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Enhanced collaborative design through Interactive Decision Room

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Abstract

Large area displays provide multiple features that should facilitate collaborative activities in a concurrent engineering aircraft development process. Based on Airbus' Integrated Design Team organisation, we propose in this paper several realistic improvement of the design process using an Interactive Decision Room.

Feasible scenarios related to distributed design phases and co-design phases have been demonstrated in that sense. They feature the possible enhancement of program management, design review and project review in remote or co-located situation.

After a brief overview of the Interactive Decision Room and adapted interaction devices some of the most representative use cases will be presented.

Keywords: Computer Supported Cooperative Work, concurrent engineering, design reviews, design teams, planning and workflow.

1. Background and Objectives

Aircraft development process at Airbus is currently based on Concurrent Engineering principles so that new aircraft developments cycle is as cost and time effective as possible. One source of improvement is focused on the enhancement of collaborative work and simultaneous engineering.

On that respect, various tools and methods have been suggested and demonstrated by EADS Corporate Research Center. In particular a large area display has been implemented in a dedicated show-room to demonstrate the contribution of such tools in the scope of collaborative work and more specifically in Concurrent Engineering all along the aircraft development lifecycle.

Such large video-wall solutions have been widely used for general supervision (control-room) and presentation (marketing). Other more specialised solutions such as Reality Centres have been implemented especially dedicated to design reviews. The objective and originality of our experimentation was to give an overview and associated demonstrations of all the ways a program development team could take advantage of such a general large area display. Our industrial context is Airbus aeronautical integration activities as a focal and co-ordination actor in a new aircraft development program. In particular, the new Integrated Design Team (IDT) organisation [1] for aircraft development is taken into account. Such program organisation has been adopted since several years by Airbus.

2. Methods and application fields

2.1 Context and applications

It is compulsory during a concurrent engineering program to plan and control integration, synchronisation and coordination phases between the various actors of the project. Depending on the concerned conception phase however various cooperation mechanisms can be taken under consideration [6]:

1. Coordination and operational synchronisation in distributed design phases
2. Integration, cognitive synchronisation and evaluation during co-design phases

The **distributed design phases** are characterised by a distribution of the tasks among the teams, each team following different sub-objectives contributing to the common main objective. The notion of "distributed decision making system" applies in that case. The design process is then exposed to two main perturbations:

- Any modification on part of the system by one team can involve modifications on sub-parts treated previously or simultaneously by other teams.
- Chronicle data instability and fuzzy design objectives constantly challenge many important choices and make previsions hard to establish [7].

It is therefore in order to ensure task distribution among all partners within the extended enterprise and manage the tasks temporal synchronisation between the different teams that the program management team must set up operational synchronisation mechanisms. This operational synchronisation involves coordination activities in order to ensure the design decisions' coherence. Our first identified use case is then to study the potentialities of the decision room to facilitate the project supervision, co-ordination and provide overall communication of the project to the participants, in other terms study how the environment can support logical-type decision.

However, distributed design has limits. Indeed, not all elements can be anticipated (incoherencies due to unplanned modifications, errors spreading among teams…). This is why design phases are interrupted with progress meetings giving place to confrontation, discussion and standardization of each team's wok. Those phases are called **co-design phases**. They can be declined in various types of meetings or review but all have as common denominator to gather all involved partners, regarding their fields of expertise, around given thematics in order to compare and integrate their viewpoint through negotiation and argumentative movements [8][9]. Those reviews define the second typology of use case envisioned as the interactive decision room is the obvious environment for collaborative meetings (design reviews, project reviews) to take place, in both remote and co-located situation. The objective for the environment is then to support analysis-type (i.e. Design Review) and investigation-type (i.e. Expert Support) decisions.

The principal outcome of those negotiation processes within co-design is that they set up construction mechanisms for design objects and evaluation processes shared perception, it is the cognitive synchronisation notion [10]. In other terms, those meetings aim at establishing a mutual knowledge context inside of which the common operative referential is defined, a shared vision. As a matter of fact, it is necessary that all participants no matter their culture have at hand a unique and unified representation of the project and its methods.

In both cases the large area display can be considered as a wide shared interface among all participants. Given its unusual dimensions (4m x 2.25m) the large area display is generally an obvious mean of synchronisation between all the project actors providing a wide shared space dedicated to the project's communications. This shared communication space thus focalises all information on a single spatial location facilitating the cognitive synchronisation of the project perception among the participants [2], we develop a collective comprehension from the collective visualisation.

The high potentialities of such displays in a collaborative engineering environment rely as well on its large display size enabling simultaneous comparative and concurrent simulations on large models such as aircraft's digital mock-ups (DMU).

The following paragraph will describe some of the Interactive Decision Room specificities while more detail on the two identified use cases will be developed in the next chapters.

2.2 The singularity of the interactive decision room environment

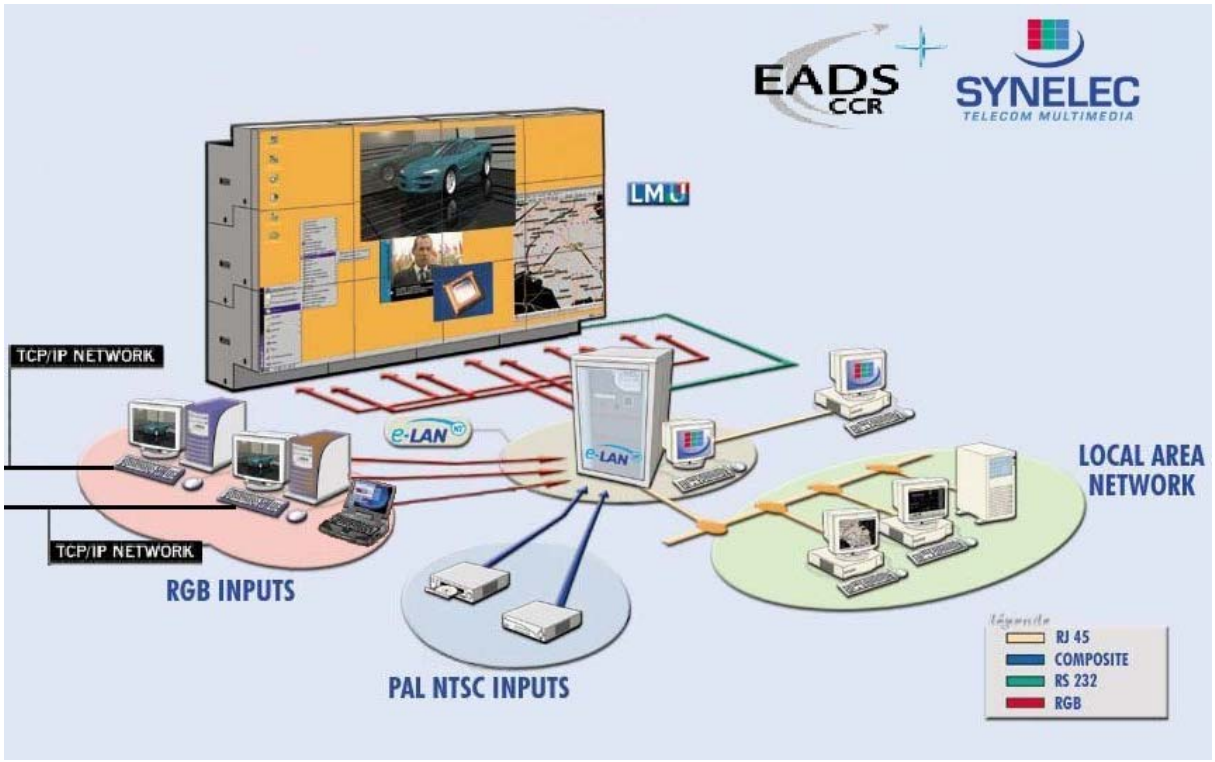

Figure 1: System Architecture

Our aim is to provide a flexible enough environment to support the scenarios we identified within an industrial context. On that respect our approach slightly differs from the one undertaken by Stanford University with the eRoom project [11] or GMD-IPSI's i-LAND [12].

While those environments mainly rely on an architecture that enables to create and add new displays and input devices, to move work of all kinds from one computing device to another, which definitely facilitates group interactions providing a high spatial flexibility and mobility of the employed information devices. And even if iRoom's EventHeap architecture [4] was implemented on a web based architecture (for control over applications), all those projects make the assumption that all devices are connected to the same network. This assumption is hardly ever true in an industrial context, especially for such an extended enterprise as Airbus.

As it seldom happens that all participants prepared the meeting material (thus need to access remote computers), use the same network, have administrator's privileges or even wish to share data with other participants (for security reasons mainly) the environment provides facilities to get connected to various networks, Internet or connect unprepared local sources (laptops for instance). The decision room supports the collective analysis of personal information while respecting information privacy.

The implemented solution, given the concurrent aircraft design context, is the new SYNELEC state of the art large area display configuration (12 LMU cubes providing 4mx2,25m display area with a 3200x1800 pixel resolution, controlled by an eLAN NTGraphic+ display manager). The underlying functionality sought, when we adopted this system, was the capacity to indiscriminately display any remote network source together with unprepared local RGB sources (laptop, PocketPC, camera document, video…). The global interface would then be one of a typical computer desktop integrating remote computer applications: LAN connection or external RGB and Video sources themselves connected to other networks (see Figure 1.).

This environment however does not provide such a high level architecture to interact and manage data as other projects might do. There is a need for a higher-level architecture to provide a ubiquitous access to the relevant information [5] as some use cases highlighted several requirements that could not be addressed by the current system's implementation. We believe that the definition of a more flexible environment based on high level control system could find some very interesting applications within the industrial context identified.

3. Overall project supervision

Regarding team and project management applications, the large area display can be used near the Integrated Design Team main sites to share team and project management's related common information, information that cannot be communicated through 17 inches PC screen in a relevant way. Heterogeneous information, provided by several sources, can be displayed taking advantage of the wide working area to synchronously and collectively capitalise it while offering outstanding interaction capabilities.

The following paragraphs present an overview of possible use of the interactive decision room close to the Integrated Design Team main sites.

3.1 Project Dashboard

Dynamic indicators committed to project follow-up and activity co-ordination can be displayed on the screen. The dynamical aspect of indicators and the large size of aeronautical Project Breakdown Structure constitute the two main reasons for a constant large display to be required in that case.

The main issue here is to define indicators to represent a concurrent engineering activity. As it has been widely agreed that the main issue during the distributed design phases is the maturity of anterior task's results since they will be used for design before going through the whole validation process we are considering a solution providing a supervision system of the data maturity exchanged between actors. Such a supervision system would display an overall view of the project's advancement while all activities remain concurrent.

Figure 2 : Development program overview

3.2 DMU Progress overview

The display can show the digital mock-up or product structure in current status, the DMU would then be a symbol of the program progress in a more “visual” form than for the project dashboard. The dynamical aspect, large size and quality (high resolution) of the display provide an efficient mean of visualisation and communication for such kind of virtual models.

3.3 Presence and Visio conferencing

On-line videos (e.g.: by web cam) from other Integrated Design Team places, in remote situation can be provided on a dedicated area of the large display. It will be very useful when the Integrated Design Team is split or geographically de-located (e.g.; Parts of the design office in Germany and France) for teamwork enhancement. The “on-live” aspect enables to better integrate virtual teams with video-conferencing without overloading the LAN bandwidth (only one web cam is required for each virtual team cluster).

4. Collaborative Workspace and Collaborative Work Environment

4.1 Interactive Decision Room and Collaborative Workspace

When considering the display system in a global context, it clearly appears that it only represents the collective display device of the co-operative workspace. Unlike the current display systems, the large area display must not constitute the unique workspace of the collaborative environment but must provide a modular architecture to enable the integration of distributed CSCW (Computer Supported Co-operative Work) applications in an Interactive Workspace [3] [4].

An interactive workspace is a physically co-located, technology-rich space consisting of interconnected computers (desktops, laptops, handheld devices, etc), utility devices (scanners, printers, etc) and I/O devices (large wall-mounted and table-top displays, micro-phones, speakers, etc) and all associated interaction devices, where people gather (with their own laptops, handheld devices, etc) to do naturally synchronous collaborative activities such as reviews in our case.

4.2 Two Review metaphors

Among the several typologies of collaborative sessions that can be encountered during a design phase two types of reviews have been identified as representative of the collaborative work scenarios diversity.

- The **project review** gathering all the different collaborators to present the project's achievements and list the current problems for a given time can be compared to a project presentation where previously validated facts are presented giving rise to little if no discussion.
- The **design review** where each step of the design process for a particular sub-task is validated (conceptual review, detailed design review, production readiness review…). During those reviews the purpose of the negotiation is the elaboration of proposals and the solution evaluation.

The difference between these two types of meetings is mainly due to the objective of the meeting, the information to be displayed and the kind of interaction to be supported between participants. A design review induces more interactions around mock-up, product structure and more generally technical artifacts for local and technical decisions (analysis and investigation type decisions), whereas project review is a more classical presentation for a global validation and decision making for project management topics (time, cost, resources) (logical-type decision).

In this respect we introduced classroom, respectively war-room ([13]), metaphors to define the interactions during project, respectively design, reviews.

Figure 3: Illustrator for a design review

4.3 Interacting with the environment

Research works on multi-modal interaction facilities between meeting participants and the large area displays have been undertaken using ergonomics and linguistics concepts to be applied on design and project reviews applications ([8][9]).

To illustrate some of the relations between the cognitive ergonomics statement and the interaction capabilities the system will have to support arguments by analogy as defined in [9] for solution negotiation context. These are arguments that highlight a precedent, i.e. they enable the present case to be compared to a typical case proposed as a model. From this assessment we can assume that the actor will refer to a previous analogue case, not initially

prepared for the meeting (on a remote computer for instance, or on his personal device), and that a parallel visualization of both solutions will be required. Interaction devices should make possible to annotate and compare both solutions as the negotiation will go on and then issue a report of the meeting. From this analyze several use cases have been listed and corresponding solutions implemented or identified.

Given the particularities of the Interactive Decision Room specific interaction solutions have to be considered. For instance, in a classical review configuration, interactions with displayed information can be made from each participant's place (in a remote location in the room). Laser pointer devices have recently been very popular for remote pointing applications as interaction device for presentation systems [14][15]. However, interacting at a distance from the display surface using laser pointers implies a certain amount of restriction and inconveniences, especially in our context. Various studies [16][17] have clearly stated the inaccuracy of laser pointing devices due to the hand unsteadiness. Filtering might reduce the jitter caused, but it still remains important and proportional to the distance from the screen and the display size (up to 15 meters away and 6 meters wide in our case, which is four times more important than any experiments undertaken). What is more, the incapacity to explicitly select objects using a pointer (in comparison with the mouse click) makes the laser pointer a slow input device (almost twice as long as a touch sensitive system) and inadequate to most of the commercialized application's interfaces where clicking is the natural way of navigating through the GUI. We could therefore not consider using such a device given the uncommon room and display wall proportions, and the diversity of applications used.

Figure 4: Direct Interaction on the wall (design review)

Thanks to rear projection facilities, interaction can be made very close to the large area display, on the displayed information itself. For that, an electronic whiteboard solution has been implemented on a small area of the large display dedicated to direct interaction work to answer the needs of direct annotations for applications such as brainstorming or DMU annotation.

In our case, the use of voice command and wireless devices (e.g.: keyboard, mouse, gyroscopic input device, pen-tablet) have been considered and illustrated for high level interaction metaphors (navigation, sources display). Together with the new system architecture, it would provide any remote user in the room with a powerful interaction capability to use the full capacity of the displayed applications, no matter which source is currently visualized.

The current interaction devices commercialized do not provide intuitive, complete and adaptable functionalities for our use cases. We are currently attempting to define a multimodal environment dedicated to various scenarios and reviews, allowing several interaction capabilities depending on our use cases' specific requirements.

It is a very challenging perspective to define such an environment where the proposed technology would fully support the decision making process and the analyse stage for collaborative program management and collaborative problem solving process in EADS business environment (e.g.: Design reviews for a new aircraft development program at Airbus). Such an environment will enable to introduce and fully illustrate the collective decision e- room concept.

5. Key conclusions

Beyond the original use of a large area display for aircraft development program, the works have tried to identify and illustrate all the facilities a large area display can provide to a program engineering team. The large area display can indeed be used near the Integrated Design Team place for team & project management, or in meeting rooms for design or project reviews.

In the context of meeting rooms, interaction metaphors and devices with the large area display have been more deeply studied and some facilities are being implemented. This global show-room framework will then be provided or proposed to Airbus development teams (A380, A400-M) as meeting facilities and collective display for Integrated Design Teams.

Figure 4: The Interactive Decision Room

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