organizational Frame of the CAD Introduction

The project of "Introducing CAD to the FAG" was split into three different project phases. The first project phase comprised the feasibility studies (the "CAD-Pilotprojekt AGIS"), the second part is the transition to CAD of departments that produce planning documents (the "Step One"); the third phase is the introduction of CAD to departments that use planning documents (the "Step Two"). These phases are partially overlapping.

The feasibility studies were done in document producing departments. Therefore, CAD was introduced in some of these departments during the first phase. Already in the second half of the project's second part document using departments have been introducing CAD to handle projects that were started with CAD in phases one or two.

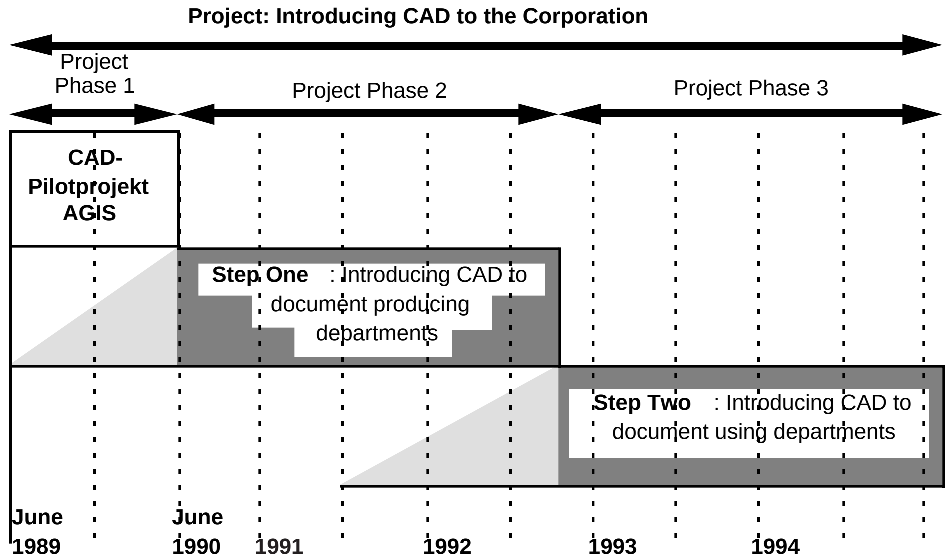

Figure 4. The subdivision of the project “Introducing CAD to The Corporation.”

3.1 The Project Phase “CAD-Pilotprojekt AGIS”

The goals of the “CAD-Pilotprojekt AGIS” (Airport Graphic Information System) were:

- testing the hardware and software for feasibility for the corporation;
- generating and propagating know-how about CAD within the corporation;
- producing sufficient experience for the continuing, goal-oriented expansion of CAD use within the corporation.

The responsibility for this project phase was located directly with the corporation's board member for technical affairs. This guaranteed a minimum of obstacles by other divisions of the corporation, and swift settlement of interdepartmental conflicts that might arise when priorities had to be determined. Participants were the CAD system producer, several consulting firms and the corporation's computer science department as executing partners. The FAG construction department served as testing field (Figure 5).

The “CAD-Pilotprojekt AGIS” was crucial in testing both, the introduction of CAD to the FAG in general and the introduction of CAD to individual departments. The corporation itself has to maintain all its activities while CAD is introduced. In consequence this means that the involved departments have to continue working on running and new projects parallel to the challenge of venturing into CAD. Especially the evaluation of the latter aspect was important for the design of the exact procedure of CAD-introduction to a department.

The conclusion of the “CAD-Pilotprojekt AGIS” was to stay with the chosen CAD system. At that time, the system comprised a VMS-mainframe system with terminals and the system producer's own workstations. However, working on a VMS-based system required the users to gain an intensive operating system knowledge. Therefore, the system architecture was changed to a UNIX-based client-server-architecture.

Steering Committee	
FAG:	The Software Producer:
Mr. Norweg, Member of the Board, Technical Affairs Mr. Meinicke, Director Construction Dept. Mr. Bonifer, Head of Project Dr. Biedermann, COMOR AG	Mr. Grevel, Intergraph GmbH Dr. Harendza, Treuarbeit Consulting

Project Steering Committee
Mr. Bonifer, Head of Project Mr. Köberle, ZGDV e. V. (for the FAG C/S Dept.) Mr. Knauth, Intergraph GmbH Dr. Harendza, Treuarbeit Consulting (for Intergraph) Mr. Wolf, Treuarbeit Consulting (for Intergraph)

Work Groups	Chairman of work groups: Mr. Wolf	
FAG-IS Coordinator: Mr. Bonifer	INGR Coordinator: Mr. Wolf	Users Coordinator: Mr. Bremser
Ms. Kupfer, Computer Science Dept. Mr. Sins, Computer Science Dept. Mr. Ickstadt, Computer Science Dept. Mr. Köberle, ZGDV e. V. Ms. Buhmann, ZGDV e. V. Mr. Roth, ZGDV e. V.	Mr. Lotte, Intergraph Mr. Mack, Intergraph Mr. Schiller, Intergraph Mr. Jacoby, Intergraph Mr. Lubda, Intergraph Mr. Schönberger, Intergraph Ms. Schade, Treuarbeit Mr. Boldt, Treuarbeit	Mr. Müller-Knaack, Construction Dept. Mr. Hartel, Construction Dept. Mr. Oestreicher, Construction Dept. Mr. Huppertz, Construction Dept. Mr. Konetzki, Construction Dept. Ms. Kleipa, Construction Dept. Ms. Mundhenke, Construction Dept. Mr. Vollmer, Construction Dept.

Figure 5. The organizational setup of the "CAD-Pilotprojekt AGIS" (June 1989 to June 1990); Treuarbeit Consulting now is C & L Consulting.

With the portation to other platforms, personal computers have been introduced as a less expensive platform, too. Most configurations are with two color monitors, and a small size (DIN A4 and DIN A3 formats, i.e., 297 mm x 210 mm = 11.69" x 8.27" and 420 mm by 297 mm = 16.54" x 11.69", respectively) black and white laser printer as output devices and graphic tablets (and keyboards) as input device. More expensive (and usually under-used) input and output devices are centralized and available via network connections. Such peripherals are large size (DIN A0 format, i.e., 1189 mm x 841 mm = 46.81" x 33.01" and larger) color electrostatic printers or pen plotters and a large size black and white scanner. For specific departments, additional equipment was provided as needed for their work, for example small size color printers and plotters (thermotransfer, inkjet, pen plotters) or scanners. Because by now the networking has progressed to include most departments that use CAD, this specialized equipment can be accessed by other departments as well when necessary (Figure 6).

The choice of software for specific workstations depends on the tasks that have to be fulfilled at these places. Depending on the tasks and the software that supports these tasks, the hardware can be determined. Especially expert add-ons are mostly available on no other platforms than the system producer's own workstations. Common for all CAD work places is the basic modeler. Most work places are provided with a software to handle raster data, as well. This is necessary to deal with the large amount of extant paper plans.

By user demand, they are currently scanned for inclusion into the geometric data base. In the long run, the extremely long run, they will be substituted by vector(ized) data. Expert add-ons are only installed at those workstations where they are needed, according to the previous task analysis. The software comprises, but is not limited to, Intergraph's MicroStation 32, IRAS/B, IRAS/C, ProjectArchitect, PLayout, InRoads, InFlow, InSewer, InSite, MGE, PDS, EESchematics, etc.

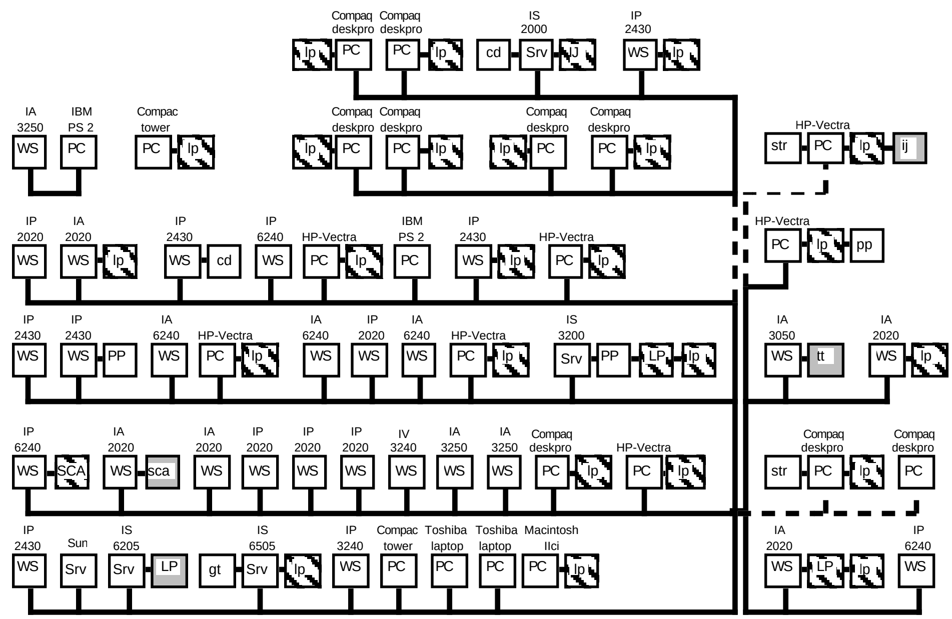

Figure 6. Hardware and network as of November 1992; abbreviations used: WS: workstation; PC: personal computer; Srv: server; LP, lp: laser printer (large formats, small formats, resp.); SCA, sca: scanner (large formats, small formats, resp.); cd: CD-ROM drive; gt: gigatape; str: streamer; tt: thermotransfer printer; IJ, ij: inkjet printer (large formats, small formats, resp.); PP, pp: pen plotter (large formats, small formats, resp.); patterns: : black and white device; : color device; solid lines denote existing networking, dotted lines planned connections.

3.2 *The Project Phase "Step One"*

The departments that were involved in the "CAD-Pilotprojekt AGIS" are central to the planning and facilities management activities of the FAG. On the one hand, they are the ones producing construction documents and the corporation's entire property plans, on the other hand they include the main archives for those documents. Because of this key position, most other departments were automatically confronted with the fact of CAD use in the corporation already during the pilot project. They had the opportunity to inform themselves about CAD, hearing about the problems of introducing CAD, the available support, and about the necessity to make it a joint effort. Of course, information included briefing of department heads as well as talks with the employees. They were made to feel able to decide about joining the effort or being outgrown eventually and remaining "manual islands" within the corporation's work flow.

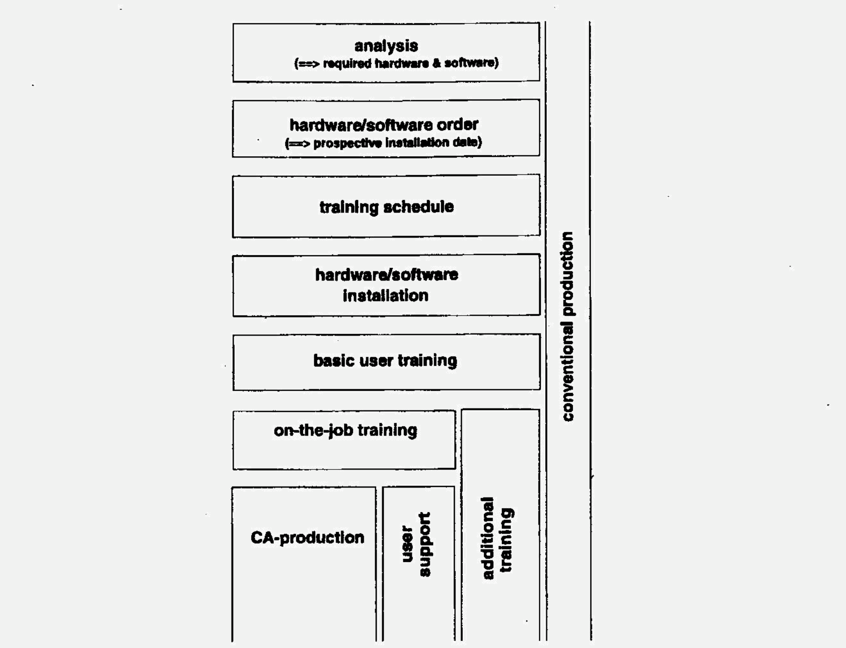

Figure 7. Time sequence of CAD introduction.

With the growing experience and better understanding of the corporation's dynamics, a standard process has been established for the introduction of CAD to a department (Figure 7). After the basic decision has been made that the department is in some way connected to facilities data by generating or using them, a close analysis of the covered tasks is performed. This analysis helps to determine what kind of data (plans) the department deals with, whether it generates them, changes or maintains (updates) them, uses them (as reference), or stores (archives) them. The interfacing to other departments and to contractors or clients is examined, as well. This information is necessary to decide on the required equipment (hardware and software) for the individual work places. Accordingly, schedules for obtaining the hardware, software, and training the department's employees are set up.

4 CAD User Training

Hardware and software installation, training, and later the guidance into production mode, are partially overlapping phases and mostly parallel to the continuing project work in the department. The scheduling of the training is important for the success of the CAD introduction. Good timing contributes to the users' satisfaction. On the one hand a good timing clearly shows the proficiency of the people in charge, on the other hand the proper sequence is a prerequisite for the training's success. When the (new) users feel they can gain mastery of the CAD system, this feeling has a positive effect on their performance in the courses and later in the supported training phase.

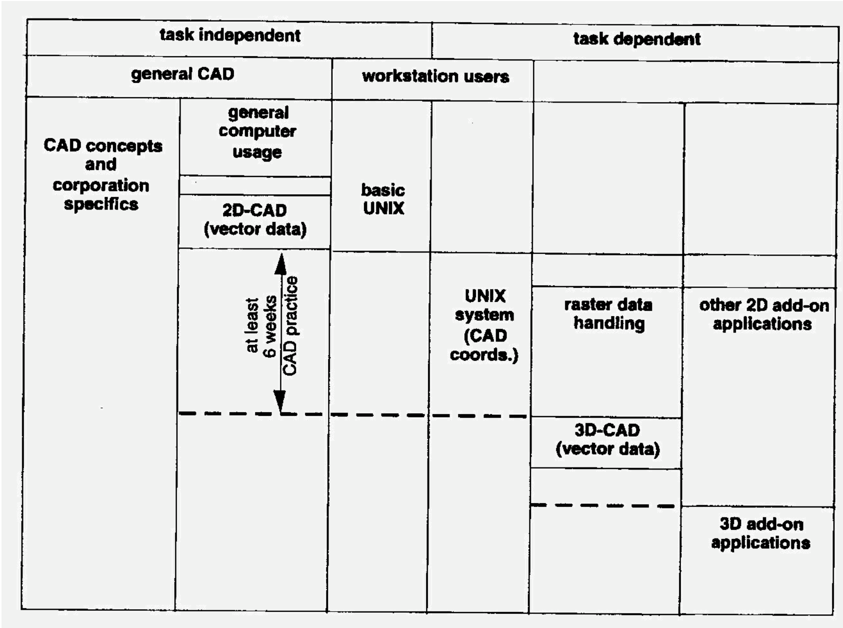

Figure 8. Sequencing of courses and distribution of content depending on the hardware and the tasks.

Several guidelines have been established concerning the desired sequential order of these phases. The hardware and software should be installed before any training starts. This gives the users the opportunity to practice what they have learned immediately after the classes. The courses themselves should be sequenced according to their content. Before future users are confronted with computers in a CAD course, they should have the opportunity to operate the machines. They should have computer experience already, or they should attend the general computer usage course. The 2D-CAD training is necessary to master the raster data handling. Some experience with the CAD system should be accumulated before visiting any add-on training or the 3D CAD class (Figure 8).

4.1 Basic CAD Courses

The general sequence of the courses is as follows (Figure 9a):

- The first course is an introduction to using computers. The users learn how to switch the machine on and off, what a file system is, how to find their way around, how to manage files, what input devices exist, how to operate a mouse, etc. Some knowledge about the operating systems is provided, too.
- Next is the 2D CAD course. This class takes two sequences of three days each to familiarize the users with the 2D basic modelling package, handling the machine, and the devices. An intermission of at least two days is provided so the trainees have the opportunity to practice the commands they have learned in the first sequence. During this time, they can demand about six to eight hours of user support.

- Sometime after the general computer usage class and before the 2D CAD course, there is a seminar about CAD concepts in general and about FAG specifics, for example: file naming conventions, directory structures, or CAD project management procedures.

4.2 Advanced CAD Courses

These three classes comprise the basic CAD education. All other courses depend on the tasks the user has to accomplish (Figure 8).

- Most users will be trained to handle raster data. The software providing the functionality can only be accessed via the basic modeler, therefore, the 2D CAD course is an inevitable prerequisite for the raster handling class. The raster data course takes three half days.
- Usually, most of the 2D courses will be completed before entering the 3D CAD course. The reason is that experience shows the return of a 3D CAD course being much higher if the trainees have sufficient mastery of most 2D CAD functions. They can concentrate on specific problems that arise out of working in a three dimensional space represented on several projection planes. The average user reaches a sufficient proficiency after about six weeks of working with the CAD system, at least four hours a day. If working hours on the system are less, it takes longer to reach the necessary familiarity with the system handling. The 3D CAD course is a single set of three full days.

Additional to this range of courses, and the trainings for specific add-on applications that are offered by the software producers, there are workshops that cover special problems like plotting or user customization of specific software. These workshops are no longer than two days and offered by demand. They are a tool to react in a flexible way to questions that arise because of software updates or changes in the system setup. The latter, for example, can be caused by major changes in the networking or by major additions to the available peripherals.

4.3 The Classroom Setting

Most courses are held either by FAG staff members or by consultants. The rest is taught by the software producers' user support staff. The ZGDV (Zentrum für Graphische Datenverarbeitung e. V., Computer Graphics Center) covers the 2D and 3D CAD courses. These courses are held at the ZGDV or at the corporation's own educational center.

The setting is a classroom with six PCs with type 486 processors and two graphic monitors each. With at most two trainees sharing one PC, the equipment accommodates a comfortable class size often. The sixth PC is used by the trainer. The PCs are connected by a "pedagogical video network." This network can transmit the screen images of the trainer's monitors onto the trainees' monitors, thas affording a highly immediate way of demonstrating certain command sequences. It is a good way to help the trainees concentrate on the trainer's explanations, as well. The trainer can also look at the screen images of the other PCs to control the exercise sessions. Of course, conventional media like overhead slides and blackboard are utilized to support the explanations, as well. Additionally, the trainees are provided with German training manuals that they can use for annotations to eliminate notetaking all the way through explanations. These manuals focus on the more important parts of the command set.

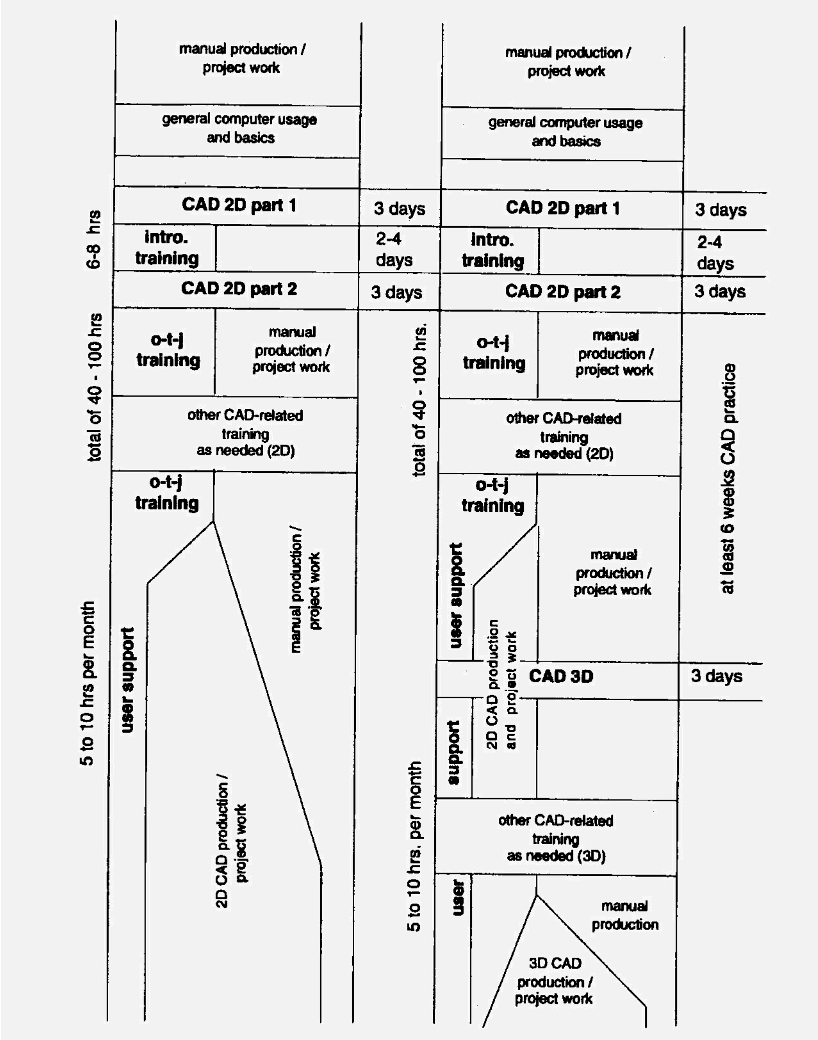

Figure 9 (a and b). Sequencing of courses and related activities with 2D CAD oriented training and with 3D CAD oriented training ("o-t-j": on-the-job).

The time frame of the classes is designed to keep the attention as keen as possible. There is no session that extends beyond one and one half hours. After this time there will be a half hour break, or the one hour lunch break. A one and a half hour session usually covers one topic or topics that are closely related. Complex topics will cover half a day. Within each one and a half hour block there are about two thirds of theory, that is explanations and demonstrations by the trainer. One third is left to the trainees for practice that is guided by exercises. The exercises are designed to repeat the more important aspects of what has been presented. They help the trainees to ask more informed questions. The class size of ten still allows for interaction between trainer and individual trainees when necessary during exercises. Sharing one PC with a colleague forces the trainees to work together on problems, learning not only from their own errors, but learning to support each other, as well.

4.4 On-the-Job Training

However, the courses cannot provide for a mastery of the software all by themselves. The basic modeler has a command set of about 350 to 400 commands. This does not account for all the possible options and option combinations. Even granted that the 2D and 3D CAD courses take a total of nine days there is a high amount of self-learning required from the users. These self-studies are supported twofold. On the one hand the reduced instruction set manuals help the users walk through the important commands. On the other hand each of the users is provided with a total of about 40 to 100 hours of on-thejob training. This training is oriented towards the specific tasks that the users will have to tackle in production mode. Usually the users themselves choose a project out of their recent or current conventional work. It is important that this training project is not subjected to the pressures of the real project work. The on-the-job training is not about meeting deadlines. It offers the users the opportunity to find out about how they can put the command set to use to meet their specific problems. The users also have the chance to develop a personal, efficient work style.

The courses and the on-the-job training are interspersed with conventional production (Figure 9). The future users have to be relieved from their normal work load with the goal that their productivity will increase after they start working on projects with computer support. The departments have to warrant this relief, otherwise their CAD introduction will not be funded.

Sometimes, however, the work load is so high that users cannot afford training time on top of the courses. Usually this leads to increased efforts when they finally decide to enter the on-the-job training phase. If at that time their work load is still too high to leave them with sufficient time for training according to their level of performance, the on-thejob training phase will be extended in a manner that is not satisfying for the users nor for the trainer. Rarely does the step have to be taken to remind department heads of their duty to distribute work in a fashion that affords the trainees to concentrate on the CAD training as needed. Without the high level backing of the project, such action would not be possible.

5 Changing to Production

Eventually the users themselves choose the time when they start production with the CAD system. Usually they themselves have a strong feeling about their proficiency with the system. The change into production is driven by the ambition to utilize *CAD* as soon as the specific advantages of computer support are understood. Another factor is the eagerness to prove to themselves what they have learned. Less important are the aspects of having to deal with data that are available only through the CAD system, or being prodded by superiors and the technical support people into production mode.

The users are not left alone when they discontinue on-the-job training and start production. There is user support available by FAG staff and by consultants. The areas of support are clearly divided, so the users know whom to ask when specific questions arise.

Currently the ZGDV deals with all questions concerning the functions of the basic modeler, in both 2d and 3d. All other areas are covered by the corporation's own staff. Experience shows that in this early stage of CAD usage in the departments an average support of five to ten hours per month per user is necessary. The time required for on-the-job training and the user support will certainly decrease with the growing experience of the users. Though there will always be "new" users because of fluctuation in the workforce, the relation in numbers of experienced users and less experienced users has not reached equilibrium, yet. Therefore, there is still an increasing potential of inter-user support.

5.1 Data Management

Heading into networked computer supported production requires thinking about ensuring data validity. Data validity comprises two main components. One is the data integrity in terms of the CAD system, the other is the correctness of the data in terms of the computer supported tasks.

Data integrity in terms of the CAD system can only be fully guaranteed if any action is prevented that possibly could damage the data, including damage caused by hardware and software flaws or severe failures. With the given complexity of the software, especially considering the interconnection of basic modeler, expert add-on, database engine, and geometric and alphanumeric database, there is an additional risk of human error damaging data integrity. All users know how to handle the basic modelling package. They can access all geometric data through this software. However, most users will not know the specific expert add-on that has to be used to manipulate a specific set of data. There is a very high likelihood that even minuscule manipulation of geometric data without using the supportive functions of the respective expert add-on will disturb if not destroy the linkage between the geometric and the alphanumeric data. The intelligence that has been invested in the data will be lost. The work that has been spent on generating these data will be lost, as well.

The correctness of the data in terms of the computer supported professional work can only be ensured by the expertise of the respective users. The user generating a set of data or performing a specific range of tasks on a set of data has to take the responsibility for the professional correctness of her or his work, or else the user's superior has to take responsibility. This is not different from the responsibility problems with conventional production. On the one hand, users have to gain confidence in their ability to handle the CAD system in a way that enables them to generate the data that they want to generate because of their expertise in performing their given tasks. On the other hand, the user's have to get the feeling that the data that they have generated cannot be incorrectly manipulated by other people, mischievously or because of incompetence.

Of course, tight control of data access can interfere with the necessities of team work as it is required in facilities planning and management. There has to be the possibility of acquiring information necessary to perform specific tasks. Users do not only need to be able to look at data that other users have generated and possibly are still working on, they also have to be able to locate these data, in the first place.

At the airport, data validity is ensured at several levels: the system management level, the operating system level, the CAD system level; the user level, the departmental organizational level, the corporation's organizational level, and the level of relations with third parties.

- Even in theory, thorough quality control of both hardware and software cannot exclude damage to data because of hardware failure or context related software bugs. In practice, new hardware is tested by its future users before it is used for production. New software and updates are tested for several weeks in a special testing environment before they are installed at any other work place.

- Daily remote backups of user data help to reduce the potential loss to a minimum.
- The operating system (a UNIX dialect) supports the control of access rights to data files on three levels. "Read," "write," and "execute" access can be assigned to the owner of a file, a group of users, or the entire world, that is, to all users that have access to the file system. Securing the data so that a user can be certain that no one will be able to change or delete data, means to deny "write" access to everyone but the user.
- The CAD system supports team work, or task distribution while protecting the data in addition to the operating system's access control. If a set of closely related data is generated by several persons, this set of data can be subdivided in different files according to the task distribution. The CAD system supports this subdivision through the possibility of referencing the geometric data that are contained in other files than the one currently opened for work. The geometric data in the referenced file is displayed as if contained in the open file, however, the data is protected. Referencing is a read-only function. Referenced files cannot be changed via the open file to which they are attached. At the same time, it is possible to open such a referenced file directly, given the proper access rights, and work as is necessary for a team working parallel on the same project.
- All users receive extensive training and support as described above. Individual on-the-job training assures maximum competence before a user begins production, that is, before the necessity to access third party data arises. If access is necessary for training purposes, this access is supervised by the user support staff.
- The data in the departments is organized according to the respective professional aspects. This enables all users within a department to reference all departmental data. If data need to be changed, a request must be submitted to the one user responsible for the respective data. This means additional coordination of tasks, but enforces the correct treatment of data and conscientiousness about responsibility for the data.
- On a corporate level, these departmental, professional criteria have been adapted for the archiving of conventionally produced data, already. The almost comprehensive system was necessary for archiving all planning documents on microfiche. This established, rigorous archiving system is now adapted in a way that can be implemented in a networked system, so all users can find all data needed for referencing. The archiving software, a custom development for the airport by C & L Consulting, supports the release of well-defined data versions to the archives by the respective user responsible for the data. In addition to all aforementioned controls of access to data, an additional access control is executed by this archiving software. This additional access control supports data protection according to the interdepartmental datafiow (Figure 10).
- A consistent semantic use of geometric data, that is one valid system of corporation CAD standards, is supported by interdepartmental coordination of the use of symbols exceeding mandatory, national or international professional and industrial standards; and by coordinating the use of attribute sets denoting specific meanings of geometric elements. These coordination efforts are supported by the corpora-

tion's own user support staff as well as the consultants.

- The interfacing with contractors is regulated through the contracts. All new contracts request contractors to deliver in Intergraph MicroStation 32 data format. Contractors are also informed about the corporation's standards. Considering the volume of contracts that is awarded by the FAG, potential contractors usually will be able to afford the necessary hardware and software, or at least take responsibility for conversion of data formats if they produce with a different CAD system.

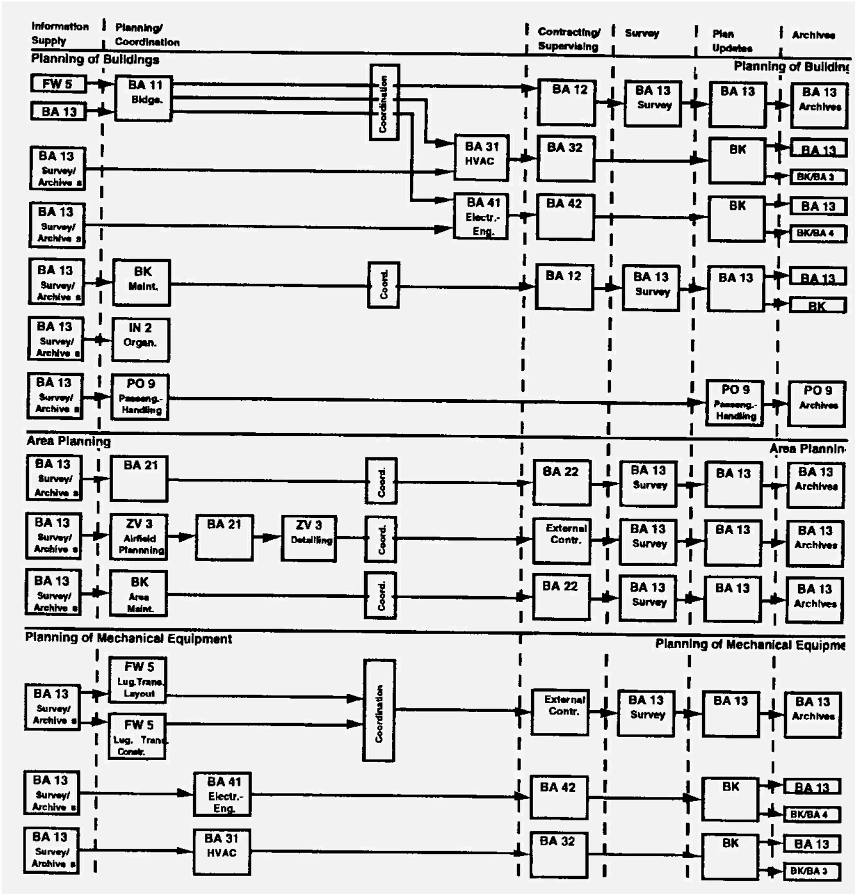

Figure 10. Flow of data in typical planning processes at the airport.

5.2 *Additional Support Through Specialized Tools*

Within the range of the CAD introduction to the airport, special problems arise that need special answers. Task analyses sometimes show tasks of a specific work place are not readily covered by the available software. Users then have to work around the restrictions of the CAD system. Usually, that means an increased amount of time and increased dissatisfaction with computer supported work. In a few cases for such tasks special software tools have been conceived. The goal of these custom designed tools is to provide more intelligence with less complexity.

One example is the system of signs in the main terminal building. It indicates directions to the available facilities, for example, the gates. There have been efforts to establish a conventional management system for these signs. About 3,000 signs have been photographed and catalogued, but there seemed to be no way to systematize these efforts so the data could be evaluated for consistency.

The solution is a tool called "BIS" that makes it possible to put the catalog into a database and to display these data not only in their alphanumeric representation, but also in the geometry they describe. The geometric part of the system is based on Intergraph's MicroStation 32 for data consistency, with a connection to a relational database engine for which a data structure has been developed that showing all entries of the catalog in an optimized fashion. Of course, alphanumeric input is dialog-oriented. Dialogs are designed close to the catalog forms so users' adjustment time to the new tool is minimized. Geometric data of the terminal's floor plans must be supplied. Display signs are generated according to the specifications in the alphanumeric database; therefore, the display is always a current representation of this alphanumeric database. This consistency should be maintained not only in the appearance of the signs, but also in their location within the terminal. Signs can be changed by altering the alphanumeric database or by editing the geometry with the CAD system. The alphanumeric database is changed accordingly. This tool was conceived and initially developed by the ZGDV, and later by a former employee of the ZGDV who did the major part of the implementation. In a future step, the system will be extended to include the new terminal building at the Frankfurt Airport.

Another example is the planning of security systems within the new terminal building. Here, as well, alphanumeric data have to be connected with geometric elements, with both sets of data consistent because they are documents for contracting. The solution currently in the concept state is called "SEC." Again, the existing forms are adapted to a dialog format for input in a relational database. The geometric elements denoting system parts in the plans are linked to the respective alphanumeric information, so queries of the database can have geometric as well as alphanumeric output.

6 Conclusion

The success of the introduction of CAD to a big corporation depends on several factors. The frame is set by placing responsibility for the CAD introduction as high up in the corporation's hierarchy as possible. Direct responsibility ensures the CEO's support and eases frictions on lower levels of the corporation's hierarchy with the chance of higher level mediation. Prerequisite for a CAD concept that meets all demands is a comprehensive analysis of all tasks that to be supported by the CAD system. While there may be some compromises on the hardware, the software has to offer all functions necessary to manage the users' tasks. User training and support must be provided by competent staff members or consultants. Competence shows in a thorough understanding of the processes, good organization, coherent concepts for training and experience. However, full success for CAD is only achieved when all users can be engaged in the introduction process, from first analysis through the concept stages, the training, and the standardization efforts to the initiation of production mode.