Nacelles
ISSN : 2552-6987

6 | 2019
Conception aéronautique : une transformation digitale à bas bruit (années 1960-2010)

Foreword

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http://interfas.univ-tlse2.fr/nacelles/791

Electronic reference
Med Kechidi and Maurice Zytnicki, « Foreword », *Nacelles* [Online], 6 | 2019, Online since 20 juin 2019, connection on 24 mai 2023. URL : http://interfas.univ-tlse2.fr/nacelles/791

Foreword

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TEXT

1 Distanced from the visible experience of manufacturing, from the documented through drawings and calculations rather than texts, and linked to software components that are difficult to use in areas falling outside the scope of their capacities, digital aeronautical design tools occupy a somewhat hidden place in production processes.

2 In view of this, the intention of the sixth issue of the *Nacelles* journal is to take up the challenge. In the aeronautics industry – and all other innovative industries – digital tools are steadily gaining importance and are radically transforming the way in which increasingly complex technical objects are designed, manufactured, tested or maintained. During a period which began half a century ago in the 1960s, they revolutionized industrial organizations, working methods and the typology of skills. Moreover, they raised hopes of increased productivity and an extension of the interaction between aircraft manufacturers and their subcontractors who gradually became partners. Public authorities very quickly recognised what was at stake and became involved from the outset. In our opinion, these reasons justify writing a history of these tools, and even more so, a history of software tools. This is a history which is still in its development stage, and this issue constitutes a step in this development.

3 Three areas are covered and they are linked to different industrial needs and to specific digitalized processes. Indeed, if computer science is the common feature of these needs, it is important that we do not neglect how much they cover very different points of view, techniques and practices.

4 The first area which will be covered is drawing. Over the last quarter of the 20th century it has moved from manual execution on large boards spread across desks the size of hangars to computerized execution on machines which have become more and more sophisticated and which match the development of processors and graphic displays. Above all, drawing moved from 2D (2-dimensional) representa-

tions on paper to 3D (3-dimensional) volumetric representations, to which were added an ever-increasing number of functions for manipulating technical data.

5 The second area is what is known as "analysis" in design offices. This concerns predicting the physical properties of parts and their assembly, *i.e.* their resistance when loaded, their behaviour under temperature variations, and their aerodynamic characteristics. If the drawing makes the part or the assembly visible, analysis anticipates their qualities. Although these two aspects are distinct, this is why the two domains remain closely related.

6 The third area concerns the overall coordination of design activities and, in particular, the consistency of the multitude of data produced by so-called "author" software of which design and calculation are good examples. This area is dealt with using testimonies provided through the Phenix programme, a project which was conducted within the Airbus group between 2007-2010.

7 Tracing the history of these digital tools, even in a fragmented fashion, is a way of following the questions and imaginations that have nourished the industry for some fifty years. Mainly used in the automotive and aeronautics industries in the beginning, digital tools gradually became a means for the systemic rationalization of many other activities including architecture, civil engineering, electronics or electrical engineering. Engineers and scientists such as Pierre Bézier at Renault, Paul de Casteljau at Citroën and Steven Coons at MIT, to name but a few, came up with first modeling elements in the 1960s. They made up mathematical models capable of defining, creating and modifying complex shapes, and controlling simple machines. Though this was necessary, these "objective" technical capabilities were not sufficient enough to explain their fast-growing rise. In line with the findings of Jean-Pierre Poitou[1], CAO, for example, the rationalisation of the use of production tools and the reduction of product development time became major business imperatives used to increase competitiveness and deal with the higher productivity of American manufacturers.

8 These manufacturers benefitted from series effects which were inaccessible to French aircraft manufacturers and the latter had to react by gradually building tools that would improve both the development

and production processes. Then a specific part of the American aeronautical sector, CAD was, therefore, quickly perceived as a key element in the competition between the two countries. In the 1950s, Lockheed launched the first piece of software that enabled human-machine interaction by leveraging the latest improvements in computer technology[2]. A few years later, relying on the emergence of first graphic terminals, notably those from IBM, the American firm developed the Computer Augmented Design and Manufacturing (CADAM) software. World aeronautics now entered a new era with Dassault and SNIAS both realising that they had to follow fashion.

9 Tracing the history of digital tools also means trying to understand what made it possible to create the complex industrial coordination we can observe today. Collaborative platforms now combine vast networks of companies participating in a supply chain, and this allows for real-time cooperation through virtual platforms. Aeronautical design has become collective, with digital models based on 3D part design and "digital twins" playing a central role and it is technical innovations that have completely transformed organisations, businesses and processes. Thanks to them, the design and manufacture of 70 to 80% of an aircraft's components are distributed to partners of major manufacturers such as Airbus and Boeing. These aircraft manufacturers have, themselves, have modified their role: at first manufacturers, they have now evolved into architect-integrators of aeronautical systems. This major evolution is closely related to the digitalization of processes in the sector.

10 Inasmuch as the upstream manufacture, and the upstream of work on materials is concerned, information technology is of paramount importance. We are dealing with the conception and the creation of products, and we have now reached the stage of imagining what can be built. Isn't this the key moment in innovation? We are no longer in the utopia of the first market studies: an aircraft is built for a purpose, it is designed to compete with its rivals, its geometry is widely known, it has to be built. Design, at this stage, is about coming up with the best way of making an aircraft.

11 So what is the origin of tools so widely used from the 1970s to the 2000s? Maurice Zytnicki, in "Aux origines d'un logiciel industriel, Catia: les outils de conception des Avions Marcel Dassault, 1967-1980"

traced the development and ripening process of Computer-Aided Design at Dassault Aviation. He describes how public authorities perceived the importance of what was at stake, but above all, he attempts to point out what influenced Dassault into putting its competitive advantage – the Catia software [3] –on to the market in 1981. The risks linked to diffusing such know-how were well known at the time. The article by Claude Carlier entitled "Dassault et la Conception assistée par ordinateur" widens and continues the study of the area, after 1981, by using the founding of software publishing company Dassault Systèmes. This article highlights both the continuity and the evolution of the strategy over a 50-year period. It describes the gradual gains made by this publisher and how it has extended its offer to cover all management cycles in the conception, development and manufacture of complicated products in addition to the interface of plant management software. In "A Brief History of Computer-Aided Design", Yvon Gardan provides a more technical examination of the links between functions and hardware features, and the algorithmic ways of representing objects. Key players, manufacturers and laboratories are presented, and this provides a sense of the competition (or emulation) that has surrounded the computerization of drawing. Incidentally, the article shows that the story of CAD was also a French story.

12 With "From A300 to A350: Technical and Organisational Innovation Trajectory of Airbus", Med Kechidi puts the computerisation of design processes into perspective by establishing links with industrial developments of Aérospatiale. This article correlates the success of Airbus success with two types of factors: the first is the technological breakthrough brought by each new aircraft programme in terms of both design and manufacturing; and the second is Aérospatiale's (EADS, then Airbus) ability to develop an industrial organization model and implement a policy of modularisation and outsourcing around hub companies, technical and organizational interfaces between the architect and integrator, and the firms involved in aircraft design and production.

13 The interviews with Jean-Marc Thomas and G. – who preferred to remain anonymous – require a slightly longer introduction. Indeed, if the influence of a drawing and the use of 3D in aeronautical design is well understood from a visually point of view, if they become almost

tangible by turning mechanical parts in all directions on computer screens, and if assemblies willingly combine themselves with sub-assemblies, the role of "analysis" in the process remains somewhat hidden.

14 As with computer science, almost everything is calculated, and it is important to specify which calculations are involved when we discuss design. This is so in the field of structures, for example, but here we would have a similar approach in the diffusion of thermal phenomena along materials. Therefore, it is vital to predict at an early stage how forces affect the parts of an aircraft, and how they affect lift, weight, drag, propulsion in order to control and anticipate – depending on the materials – the shapes, functions and flight phase. Equally, it enables the control and anticipation of deformations, wear and tear, and even ruptures, which could affect components. We are dealing with the dynamics of constraint which affect the craft and with the validation of drawings, and we are dealing with computerised simulation of the behaviour of material structures.

15 The two interviews are very different. Whereas, Jean-Marc Thomas is well known for having been the General Manager of Airbus's site in Toulouse and for being the President of Airbus France in the 2000s, the interview did not concern this period. It dealt, on the other hand, with an earlier part of his career and when he worked in the Aerospace Engineering Department in the 1970s and 1990s. Jean-Marc Thomas's testimony bears the imprint of the manager he later became, and that of the devoted engineer he was at the time. It is, therefore, an unusual testimony which deals with the years he spent making calculations.

16 G's experience is that of an operator whose expertise was acquired over thirty years spent in an office of engineering where he worked mainly on the structure of Concorde and on other programmes such as Airbus and ATR. The interview focused on the advent of IT in structural analysis, how functionalities evolved, and how methods were modified. Three periods were taken into consideration – the 1970s, 1980s and 1990-2000 – and this enables us to see just how old the study of material physics actually is. By going over these methods, the interview outlines what transformations took place.

17 The interview with Jean-Pierre Poitou is of a different type. He was a sociologist, an articulate ethnologist and, therefore, was a man whose primary knowledge was far removed from the industry in question. His view of engineering offices is, thus, original and highly valuable as he studied the CAO from the perspective of cognitive practices and issues. As the author of "30 years of CAD in France" published by Hermès in 1989, sound archives relating to his research are available at the MMSH in Aix-en-Provence. They contain interviews with those who played leading roles in design in the 1980s and include interviews with designers and users of CAO's products. Jean-Pierre Poitou died in 2017.

18 The Sources, Actors, Testimonials section is devoted entirely to the PLM Harmonization ENhanced Integration & eXcellence (Phenix) programme which was conducted within the EADS group and which was launched in 2007 on the initiative of Louis Gallois, then the CEO of EADS. This programme responded to the industrial problem that significantly delayed the manufacture of the A380. Indeed, due to incompatibilities between the electrical design tools used in Germany and France the aircraft wiring could not be completed as the electrical harnesses as they were at the time could not be connected. It was decided that a global view of the problem be taken and that all tools and design methods used by the EADS group should be harmonised.

19 This being an extremely difficult job, Phenix targeted EADS three main roles: the production of commercial airliners, helicopters and satellites. These, however, are areas that are subject to very different constraints and it resulted in Phenix mobilising highly rare, and even unique skills. Doing so produced an impressive body of knowledge on the design and definition phases of complex products and, therefore, constitutes a prodigious reference point in the transformation of aerospace industries as well as providing first-hand accounts.

20 In an article entitled "Phenix: comment et pourquoi?" Jean-Yves Mondon describes the time when he was appointed Programme Manager by Louis Gallois. This testimony from one of the leading players provides an insight into the intentions of EADS' higher echelons of management at the end of 2006, and at the beginning of 2007.

21 Amaury Soubeyran was Jean-Yves Mondon's deputy, and being at the heart of "EADS: a young group of old companies" she is able to remind

us what EADS was like when the problem of harmonisation arose.

22 Francesco Sperandio was a member of the management of the Airbus Concurrent Engineering (ACE) programme which can be considered as a precursor of Phenix. "Airbus Concurrent Engineering, a precedent for Airbus in the Aircraft Division (1995-2005)" provides updates on the activities of offices that have been involved in engineering for the past twenty-five years.

23 Maurice Narayanin was Deputy Manager of the Phenix programme's Helicopter Division. In "Thinking about half a century of information: Phenix and the Helicopter Division", he shows how this part of industry differs from the aircraft industry and the Product Lifecycle Management (PLM) issues to which they are specifically related.

24 Frédéric Féru who was head of the Architecture working group, and Maurice Narayani, the author of "Unir et démêler informatique et métier: choisir les outils", deal with one of the most important aspects of the Phenix programme: choosing a common software programme. Although this choice was subsequently reviewed due to changes in market offers, the fact remains that this "benchmarking" has resulted in developing a process to weigh up the needs and to a comparison process from which much can be learned.

25 Philippe Mussat headed Astrium's[4] work on observation satellites and, in particular, piloted workshops on product definition. We can only imagine how difficult it was to piece together a definition, but we can also think about how interesting it must have been. In "Identifying and collecting abundant data, sharing its use and ownership: the Aspire program at Astrium", Mussat describes how it was necessary to go beyond certain limits.

26 If a history of design tools contributes to the understanding of the transformations that have affected the design itself, it only provides a short insight. In fifty years, design offices have undergone profound changes in terms of operations, recruitment, relations with the outside world, and their involvement in the complete production of the final product. The aerospace sector is just as concerned as the entire industry. Nevertheless, the fact remains that the extended enterprise and distributed design – made possible because they were digital and

possessed a global dimension – provide fertile ground for future research.

NOTES

1 L'évolution des qualifications et des savoir-faire dans les bureaux d'études face à la conception assistée par ordinateur, J.-P. Poitou, *Sociologie du Travail*, Vol. 26, No. 4, 1984

2 Interactive Graphics for Computer-Aided Design, by M. David Prince, Addison Wesley, 1971.

3 Originally CATIA stood for Conception assistée tridimensionnelle interactive appliquée. But with its popularity it became a brand name as such, and its initial meaning has gradually disappeared.

4 Today Astrium is a part of Airbus Defense and Space.

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