DESIGN-BUILD TEAMS AT AEROSPATIALE

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Summary

Aerospatiale is one of the largest aerospace companies in Europe, with 37000 employees. The Aircraft Division, located in Toulouse, France, has 14000 employees. It designs and performs the final assembly of the Airbus family of commercial aircraft. Other divisions make helicopters, tactical weapon systems, and space systems. This article focusses on the Aircraft Division.

Aerospatiale has used computers in the aircraft design process since 1977, and launched the "design-build team" concept two years before. Since then, the emphasis has been on using computers to integrate the design process, not simply to make drawings of parts. Today, almost all of the A340's parts are designed by computer.

While design of individual parts is now well under control, M. Bernard Vergne, responsible for aircraft definition capabilities, says that modeling and planning assembly is their biggest problem. He has been seeking computer tools to aid this process "for 20 years" and only now has the first one appeared, the Assembly Design program from Computervision. It helps with configuration control but is not useful enough for predicting assembly problems. (See the ESNIB article "Object-Oriented Cad And Expert Blade Design At Rolls-Royce"for another view of this software.)

Another important area is sheet metal forming. Folded parts represent 40% of all parts on their planes, and no tools exist for accurate design that takes account of springback and bend radius. As a result, it is difficult to provide the shop with flat versions of these parts and specific bending instructions. At the moment, Aerospatiale is looking at using Artificial Intelligence (AI) methods to attack this problem.

History of CAD/CAM at Aerospatiale

Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) began at Aerospatiale in 1977 in the lofting shop, wheremetal patterns for sculptured surfaces were laid out by hand in the past. Later CAD was extended to the drafting department. Since the beginning, Computervision's CADDS software has been the standard. CADDS4X is currently in use. (At the helicopter division, Dassault's CATIA is used.)

CAD was introduced slowly by applying it to part families identified by group technology methods. The main families cited are "folded" (bent): 40% by part count, flat: 20%, rotational: 10%, the rest everything else, of which many are pipes and wires. Since the majority of these parts have simple shapes, the 2.5D and surface capabilities of CADDS4X are sufficient. No switch to solid modeling will occur until the consequences for manufacturing are thoroughly investigated. About 80% of the parts are made by outside contractors. The French data exchange standard SET (Standard Exchange and Transfer) is used to exchange data with with "design-build" contractors, but contractors that just design parts for Aerospatiale or other contractors to make must use CADDS4X.

CAD / CAM was introduced into an environment in which "design-build teams" had already been operating for two years. That is, the reorganization of the design process began first, and then computers were introduced. Design-build teams (a method recently adopted by Boeing for the 777 development program) seek to co- locate design, engineering analysis, manufacturing, and inspection people so that they can anticipate problems during design.

While the process of integrating design and manufacturing, and computerizing them, is still continuing, the sequence (reorganize, then computerize) was important. Top management drove this process and put it in the hands of engineers, not information technology people. The goal was to integrate the process from the beginning, not just to prove that computers could help design or manufacturing separately. At least, that is how the history is viewed now, after many years of pursuing the goal.

The implementation has two main parts: the geometric modeling software, provided by Computervision, and the database, designed by Aerospatiale. M. Vergne says they have spent twice the cost of their commercial software on their own developments, which include several kinds of analysis programs in addition to the database.

In spite of the computerization effort, much of the knowledge needed to integrate design and manufacturing is still in the heads of experienced people. This experience is concentrated at Aerospatiale by the strategy of focussing each manufacturing facility on just one of the types of part family.

Because the Airbus is a consortium of many companies in many European countries, Aerospatiale has had access to their design methods. Some of the things they saw surprised them.

At one company, designers cannot find the information they need quickly, especially information about manufacturing constraints. "Their problem is that they don't know anyone in the manufacturing department," says M. Vergne. At another company, CAD drawings of pipes still are in the three-view format of manual drawings with many cross-sections, whereas modern CAD permits pipes to be shown in realistic views with selected cross-sections and component lists where needed.

"The Database is Our Art"

Much of Aerospatiale's computer effort has gone into their database, which unifies the design and production processes. M.Vergne says "It is not a storage place but rather an industrial plant," where information is coordinated, checked, altered, plotted, and so on. The basic structure of this database is entity-relation; it is not an object-oriented database.

It contains not only the geometric data, but allowed lists of components (pipe fittings, electrical parts), tool information, surface finishes, and so on. The capabilities of the specialized factories are also available, though I got the impression that most of the detailed information is kept by people in their heads. So the computer is often used to exchange information between people rather than just look it up.

M. Vergne noted that the average time to make a CAD drawing is still the same 50 hours that it was when manual drafting was used, but the comparison makes no sense because a "drawing" today contains so much more information. Production information and process plans are the main addition, and many loftmen and process planners are no longer needed. In addition, there are standard quality sheets, technical directives for standardizing processes, and lists of allowed components. The database is designed in such a way that the production people can easily find these data.

Problems and Future Needs

M. Vergne cited three main problem areas

1) assembly

2) fabrication of folded parts

3) data exchange and data persistence

Assembly

Current CAD systems support the design of single parts but not assemblies. Computervision has recently introduced a product called Assembly Design, which permits users to create assembly drawings (drawings that show several parts in their correct relative positions and orientations.) Strictly speaking, this is assembly drawing design, not assembly design, since none of the essential tasks in assembly planning are supported: interferences between parts, sequences, access for tools or assembly people, disassembly for maintenance, and so on. However, the product is a useful first step, and Aerospatiale is making heavy use of it.

The present way of designing things consists of converting a preliminary design into single parts and then subassemblies. When assembly problems are discovered, the single parts must be redesigned. He wants to be able to validate assembly before single parts are designed, but there is a paradox in this hope: many assembly problems are caused by very small details on the parts. Checking assembly at a preliminary design stage will therefore not catch all the problems. However, major interferences, sequences, and access issues can be addressed. "You don't want to put an air conditioning duct where it might drip condensate onto a computer."

To encompass assembly properly, the database will have to be revised. Several views of parts and assemblies will be needed, including several degrees of detail and stages of subassembly. Also, a new kind of person will be needed, the assembly checker. Such a person may be needed for each main engineering system (air conditioning, for example). The subcontractors will have to be involved in this as well, and by remote access from various parts of Europe.

Experience from the A340 program is being collated and fed back to Computervision.

Folded Parts

Folded parts represent a different kind of challenge since process and material properties are involved, whereas assembly planning is mostly geometric and logical. The issue is to standardize all the knowledge concerning different materials and machines and to create a drawing of the flat part plus instructions on how to fold it into the desired final shape within tolerances.

The CAD companies, in Vergne's opinion, are presently in no position to produce software like this. They do not have the resources or the experience with manufacturing. But he feels that the companies are trying to offer this kind of service anyway since they have found that they cannot make money on either hardware or graphics software anymore.

When I asked if Aerospatiale would join with other aerospace companies to solve problems like this in the future, he said that some of their Airbus partners do not even see the strategic value of standardized data exchange, a much more basic problem.

So an entirely new kind of CAD/CAM is needed, of which both assembly and folded parts are examples. They focus squarely on the interface between design and manufacturing and involve a different kind of data and knowledge than the standard procedures and parts lists that Aerospatiale has been able to put in its database so far.

Data Exchange and Data Persistence

Aerospatiale apparently recognized the need for standardized CAD data exchange several years ago but, as noted above, has not been able to bring all of its partners along. SET is being used because IGES[1] does not work reliably and PDES/STEP[2] has not emerged yet.

Even if data exchange is solved, data persistence still looms. By persistence, he means the ability of CAD systems 25 years from now to read the data that were created last year or 5 years ago. Aerospatiale is not waiting for outside solutions but has written its own database in such a way that future CAD systems will be able to access it. This is accomplished in a way that is analogous to pseudocodes and cross-compilers in software: every time a new CAD system is adopted, a new interpreter is written so that it can read the database. He hopes that the US program CALS (Computer Aided Logistics Systems) will help, since CALS is aimed at similar problems. Note to Scientific Director: The following section was supposed to contain the lessons for US researchers. Since it didn't strike you as being on this topic, some additional words have been added to make the intention more obvious.

Research Implications

Two main issues appropriate for future research stand out here, although they can be seen at other companies as well. The first is the idea of the product data model (PDM) and what it should contain. The second is the question of providing early information to designers about future fabrication and assembly problems.

The PDM at Aerospatiale clearly is a mix of geometry and text, with the latter containing notes and information that all designers and engineers, including production people, can access and comment on. However, it does not contain much knowledge or many explicit process models. While folded parts are the example given, there are undoubtedly many others, here or at other companies. The problem is that they appear at present to be specific to each company (its knowledge, its machines) or to an industry. This means that the CAD vendors will have trouble creating a critical mass of resources and support to attack each one separately. Either the users must join together, or else the apparent differences between, say, airplane folded parts and automobile folded parts must be removed by research into the basic processes and machines.

Predicting future problems in fabrication and assembly during concept design runs straight into the paradox cited above: small details can have big effects. This fact eliminates strategies that depend on scaling laws and forces one to track all the details down sooner or later. Thus a triage of problems needs to be carried out, so that those which really can be handled during concept design receive researchers' attention while the others are left aside.

On this basis, a priority list of problems to attack might look as follows

1. detection of gross incompatibilities between assemblies in terms of function, malfunction, proximity, and so on (moisture, heat, flying parts due to engine failure, human access during normal operation, diagnosis, or repair)

2. finding access for routine things like original assembly or scheduled maintenance (requires database annotations indicating items that need regular maintenance)

3. finding access routes for interconnections between things, including approach paths to the items being connected

4. establishing the general "layering" of things: what's on the outside, what's next, etc.

5. detecting incompatibilities or interferences between single parts

Point of Contact

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[1] International Graphics Exhange Standard
[2] Product Data Echange Using Step / Standard for Exchange of Product Data