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Research on Multi-Specialty Coordination, Multi-Discipline and Multifunction Integration Oriented Modeling and Simulation Innovation Technology

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Abstract

The paper mainly covers the connotations, the functions and the key techniques of the Aircraft Digital Cooperative Robust Integration Optimization Performance Simulation Technology. The Performance Simulation Airplane Integration Design Platform, which has been established by the Performance Simulation Airplane construction analysis, a series of Standard Specification Establishing, the key modules development and a series of the supporting work implementation. It can be customized and be extended, and it is easy to be demonstrated. The platform contains the engineering database including the Performance Simulation Airplane model, simulation process data, simulation results data, and so on. It also provides the closed development process from the initial design to the optimized design, and end to the final detail design. It carries out the configuration selection and performance analysis for the airplane various configurations under the product development requirements in the entire process. It is applicable for the cooperative simulation analysis about the General Configuration research, the Aerodynamic design, the Structure design, the Strength design and some system specialties. This technique system has brought revolutionary changes to the traditional technological concept and Architecture, and it has been proved that the design period of the product is shortened by more than 25%, and the simulation test period is also shortened by more than 25%.

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Keywords: Performance simulation plane; Coordinated development; Robust integrated optimization; Value drivers;

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1. Introduction

Under the current background of product marketization and competition globalization, customer demand, environmental requirement, system policy and market expectation all require the manufactured airplanes to have more excellent overall performances, so we must weigh and decide various performances and the new technical applications that achieve such performances. Airplane, as an extremely complicated assembly involving multisystem operation and mutual effect, needs various multi-discipline and multi-specialty parameters to reflect the overall performance index thereof. During the whole R&D cycle of the airplane, a large number of scheme comparisons and reasonable trade-offs are needed due to the interrelation and mutual effect among various disciplines. Therefore, it is necessary to effectively manage all characteristics that present the performances of the airplane in order to prevent reworking and wastage of development cycle & cost. Generally speaking, airplane design includes six stages, namely, project argumentation, preliminary design, detailed design, experimental verification, test flight and delivery. Especially, at the early stage of design process, the multi-physics field analysis is needed to eliminate risk and accurately predict the functional characteristics of the detailed design stage. Furthermore, due to stricter requirements on test and certification, the advanced verification carried out through simulation is also needed. Additionally, most of our airplane design is discrete, isolated and non-systematic, and the design data have not been effectively shared till now and cannot form automatic cycle, thus causing a lot of duplication of labor, low design efficiency, long design cycle, high cost and in adaptation to the development task requirement under new situation. Accordingly, it is necessary for us to research multi-specialty coordination, multi-discipline and multifunction integration oriented modeling and simulation innovation technology.

2. Present Foreign and Domestic Research Status

Multi-specialty coordination, multi-discipline integration and multifunction integration oriented airplane development has become the development trend of airplane R&D in the future. Looking at the aviation product development mode in the whole world, cooperative development, discipline and performance integration have already become the most effective and powerful methods for comprehensively improving development quality and shortening development cycle as well as the technological base for supporting the aviation industry to rapidly strain and thus adapt to market. The innovative development mode firstly applied by the western developed countries represented by US in airplane development field has obtained obvious benefits. Under the support of digital technology, Boeing Co. and Airbus enable the developers at different regions to get together for airplane development project so as to support the global parallel airplane development and thus bring the global optimal airplane development capability into full play as well as achieve capability integration. Obviously, the advanced innovative development mode has already become the new mode for modern airplane development and the important part of industrial core competitiveness.

CRESCENDO (Collaborative & Robust Engineering using Simulation Capability Enabling Next Design Optimization) Project Research carried out by 59 partners in 13 EU countries aims at improving the airplane performance dataset management and the performance data generation process so as to respond to the great challenge of airplane development in future, thus ensuring the maturity (on all levels) of all products from the beginning to the operation process [1]. The goal of the project is to make a great progress in the field of the traditional modeling and simulating technology application through the cooperation among multidisciplinary teams of cooperative enterprises in order to obtain more product performance, time effectiveness and cost effectiveness during the development of new aviation products. CRESCENDO Project enables the R&D cycle of airplane in future to be reduced by 10% and enables the overall design and manufacture reworking rate to be reduced by 50% as well as enables the physical test cost to be reduced by 20%. Task and schedule of strategic research on aviation industry mainly influenced and changed thereby include the following three aspects: 1) make use of advanced digital analysis, design, manufacturing and maintenance tools, methods, means and process control to halve the market cycle of the new products; 2) strengthen the integration of the supply chain and the overall R&D process of products through network-based cooperative development; 3) significantly cut down the operation cost and continuously reduce travel expenses in a stable way through network-based cooperative development. Therefore, during various stages of R&D cycle of airplane products, CRESCENDO Project can provide effective management tool for

aviation supply chain to effectively manage the parts and the functional requirements thereof of the enterprises on the supply chain and meanwhile promote the maturity of the virtual products. The main achievement of CRESCENDO Project includes: developing the basic environment for supporting BDA structure, which includes three key concepts, (Fig. 1).

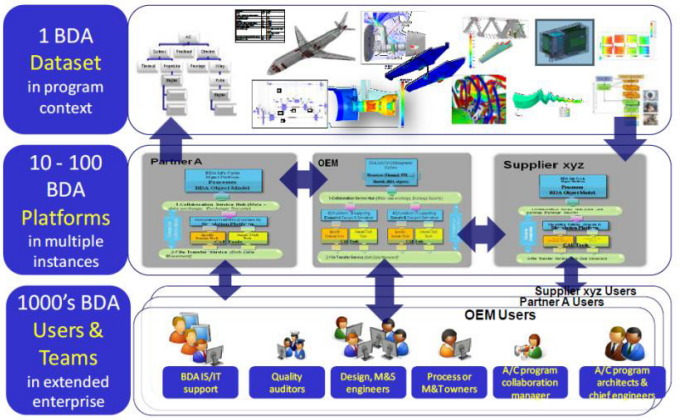

Fig 1. BDA involves data collection, platform and users

One BDA shared dataset which refers to the dataset expressed by a kind of multi-partner, multilevel, multi-discipline and multi-quality characteristic digitals during the R&D process of airplane, the system and the sub-system thereof, and it is a non-federal unique data source, and each airplane R&D project has an independent DBA dataset. 10-100 DBA specialty platforms can be used to provide cooperative service and multi-physics field simulating capability in order to manage, operate, maintain, reuse and enrich all models and relevant data used for creating, evolving and maturing DBA datasets. More than 1000 DBA platform users include thousands of potential users and design teams of cooperative enterprises, so they can make use of this platform to efficiently create shared information, generate and construct DBA datasets, wherein these users include airplane project leader, general designer and project design personnel who are responsible for design, modeling, stimulating, etc., with support from information system and IT experts.

CRESCENDO Project totally completes four application cases, including: value-driven design, heat integration (or called hot airplane), power integration and energy integration (or called energy airplane). During the implementation of the project, the technological innovations brought by deploying DBA platform are as follows: 1) form the cooperative work environment that supports multi-partners; 2) form multi-layered model organization and management; 3) form multi-physics modeling and simulating (M&S) integration and carry out end-to-end modeling and simulation at the early stage of the development cycle, which includes quality assessment of validation, verification and affirmation (VV&A), value and risk prediction decisions (including risk capture), etc.; 4) achieve the reusability of knowledge, model, method and tool; 5) form airplane project structuring design decision environment, etc. Fundamentally, CRESCENDO Project enables the results of preliminary design and early definition stages to become the result of "simulation-driven cooperative design" and gradually transfer it into the "cooperative design verified by simulation" at the later test and certification stages.

Looking back to the domestic modern airplane development process, multi-specialty and multi-discipline cooperative design is more or less applied to the development process, thus breaking through specialty, discipline and region limitations, etc. Meanwhile, compared with traditional mode, such development process also has certain innovation and breakthrough in the field of informatization application and construction, but there are still many design and management problems to be solved urgently, for example: 1) although concurrent engineering concept has been introduced, the design platform for multi-discipline integration and the ability for multi-specialty coordination and rapid loop iteration design are lacked and half "concurrent" design mainly exists among specialties,

thus causing low work efficiency; meanwhile, some performance analysis, assessment and display are lagged; 2) the effective measure for the complete process integration is lacked, namely, without fully integrating the design means (such as software and database) among current specialties, so it is difficult to achieve some performance analysis, assessment and display of airplane and the system thereof at preliminary design and scheme design stages, due to the excessive dependence on physical and semi-physical tests at detailed design stage or pilot stage, which makes the problems discovered at later period and causes the frequent reworking phenomenon; 3) the simulation process data is not effectively managed, most of the simulation analysis process data of various specialties is personally stored, without any platform for effective management, so it is difficult to achieve the requirements of unique data source, data sharing and data traceability; 4) CAD and CAE models have poor common use property, due to the existence of specialty and software barriers as well as information isolated island; there is also a lack of effective measure to directly convert CAD model into CAE model, so it is difficult to achieve the requirements of rapid static and mobile analysis and fatigue strength analysis as well as other simulation analysis; 5) knowledge-based design process is not solidified; although such design process has the experience of multi-model development, it is still difficult to describe such experience in the design process and meanwhile the deposited knowledge cannot be presented in the design process, etc., so there is still a certain gap existing between the design process and the foreign CRESCENDO Project. Therefore, it is necessary to carry out relevant research to solve the problems we are facing at present.

3. Research on Digital Robust Collaborative Optimization Performance Simulation Technology for Airplane

The research on digital robust collaborative optimization performance simulation technology for airplane aims at clearly defining the digital performance simulation airplane and developing the systematic and integrative airplane framework with digital performance and engineering practicality. The digital airplane R&D mode with “template engineering knowledge, product design coordination, design analysis processization as well as visual performance index” can be achieved through comprehensively applying project management, process management, resource management, CAX software integration, etc. so as to build the digital performance simulation platform based on multi-specialty coordination and multi-discipline integration design, simulation and optimization technology, get through the digital, performance-based and value-driven design flow and construct the digital airplane simulation verification system as well as improve the design efficiency, standardize the design process and improve the design quality[2-4].

3.1. Research Target

The target of the research on digital robust collaborative optimization performance simulation technology for airplane is to achieve the effective management of data, process, personnel, etc., obtain and display single and comprehensive performance results of airplane, visually and real time assess the performances of airplane at the design stage so as to rapidly improve the probably existing performance defects and further achieve the multiple iteration and the rapid multi-discipline optimization of the specialty schemes concerning overall airplane, pneumatic, strength, structure, system, etc. Meanwhile, the target thereof is also to form a set of digital closed development process which can not only meet multi-specialty coordination design and analysis concerning overall airplane, pneumatic, structure, system, etc., but also apply to multi-discipline coordination and integration concerning static, mobile, electric and liquid disciplines, etc. from initial design to optimization design then to detailed design drawings as the termination so as to achieve the rapid model selection among multiple configurations and the performance analysis for airplane which can meet the product development requirements during the whole process, thus guiding airplane designers for high-speed decision, effectively improving the design level and the design efficiency of the design schemes for airplanes, shortening development cycle, saving development cost and improving development quality. Finally, the extensible and customizable knowledge-engineering-based digital performance simulation integration development platform is established through the construction of performance simulation airplane model, simulation process data, simulation result data, etc., the stipulation of a series of standards and specifications, the development of a batch of key parts and the detailed implementation of a series of supporting work. The key technologies of research on digital robust collaborative optimization performance

simulation technology for airplane include distributed software integration and standardized data interface construction technology, process-driven heterogeneous data recognition, transmission and management technology, rapid hybrid modeling and partial model reconstruction technology, distributed high-performance computing environment construction technology adapting to performance simulation airplane, etc.

Generally, research on digital robust collaborative optimization performance simulation technology for airplane is divided into performance simulation airplane definition and performance simulation airplane platform construction, wherein the performance simulation airplane definition is focused on researching connotation, extension, function, modeling method, supporting environment, etc. of the performance simulation airplane so as to provide the theories and methods basis for constructing the performance simulation airplane platform, while the performance simulation airplane platform aims at taking advantage of information integration and data management technology to meet various performance indexes of airplane, and this platform is an organic integrity jointly formed by performance simulation airplane structure, solidified design and business process as well as the performance data obtained from simulating calculation. Furthermore, researchers focus on researching the key technology of digital coordination robust integration optimization performance simulation technology to set up multi-specialty, shared and open environment concerning overall airplane, pneumatic, structure, system, etc., provide various performance calculation simulation, simulation result display and performance data management of airplane, achieve the effective management of data, process, user permission, tasks, etc. according to different design tasks needed to be completed by various specialties and performance indexes, support simulation analysis for various performances of a complete airplane, optimal selection and comprehensive performance display, achieve technology optimization and simulation taking demand pull and value drive as the technological indexes, effectively reduce design complexity and provide effective technical support for making decisions at various stages.

3.2. Research Contents

Process drive and process management are adopted for digital robust collaborative optimization performance simulation technology for airplane in order to improve the reusability of data and the traceability of process data, wherein the process drive aims at seamlessly transmitting the data needed and generated by each analysis software during the design process so as to make the tool, resource, personnel and method needed in the development form an effective integrity. Simulation process aims at overall planning of the development process, including business process and design process. Firstly, the advanced digital technology, the heterogeneous data integration and the cluster dispatching are adopted to get through the simulation digital stream and meanwhile solve the problems of the long large-scale computing time and low efficiency; secondly, a good deal of foundation database is established in order to provide convenient design tool and knowledge base for design personnel, real time display airplane performance design results on the basis of taking the performance simulation airplane as the final product of the design, and thus provide perceptual intuition for designers to evaluate and decide schemes[5-9]. Additionally, the digital robust collaborative optimization performance simulation technology for airplane can greatly simplify design test, development, test flight and other relevant processes in order to significantly reduce physical test and reworking, shorten production arrangement period, improve first-pass yield as well as reliability and quality of products, effectively reduce development risk and cost.

Performance simulation airplane is the digital airplane which is established by virtue of relevant standard, specification, tool, process and platform and which is also able to achieve performance definition, analysis evaluation, optimization, cross-linking and display for complete machine, system and subsystem at various stages of airplane development. Therein, 1) standard specification: quality guarantee for the construction of performance simulation airplane, common criterion and general “language” for communication; 2) tool: measures for constructing performance simulation airplane, such as CAD, CAE, simulation software, programming tool, etc.; 3) process: design process and business process, which are the measures for the efficient construction and effective management of performance simulation airplane; 4) platform: it includes software and hardware platforms, which is the environment for the construction of performance simulation airplane; 5) development stage: it can be the seven stages, namely, concept design, preliminary design, detailed preliminary design, detailed design, trial manufacturing, design finalization (airworthiness evidence acquisition) and use guarantee stages; 6) complete machine: airplane

level property and technical characteristic carrier; 7) system: property and technical characteristic carrier of certain specialty of airplane, such as overall specialty, pneumatic specialty, strength specialty, airframe structure, dynamical system, fuel system, etc.; 8) sub-system: constituent part of the system, such as hydraulic pressure subsystem of undercarriage, cabin pressure subsystem, etc. 9) performance definition: it means to define the property and characteristics that the airplane will meet on the basis of digital model; 10) performance analysis, evaluation and optimization: it means to calculate, simulate, optimize, virtually test, evaluate and decide the property and characteristics of the airplane by virtue of software and evaluation criteria integrated in the performance simulation airplane platform; 11) performance cross-linking: it aims at improving the overall performance of airplane and refers to the co-simulation in and between the specialties of the design department as well as the co-simulation between the design department and the manufacturer &supplier; 12) performance display: it means to display the property and characteristic of the airplane through visual modes, such as cloud picture, curve, chart, image, animation, etc.[10]; 13) performance simulation airplane: relatively to the real airplane, it refers to the dataset including various properties and characteristics of real airplane and constructed by virtual measure. The performance simulation airplane is the digital airplane jointly composed of many simulation models and simulation results in various specialties, which is visually expressed by several performance display systems. The core thereof lies in obtaining the performance data of various specialties through multiple simulation optimization iterations, and accordingly the designers can rapidly and visually obtain the main performances data of airplane through the above mentioned performance data.

Through digital simulation measures, the performance simulation airplane displays the relevant performances of airplane by different stages, specialties, disciplines and layers on the basis of airplane design process. The performance simulation airplane is composed of three parts according to the core functions thereof, namely, performance simulation airplane integration platform, design and operation process, and airplane performance simulation data, which is shown in Fig. 2.

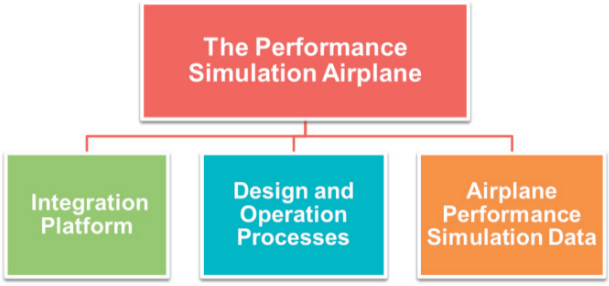

Fig 2.Performance Simulation of the Airplane

The digital robust collaborative optimization performance simulation technology for airplane places emphasis on constructing the integration design platform for the performance simulation airplane and getting through multi-specialty coordination and multi-discipline integration oriented design process, and focuses on solving the process drive problems concerning the specialties of overall airplane, pneumatic, system and structure, etc. of performance simulation airplane as well as the interface problems between some subsystems and the performance simulation airplane. The performance simulation airplane platform includes platform software, interface software, full life circle data management system and airplane performance display system. Therein, the platform software can implement process drive and integrated management for the commercial software and the inside procedures of the enterprise so as to ensure continuous communication and interaction of the data flow during the design process, thus achieving the customization, capsulation and management for design process and supporting the modularity call of process to enable the platform to have good openness and expandability as well as continuously enriched contents. The interface software is used to achieve the interface between various specialty software and platform so as to ensure the smooth communication among the specialty data. The full life circle data management system is an important part of the construction of the performance simulation airplane and aims at achieving the effective

simulation data management, thus ensuring convenient data acquisition, storage and management, wherein the simulation data management has traceable and convenient tree form file structure and is able to provide version control, convenient backup and storage as well as data sharing and cooperative coordination [11]. The airplane performance display system can comprehensively display the performance of various specialties through proper post processing mode, including airplane appearance, flight quality, flight load, structure strength analysis, dynamics simulation, strength margin cloud picture, cross-linking conditions of various systems and other relevant airplane performances.

During airplane development process, under the performance simulation platform, designers construct the design process, assign the resources for the business process and manage the personnel dispatching as well as obtain various airplane performance data after multiple iterations according to the design input, thus forming the digital performance simulation airplane through such trinity mode. Among the three parts, platform is the foundation for constructing the performance simulation airplane, the design process and the business process are the key to complete the performance simulation airplane, and the airplane performance data is the core to realize the performance simulation airplane. The establishment of the airplane design process is the key point to decide whether the performance simulation airplane can meet the design requirements or not, and is also the core layer of the digital performance simulation airplane. On the basis of the summary for the traditional airplane design process, the characteristics of the performance simulation airplane is taken into consideration for various specialties in order to collect, extract and consummate the traditional design process, thus forming the effective airplane design simulation process, wherein the design process of the simulation airplane can complete the design analysis concerning various specialties, such as overall airplane, pneumatic, structure, system, strength, etc., and also can carry out calculation analysis, scheme comparison and optimal selection for various airplane performances. The business process includes the data exchange in and among various specialties and the interdisciplinary coordination and management is achieved through managing the business process, wherein the business process can be divided into four layers according to the hierarchical relationship thereof, namely “design stage”, “work package”, “work item” and “work”. The design process takes “work” as the termination and refers to the practical work process of designers, wherein this process is one-way and non-recyclable template process, but can be repeatedly executed. Furthermore, the business process co-exist with the design process so as to ensure the smooth completion of the design process according to the node requirements and meanwhile control the personnel permission and the working range, and this flexible process achieves the application mode of taking the data center as the core to ensure the uniqueness and coordination of the data source of various specialties and perform the clearly-layered structuring management for the design scheme data. The airplane performance data is the ultimate goal and inspection standard of the digital performance simulation airplane, the performance data of each airplane will become a unique identify label and can completely express the partial or full performance of the airplane of this model and also support for the model selection optimization. In the process, the completed parts of the upstream specialties can be transmitted according to the working condition or the work of upstream can be completed and transmitted according to the requirement of the downstream specialties, in order to enable the downstream specialties to have more time, thus shortening the iteration cycle and preventing risk in advance.

3.3. Technical System Framework of Performance Simulation Airplane Platform

Performance simulation airplane platform covers foundation database, overall specialty integration design platform, pneumatic specialty integration design platform, structure specialty integration design platform, system integration design platform and extensible interface platform, etc., which are plotted in Fig. 3. wherein the foundation database (parts library, material library, standard part library, etc.) provides bottom design data support for various specialty platforms through data flow, and each specialty platform includes its own performance analysis and optimization tool and method, and meanwhile the data sharing based on common framework among these platforms are achieved through advanced data integration and strong data management.

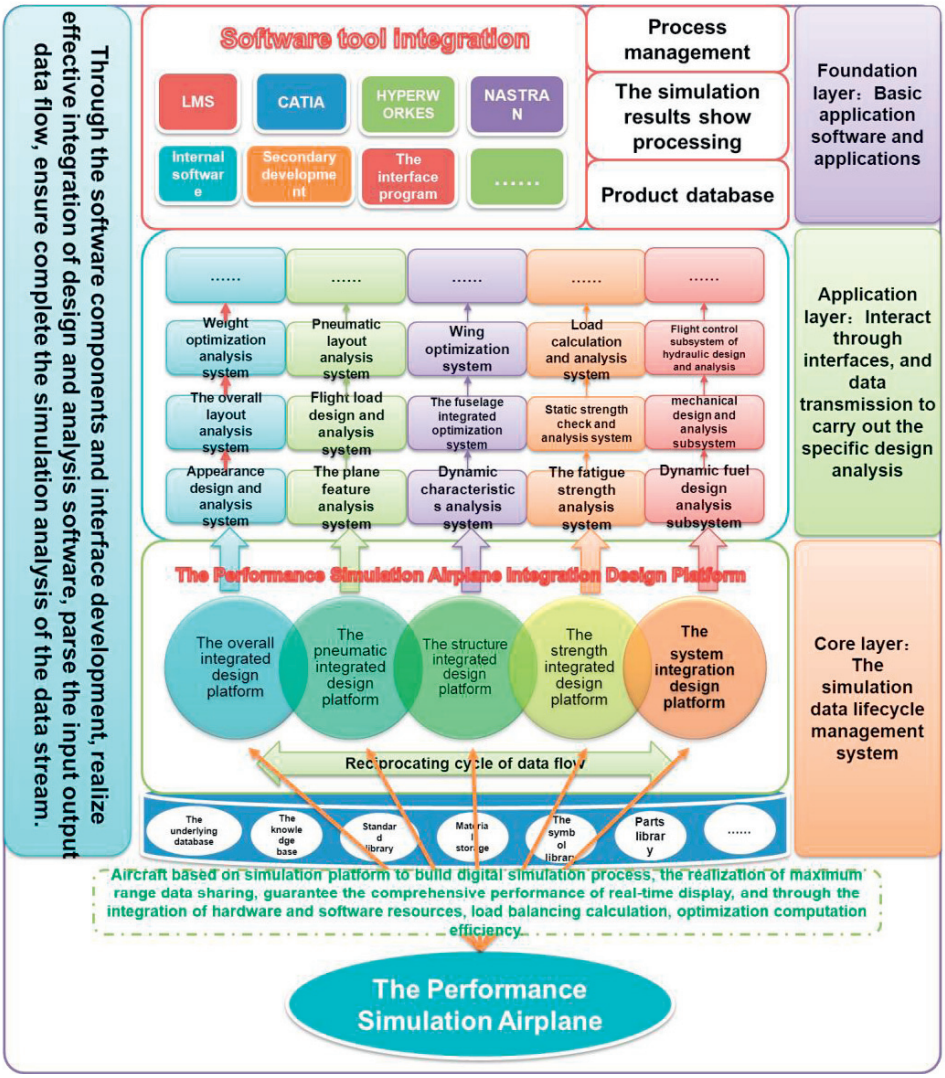

Fig 3. Performance Simulation Airplane Topology

Airplane performance refers to the capability of the airplane for completing various tasks and the evaluation for the task completion situation, and various performances jointly constitute the important indexes for judging the success or failure and the quality of the airplane design. Therein, the airplane performance includes simulation model, calculation model, calculation result, etc. of pneumatic, material, electronic, electric appliance, control and communication disciplines, etc. of structure, system and overall specialties, etc. Part of the data is the foundation data already existing, and part of the data is the process and result data generated along with the design process, and all the data can be independently or comprehensively expressed through various forms, such as data, figure, table, cloud picture, video, file, etc. In summary, the data that the performance simulation airplane platform accesses and manages can be divided into the following categories: 1) foundation data: design specification, model library, optimization algorithm, material database, standard parts database, etc.; 2) design data: three-dimensional data (including data state, creation time, creator and other relevant information), product data, composite material layer database, etc.; 3) analysis simulation data: finite element calculation result of various iterations, many-body

dynamics simulation result, structure optimization result, version control and historical updating information, etc., including process data and result data; 4) business management data: mainly involving personnel, role, permission, task, state and node information, etc. of the design process, wherein the foundation database (parts library, material library, standard part library, etc.) provides bottom design data support for various specialty platforms through data flow, and each specialty platform includes its own performance analysis and optimization tool and method, and meanwhile the data sharing based on common framework among these platforms are achieved through advanced data integration and strong data management. Additionally, the performance simulation airplane platform shall be able to efficiently access and effectively manage the above various data in order to achieve the effective integration and the maintenance control for the distributed and heterogeneous data source and further ensure the effectiveness and traceability of the design data.

According to the progress extension and functional partition of the airplane development, the performance simulation airplane can be divided into three stages: 1) first-level performance simulation airplane: it is applied in the concept design and preliminary design stages and used for guiding the physical tests at the early stage through the performance digital airplane at this stage, such as model selection, principle, verification, etc., so as to select the key design scheme. 2) second-level performance simulation airplane: it is applied in the detailed preliminary design stage and used for preliminarily simulating the production process so as to find the improvement links and the key control links, transfer the verification into guidance and transfer the whole to key part. 3) third-level performance simulation airplane: it is applied in detailed design stage and obtained from simulation analysis through the complete input data at all levels after the completion of the detailed design stage of the airplane, and it is also used for expressing the complete performance information of the airplane. Additionally, according to the requirements of different personnel on the airplane performance, the performance simulation airplane can be subdivided into three levels, namely, full-airplane level, system level and parts level, and the performance indexes for the above three levels can be further subdivided and they belong to subordination and inclusion relations. In detail, 1) full-airplane level performance simulation airplane: it mainly orients to the requirement of the top application layer, and focuses on the overall concept display of the airplane level products and the general analysis of the overall function and main performance of the airplane. 2) system level performance simulation airplane: it mainly orients to the requirements of the system implementation layer, and focuses on the overall design display of the system level and the general analysis of the overall function and main performance of the system; as for the whole airplane and the technology decision-making level, it can objectively represent the technical characteristics and reflect the conformity of function and performance to the overall requirements, thus providing modeling basis and support for the airplane level performance simulation airplane. 3) parts level (finished products) performance simulation airplane: it mainly orients to the requirements of the parts level (finished products) implementation layer, and focuses on the overall design display of the parts level and the general analysis of the overall function and main performance of the parts system; as for the system design requirement and the parts technology decision-making level, it can objectively represent the technical characteristics and reflect the conformity of function and performance to the parts requirements, thus providing modeling basis and support for the system integration performance simulation airplane.

3.4. Application System Structure of Performance Simulation Airplane Platform

The application system structure of digital performance simulation airplane platform is constructed according to the three-layer system structure that includes foundation layer, core layer and application layer, which are plotted in Fig. 4.

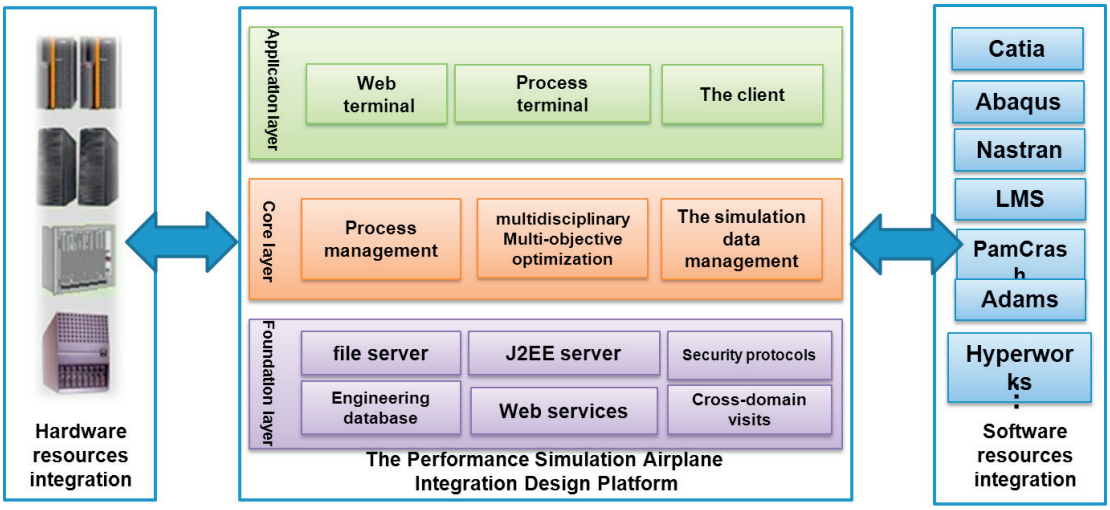

Fig 4. Performance Simulation Aircraft Platform Application Architecture

(1) Foundation layer: it mainly includes file database, engineering database, process database, application server, security protocol, etc. and functions as the bottom support for the construction and operation of the performance simulation airplane platform. Therein, the file database is mainly used to store and manage design specification, design requirements, calculation analysis report, etc. generated during the design process; the engineering database mainly includes special parts library, general parts library, standard parts library, material database, etc. and aims at meeting the management requirements on the foundation data source for design; the process database is mainly used to store and manage the middle process data formed during the design and iteration process, such as multiple finite element analysis data, simulation data, etc. Meanwhile, the foundation layer also needs to solve a series of key problems, such as data exchange standard, heterogeneous data source integration, information exchange, software architecture, etc., and mainly includes various communication protocols, data exchange standards, various software interface programs, distributed service based on web service, etc.

(2) Core layer: it mainly manages and controls the core business processes, such as design calculation and simulation analysis, and includes stipulation and management of multi-discipline process, finite element analysis, dynamics simulation, multi-objective optimization analysis, product performance data management, etc. The core layer aims at achieving the integration and concurrent control for the distributed computer hardware resources as well as the comprehensive usage and seamless connection for various software tools from the design process. Furthermore, the core layer also achieves the closed loop design process from the pneumatic configuration of the overall specialty to the load analysis of the pneumatic specialty and then to the comprehensive optimization analysis system of the structure specialty, and provides the interface for some system specialties to connect with the integration design platform of the digital performance simulation airplane.

(3) Application layer: it is a user interactive interface and provides friendly and multiple views (management view, process view, product model view, etc.) for users to check, wherein the user interactive mode includes application program interface, various CAX tool interface and Web browser, etc.

3.5. Function System Structure of Performance Simulation Airplane Platform

The primary simulation management task of the performance simulation airplane platform is data management and process management. SLM (Simulation Lifetime Management) and FIPER (Federated Intelligent Product Environment) of Dassault Co. are adopted for the project to construct the function system framework of the digital performance simulation airplane and accordingly build and integrate various function modules so as to achieve data management, process management and other relevant functions, which are plotted in Fig. 5.

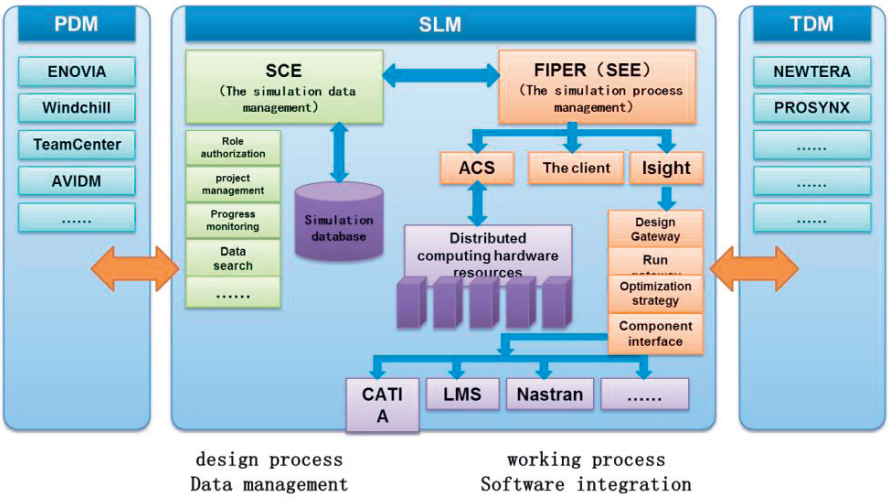

Fig 5. Performance Simulation Aircraft Platform Application Architecture

SLM system structure of the performance simulation airplane is responsible for storing and managing design simulation process data, detailedly recording the activities and the history thereof related to the simulation so as to make the simulation history have traceability. It is also responsible for managing the version, permission, etc. of the process data, achieving the seamless integration and mutual resource access with the present product library database (e.g. LCA) as well as the creation and management functions of the business process. Based on FITER integration platform, it also completes the creation and management of the design work process, achieves the definition and capsulation of the design data flow and modularly completes the specific calculation analysis and simulation optimization. FIPER application controller integrates software and hardware resources to achieve the integration application of design and analysis software as well as the balanced load and automatic arrangement of the distributed computer resources.

4. Research Achievements of Digital Robust Collaborative Optimization Performance Simulation Technology for Airplane

Digital robust collaborative optimization performance simulation technology for airplane is mainly used to develop performance simulation airplane framework which is the foundation for achieving multi-specialty and multi-discipline integration modeling and simulation, thus making any specialty and any discipline work cooperatively on the basis of requirement and performance. Meanwhile, this framework is also favorable for managing the evolutionary process of the airplane performance from the concept design to the virtual test and then to trial production, and provides the standard language for coordination so as to enable the engineers to obtain the production information and support information during the end-to-end development cycle and further completely obtain the overall performance of the airplane products and accordingly make predicted decision based on a large amount of knowledge. The major achievements of the project research include:

- General requirements for the definition of the performance simulation airplane;
- General requirements for the integrated environment construction of the performance simulation airplane;
- Construction scheme report for the integration design platform of the performance simulation airplane;
- Database construction method and application guide of the performance simulation airplane;
- Construction guide of the performance simulation airplane platform;
- Relevant support database of the performance simulation airplane platform;
- Performance simulation airplane platform environment;
- Definition research report of the performance simulation airplane;

- Application verification report of the performance simulation airplane;
- Constructed airplane structure and verification model of system design and simulation analysis.

5. Conclusions

Different from the traditional digital airplane, the digital performance simulation airplane can completely achieve the simulation analysis and optimal selection of various performance of airplane, effectively manage airplane performance data, intensively express airplane performance through various forms and continuously extend according to the model change, so it is an organic integrity jointly composed of the performance simulation airplane platform, the design and business process construction and the performance data obtained from simulation calculation. Through the research on the definition and the used technology of the performance simulation airplane, researchers have made an overall breakthrough on the technologies, such as design, manufacturing, test, etc. of the digital performance simulation airplane and greatly improved the quick response ability of airplane development. Meanwhile, through engineering application, researchers have completed digital design, engineering analysis, simulation and test for the full airplane, established the performance simulation airplane samples of all levels, completed digital simulation of the structures and various subsystems in the computer so as to clearly definite the relation between model design and value demand, and also completed function demonstration, performance computation and test analysis so as to make the influence relationship of model change more transparent, thus effectively shortening the development cycle and reducing the development cost, minimizing the discordance and reworking caused by design demand misunderstanding and improving the overall performance of the airplane.

Performance simulation airplane platform, as the leap of digital application of airplane, is produced on the basis of the improvement of multi-specialty and digital levels of airplane, the correlation of various specialties and the airplane design requirements. This technology not only directly serves for present airplane development, but also provides technical support for the new airplane to be developed so as to improve the core competitiveness of the aviation enterprises and play a role of demonstration in the whole national defense industry to promote the rapid development of weaponry, as well as provide advanced technological measures for the development of the key model airplanes and the industrial process, thus making a great progress in the general airplane design level of our country and meanwhile improving our international competitive ability and sustainable development ability.

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