Development of a computer aided design system for assembly equipment of MC-21 aircraft

M V Lavrentieva, P E Chimitov, A S Govorkov
Irkutsk National Research Technical University, 83, Lermontov St., Irkutsk, 664074, Russia

Abstract. The article considers how to use computer-aided design systems in modern "digital production" for the development of standard elements of assembly devices for the assembly of components of MS-21 aircraft. It describes the initial data and the most significant factors determining the architecture of the developed system. An example of an assembly device frame describes a software algorithm capable of replacing the designer's work.

1. Introduction
The assembly device (AD) is a complex structure consisting of many different elements [1]. Thus, on structure of elements (types, classes) and their mutual spatial position concerning each other and bases of aircraft AD can considerably differ (in most cases SP is unique for each separately taken product) [3]. Nevertheless, from the whole set of used joint AD it is possible to allocate some typical constructions (solutions) of AD (and their elements), with some general signs, which variability of execution is possible to realize by means of program procedures [2].

From the point of view of the production situation at Irkutsk Aviation Plant, the most expedient for the development is the AD for the assembly of MS-21 assemblies (since the technological design process is in the active stage and a large volume of ADs is being created). Taking into account the large volume of FFU (flat frame units) in the design of the aircraft from the whole set of joint ventures for the assembly of the joint venture MS-21, the joint venture for the assembly of this class of assembly units (units) was chosen as a prototype. Thus sizes, arrangement and mutual arrangement of the basic elements of the AD do not matter as the variability of these parameters of the AD construction is provided by the program procedures of the system (at the expense of changing the input parameters without changing the source code of the program module) [4].

2. Results
On the basis of the above mentioned, as a prototype of the AD for the assembly of the MC-21 assembly, the device for the assembly of the bends was chosen (Fig. 1).
It should be noted that the use of a specific prototype of a AD does not mean that the system's software modules are created exclusively for building only one specific AD design. Variability of program procedures allows to create set of various ADs united by one classification attribute (AD for loader assembly) [6]. In other words, the following changes could be made to this prototype AD:

- size change;
- changing references to databases (orientation);
- changing the frame design, frame cross-section, end trimming, etc..
- changing the set and position of clamps and locks;
- changes in the type, kind and location of supports;
- changing the size, configuration, position of kurchiefs, ring bolts, nests for ring bolts, fences, etc.

At creation of the program system the basic functions which it carries out are considered not only, but also directly structure, architecture and principles of functioning directly of the program (as a uniform program complex).

The architecture of the system under development itself is determined by a number of factors, the most important of which are [8]:

- system assignment;
- operating environment;
- software structure;
- development tools.

Taking into account heterogeneity of objects of designing, there is a problem of optimisation for the purpose of reducing labour input into creation a system program modules.

The system is being developed for operation in the existing infrastructure structure of Irkutsk Aviation Plant's core business unit, the main features of which are:

- all users are connected to the same information network;
- centralized corporate servers are provided for storing the necessary information;
- The main CAD system adopted by Irkutsk Aviation Plant for design and technological preparation of production is CADSiemensNX and PDMSiemensTeamCenter;
- administration of all information infrastructure of the enterprise (including CAD and PDM) is carried out centrally.

In connection with the above described features of the operating environment, the developed system is designed rationally on the principle of two-level application (client - server architecture). Thus taking into account specificity of the organization of IT infrastructure it is preferable to use a principle of interaction "the fat client". In this case the most part of program procedures, the user interface, executive
files etc. are a part of a client part of the system established locally on the computer of the user. The server part in this case represents only the database.

The following data are used as input data for the system:

- the list of the main classes of service stations that require design automation;
- the list of standard representatives of service stations groups that require the development of automation means for their design (standard designs and variants of service stations for each class);
- the list of typical elements of service stations for each group, requiring automation of design;
- requirements for the construction of the College of Electric Power Engineering and Machine Building adopted by Irkutsk Aviation Plant;
- typical methods of construction of service stations and their typical elements;
- Normal libraries used in the design of service stations in the customer's design departments (College of Electric Power Engineering and Machine Building standard standards and library UDF, family of parts, etc.).

Due to the fact that the basic principle of the system operation is the principle according to which program procedures of the developed automated system should repeat (reproduce) the traditional method of construction of College of Electric Power Engineering and Machine Building service stations, adopted at the production site, it is necessary to use and inherit the main aspects of traditional design of College of Electric Power Engineering and Machine Building service stations. These parameters (the data necessary for building the program procedures of the system) include:

- principles of setting up databases for service stations MS-21 (in respect of which product axes and service stations the binding is set; in which cases it is possible to introduce additional bases; required dimensions, etc.);
- the main approaches in the formation of the structure of service stations MS-21 (the coordination of elements of service stations among themselves; the hierarchy of the dependence of sizes of elements of service stations; mutual influence of sizes; principles of positioning, etc.);
- rules and recommendations for the construction of College of Electric Power Engineering and Machine Building MS-21 (typical NX commands used in the construction of standard structural elements; preferred construction operations, etc.)

The data described above are used to create the logic of the work of program procedures of construction of service stations, as well as for the selection of specific classes from the library NXOpenAPI, necessary for the software implementation of procedures of building an electronic model in the SiemensNX environment (the peculiarity of the implementation of NXOpenAPI is that the "objects" created by the classes from the number of NXOpenAPI correspond to the corresponding objects of NX (geometric primitives, construction operations, etc.).

By virtue of complexity and multifunctionality of the developed system, it is rational to build it on a modular principle, and the system will have an internal organization (structure), formed by interrelated software modules (classes).

All element base of service station is subject to classification: prototypes (PR), standard products (SP), program classes (APP_CLASS)[11]. Classification is performed in order to provide the required manipulations with the element base:

- item grouping;
- selection of elements that meet the specified requirements;
- sorting.

The system uses two classifications:

1. Classification by service station group (CPSTO). The classification contains three levels: class (one sign), subclass (one sign), type (one sign).
2. Classification by design feature group (CPCP). The classification contains three levels: class (one character), subclass (one character), type (one character).

Relationships of system components are shown in the figure 2:

- each CPSTO classification grouping (CG) corresponds to a single CG according to the CPCP
Each CPCP classification grouping (CG) corresponds to a single CG according to the CPSTO classification;

- each CPCP-compliant CG has a single implementation in the program code (program class (APP_CLASS));
- one APP_CLASS can correspond to several CGs by CPCP / CPSTO classifications;
- one APP_CLASS (e.g., ladder class) can be implemented when building a model by several prototypes (PR) [12].

Figure 2. Relationship of system components

A vivid example of the elements is the version of the frame section of the assembly device for the assembly of components of the MS-21 aircraft. At construction of frame AD (both for assembling of panels, and for assembling of knots) the program module at creation College of Electric Power Engineering and Machine Building allows the user to choose type of section (a channel box or a square), and as the size (from among the sizes of hire accessible in accordance with GOST) (fig. 3, fig. 4 [13]).

```cpp
STO31::ASSY::Frame::Frame()
...
sections.insert(std::make_pair(doubleChannel, "Швеллерная коробка");
sections.insert(std::make_pair(squareTube, "Прямоугольная труба");
sections.insert(std::make_pair(compoundChannel, "Составное");
sectionNameArray.insert(std::make_pair(1, "Num10");
sectionNameArray.insert(std::make_pair(2, "Num22");
...
```

Figure 3. Code fragment of the AD frame parameter selection program
3. Conclusion

Thus, the following factors were taken into account in the selection of the AD prototype (on the basis of which the software modules were developed):

- the actual production situation at Irkutsk Aviation Plant;
- maximum prevalence of the AD prototype;
- set of features of the AD that provide maximum design automation (elements of the AD with the highest design typification and formalization of design).
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