

A VIRTUAL RAFALE

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ABSTRACT

To survive in strong present competition, Dassault Aviation has to ensure a constant update of its organisation, management methods and information system. This permanent research has to produce a right compromise between cost, cycle and performances, both for civil and military aircrafts.

The Digital Mock-Up (DMU) provides support for Concurrent Engineering (CE) methodologies and contributes directly to customer satisfaction.

In a first part, we will introduce the Dassault's use of CE methodologies as a systematic approach to integrated development of product with the manufacturing processes and customer support. We will emphasize the importance of Teamwork-based decisions, co-specifications, cross-discipline cooperation, efficient communication, change management, simulations...

The second part will be dedicated to CAD/CAM techniques and their extension: Virtual Reality (VR).

We will not mention all the activities related to flight simulators.

RESUME

La survie d'une entreprise du type de la nôtre, passe par la remise en cause continue de son organisation, de ses méthodes de management et de gestion ainsi que des outils informatiques qui y sont utilisés. C'est une recherche permanente qui doit déboucher sur le meilleur compromis coûts, délais, performances que ce soit dans le domaine civil ou militaire. L'ingénierie concurrente correspond à cette nécessité. Les conséquences informatiques relatives à la CFAO (Conception et Fabrication Assistées par Ordinateur) et à la "réalité virtuelle" associée sont présentées ici dans la dimension industrielle du programme Rafale.

Les aspects relatifs aux simulateurs de vol ne seront pas évoqués.

A CONCURRENT ENGINEERING APPROACH

The gains necessary for our survival cannot be obtained merely by optimizing the existing industrial structures. A new way of working must take place, it is often referred to as CONCURRENT ENGINEERING.

A typical definition of Concurrent Engineering is :

" A systematic approach to creating a product design that considers in parallel all elements of the product lifecycle from conception of the design to disposal of the product, and in so doing, defines the product, its manufacturing processes, and all other required lifecycle processes such as logistic support.

These activities must be started before all prerequisites are frozen and hence must be adjusted afterwards. In this way, it is possible to do much work in parallel with the main goal to shorten the elapsed time. By powerful computer and communication network support Concurrent Engineering also opens the possibility to test a number of alternative solutions.

Achieving this, the ultimate effort of Concurrent Engineering is to integrate product and process design."

Concurrent engineering contributes directly to the business drivers such as :

- Improved time to market
- Improved product quality and reliability
- Reduced cost of design, development, production and support.

In this perspective, a decisive tool is Digital Mock-Up, supporting the effort in modelization and simulation. The result is a decreased risk in the design of a new product.

ORGANISATION

For DASSAULT Aviation, the organisation is structured with professions and skills necessary to :

- sell,
- design,
- manufacture and support,
- test and validate

an aircraft.

This organisation empowers the technical teams and develops cooperation between programs. To be more efficient in the development of a given program, it was decided to create a dedicated Directorate.

This Directorate is in charge of all synthesis and has to ensure a technical coherence, respecting the contract in terms of performances, cost, cycle and quality.

Since 1990, every actor is reporting both to a technical manager from a hierarchical point of view and to a Program Director from a functional point of view.

This implies a new way of working in internal cooperation.

INFORMATION TECHNOLOGY TOOLS

With the CE approach and the use of "up to date" hardware and software, it is now possible to deliver the right piece of information, at the right time, to the right person, giving to everybody a coherent vision of one project.

Since 1979, CATIA has been used at Dassault Aviation for design and manufacturing activities. At first the problem was to define a single part (mechanical, sheet metal...). We have defined optimized product lines. A product line is characterized as a data flow between activities associated to an aeronautical part category, from design to manufacturing, including quality control inspection and customer services.

Benefits of this global optimization are definitely higher than pure local adjustment or automatization of isolated tasks. Results have been achieved on one hand with a clear settlement of our CAD/CAM use in our business processes (the dissemination of standard rules and procedures among all partners -internally or outside the company) and on the other hand with the

development of many dedicated softwares (integration of our knowhow) on the same CATIA platform.

- see figure 1 -

We are used to call this approach a vertical integration. This is today under control in our company. We are enhancing it with an industrial exploitation of "design by features" which allows us to encapsulate information in entities (features) of the digital definition [FEMOD]. Afterwards, during the manufacturing phase, automatic routines are based on features recognition. Today, "design by feature" is a reality for sheet metal parts at Dassault Aviation.

But now the challenge is to manage not only one part, not only an aircraft, but the whole family of RAFALE (several hundreds).

For the Falcon 2000, RAFALE and the future airplanes, our company has taken the very decisive choice to replace the "physical mock-up" (PMU) by a "digital mock-up" (DMU). Today, DMU specific applications for design, manufacturing and support activities are running on Dassault Aviation sites.

- see figure 2 -

By means of a large scale digital assembly application, every designer can (as frequently as necessary) search in the database for parts located in a given area. By this way, design development is an iterative cycle starting with the creation of 3D models then checking, revising and sharing the assembly until this one is achieved. This application is based on CATIA Data Management (CDM), in a Relational Data Base environment.

At the design office level, all parts of an aircraft (more than 20.000) are created and DMU is used by every designer who is checking that his layouts fit with those which are concurrently defined by other teams (structure, hydraulics, wire bundles). The user is in position to check for collisions or to analyse accessibility and assembly-disassembly methods without having to rely on physical mock-up. With VR techniques, we are improving our capabilities in visualisation and space navigation. It is particularly important when we are working in group (more than ten persons) to validate the definition of some areas. For this occasion, they are persons representing quality control department and some other from the different disciplines involved in the particular area.

At the manufacturing engineering level, we have developed a specific application which allows the user to build the "as-planned-for manufacturing" view of

the product from the "as-designed" view released in the DMU. We create information for installation datasets, process plans and working instructions for assembly, documentation for certification or customer support.

This leads to continuously manage through DMU the configuration of each physical airplane "as designed", "as-planned for manufacturing" and "as really built". This management is organised for long term (30 years).

Concerning any extension of our data model, we are focusing on ISO 10303-203 recommendations (STEP AP 203) for product structure and configuration.

- see figure 3 -

To be more efficient we are combining the PDM and the CAD/CAM functionalities in our information system.

We are used to call this approach an horizontal and vertical integration, because this is dealing both with the different product components and the different stages in the product life cycle.

Our vision for the future of design and manufacturing engineering activities is what we call "an integrated space for definition". The output will be numerical definition of a product and the related manufacturing processes. This data will be the result of cooperation between multiple partners (some of them in Dassault Aviation premises some others outside, in France or abroad). To analyse efficiently this huge amount of data, different techniques will be used, but for the geometrical aspect, the "navigation" with the associated VR techniques will be decisive.

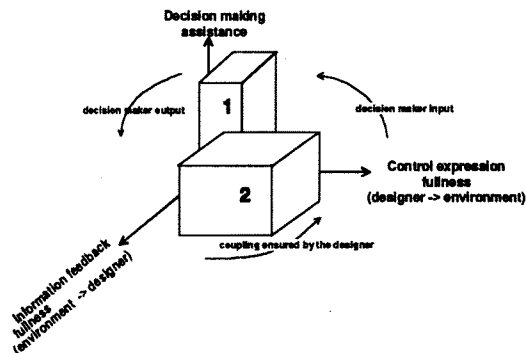
DMU AND VIRTUAL REALITY

Virtual Reality approach

It is possible to characterize VR with 3I [BUR93] : Interactivity, Immersion and Imagination (assistance to solve problems). From our point of view, these features can also be mapped on the following three dimensional diagram [CHED96].

- see figure 4 -

The first horizontal axis supports the **control expression fullness** level (designer -> environment) whereas the second one the **information feedback fullness** level (environment -> designer). This horizontal plane allows a classification of interface technologies. The vertical axis supports the fullness level of **system assistance** (optimization algorithms ...).



Various VR technologies are becoming available today, however our choices are based on compromises depending on tasks categories.

Tasks related to DMU can be grouped in two categories :

- **Create / Share information** : Tasks are performed by designers which are familiar to CAD/CAM. Here, emphasis is on system assistance performance. VR solutions are located in the area 1 (vertical high) of the above diagram.
- **Review / Global release** : These tasks are performed by a group of managers in different disciplines. They are not necessary CAD/CAM experts. Here, emphasis is on interface and VR solutions are located in the area 2 of the above diagram.

Create / Share information

In this case, design environment is composed of ten or so up to two or three hundred parts. Work is calling for a great concentration and skill of the designer during all the work session duration which is quite high (two or three hours).

Creation and modification of geometrical data require interactive access to the CAD/CAM database. Designers are working on 3D exact models. Geometrical consistency and technological rules are continuously checked and runned (for instance, electrical wire bundles curvature is automatically linked to material specifications and checked during design phase).

Due to the great number of stations devoted to this kind of work, we come to the decision of a reasonable cost per unit. Our solution is based on workstations IBM RS6000 connected to a mainframe as a central node (type of mainframe is dependant of the industrial site).

Information necessary for geometry and visualization is processed locally while all information is stored at the central node.

Implementation is performed through an intensive use of CATIA, completed with specific applications developed by Dassault Aviation.

Among these applications we can hold up as examples :

- PACMAN which performs the assembly of different parts of an airplane according to a run-time query based on functional and/or localization criteria.
- ERGO which performs ergonomic simulation of various tasks (from the airplane pilot to the repair worker) and a complement ATTEINTE which solves the accessibility problem to an equipment while improving the quality of the simulated posture.
- various applications for manufacturing which give assistance and sometimes full automatization for manufacturing process planning and programming.

As a conclusion, our action in this domain is rather intended for an optimization of current CAD/CAM solutions. So, virtual reality is rather a new term than a fundamental technological change.

Review / Global release

This case is quite different. New information interface technologies are unavoidable because "mock-up reviews" which were formerly achieved on a physical mock-up at workflow must be now carried out in dedicated rooms at design office.

The name has been changed from "mock-up review" to "digital assembly review" but the principle to "navigate" in the environment still remains. The project manager is asking for the expertise of the different specialists during common navigation in order to get consensus and validation.

This activity requires a few rooms fitted out with big screens, so investments can be noteworthy. Pure visual feedback will have to be completed with force

feedback in order to validate, for instance, assembly or disassembly of heavy equipment.

However, decisions at this step are not immediatly executed; they usually presuppose long interventions of CAD/CAM specialists. So, the visualization database may be different from the CAD/CAM database provided reliable updating.

Our action in this domain is still an optimization of CAD/CAM solutions (especially visualization time delay) and futhermore an integration of new simulation tools (datagloves, masterarm, headmounted display...).

The final transparencies will give you an idea about the "reality of this virtual RAFALE".

CONCLUSION

CE techniques use hardware and software as means of communication to help men and women to ensure their mission to sell, design, manufacture and support aircrafts. VR techniques enrich this tools.

It is wrong to think that these techniques will reduce the exchanges between persons. On the contrary, they will break some organisationnal frontiers and decrease the distance effects allowing people to work together.

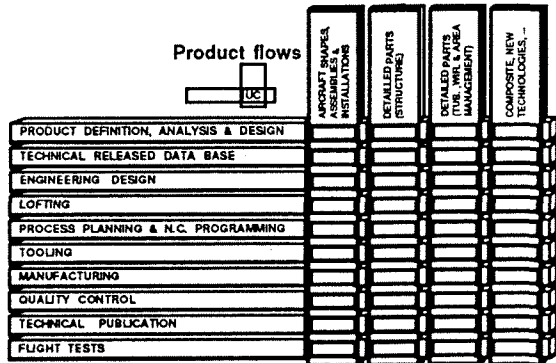
Many progress are still necessary in DMU and associated Tools and Methods but today it is a reality at Dassault Aviation and will be a competitive advantage for the future.

REFERENCES

- [BUR93] G. Burdea, P. Coiffet : La Réalité Virtuelle - Editions Hermès
- [CHED96] P. Chedmail, T. Damay, C. Rouchon : Integrated Design and Artificial Reality - Accessibility and path planning
- [FEMOD] BREU 033 Th. Hardy - Final Report February 96

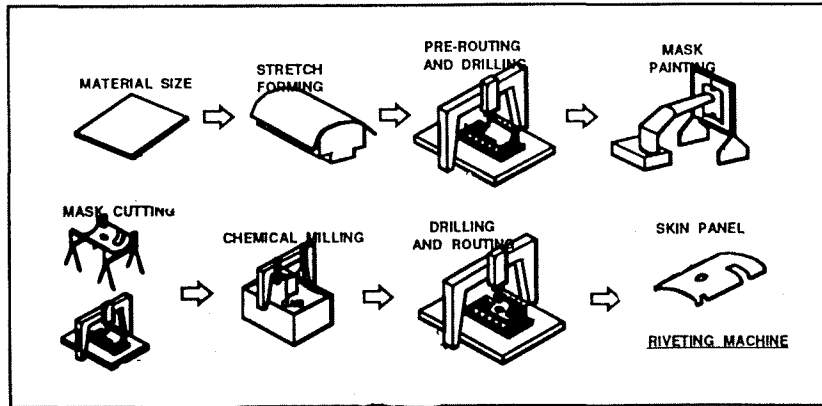
Vertical integration

MATRIX OF PRODUCT LINES vs CAD/CAM ACTIVITIES



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PRODUCT FLOW ANALYSIS (i.e. sheet metal panels)



PROCESS MODELLING & OPTIMIZATION

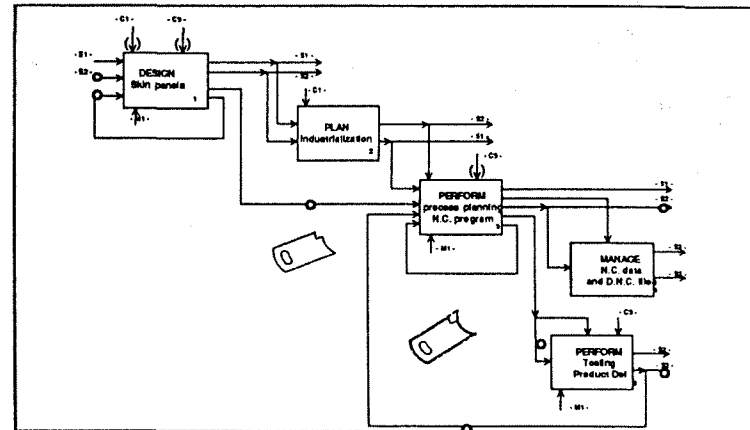


FIGURE 1

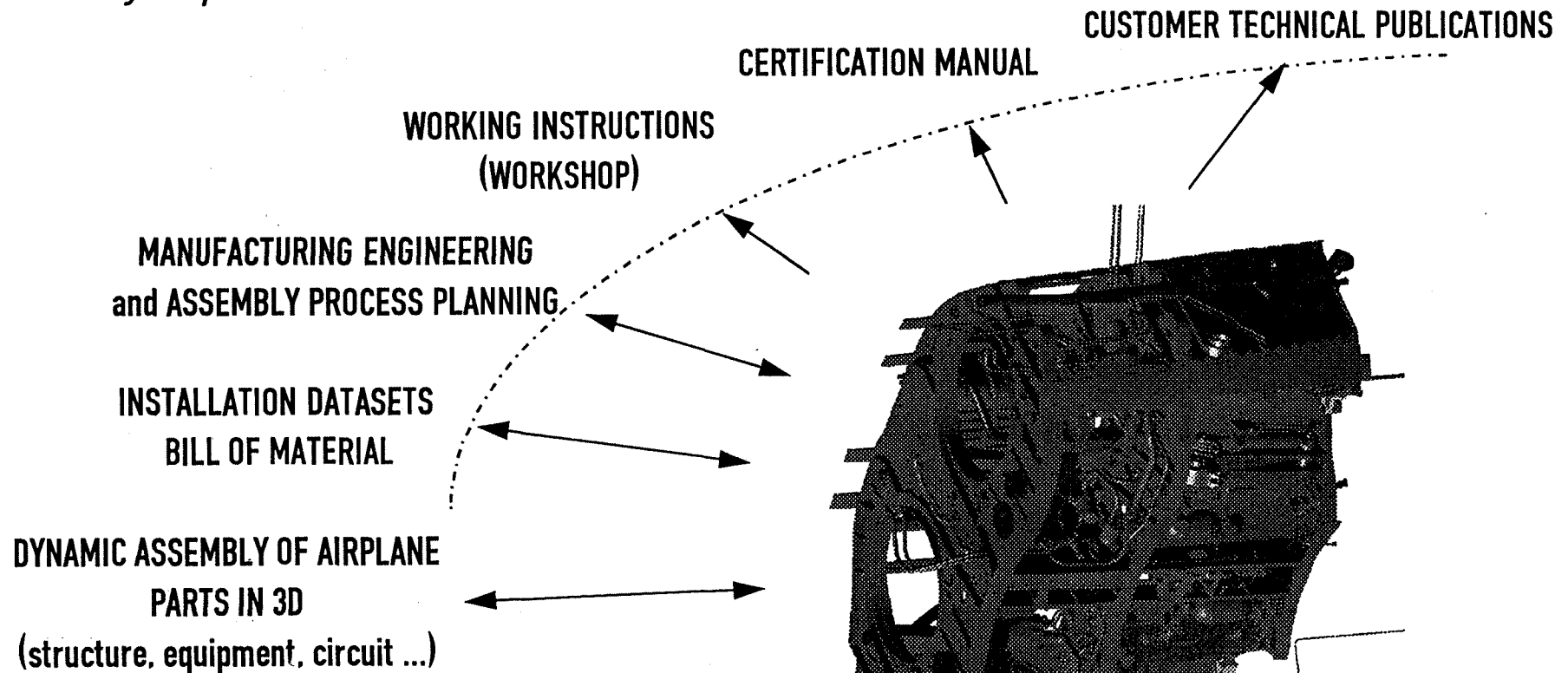


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DMU : from a design tool toward the product definition tool

Today exploitation :



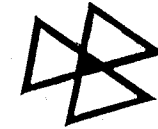
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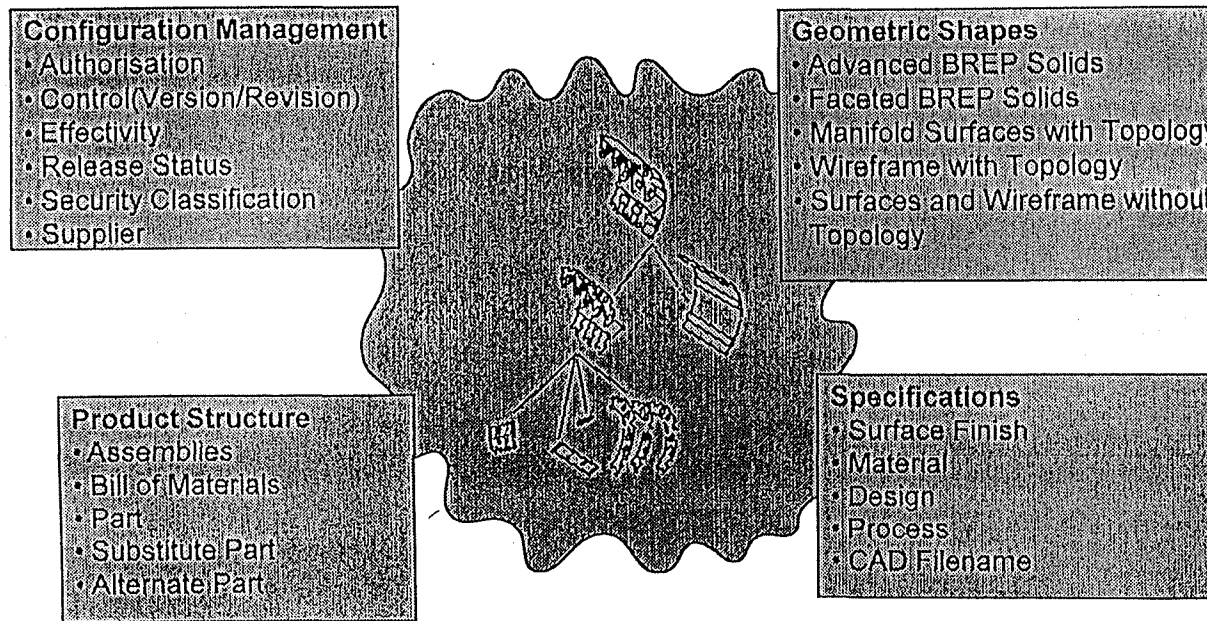
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ISO 10303 (STEP) : Scope of Application Protocol 203

AP 203: Configuration Controlled 3D Designs of Mechanical Parts and Assemblies



PDES, Inc.



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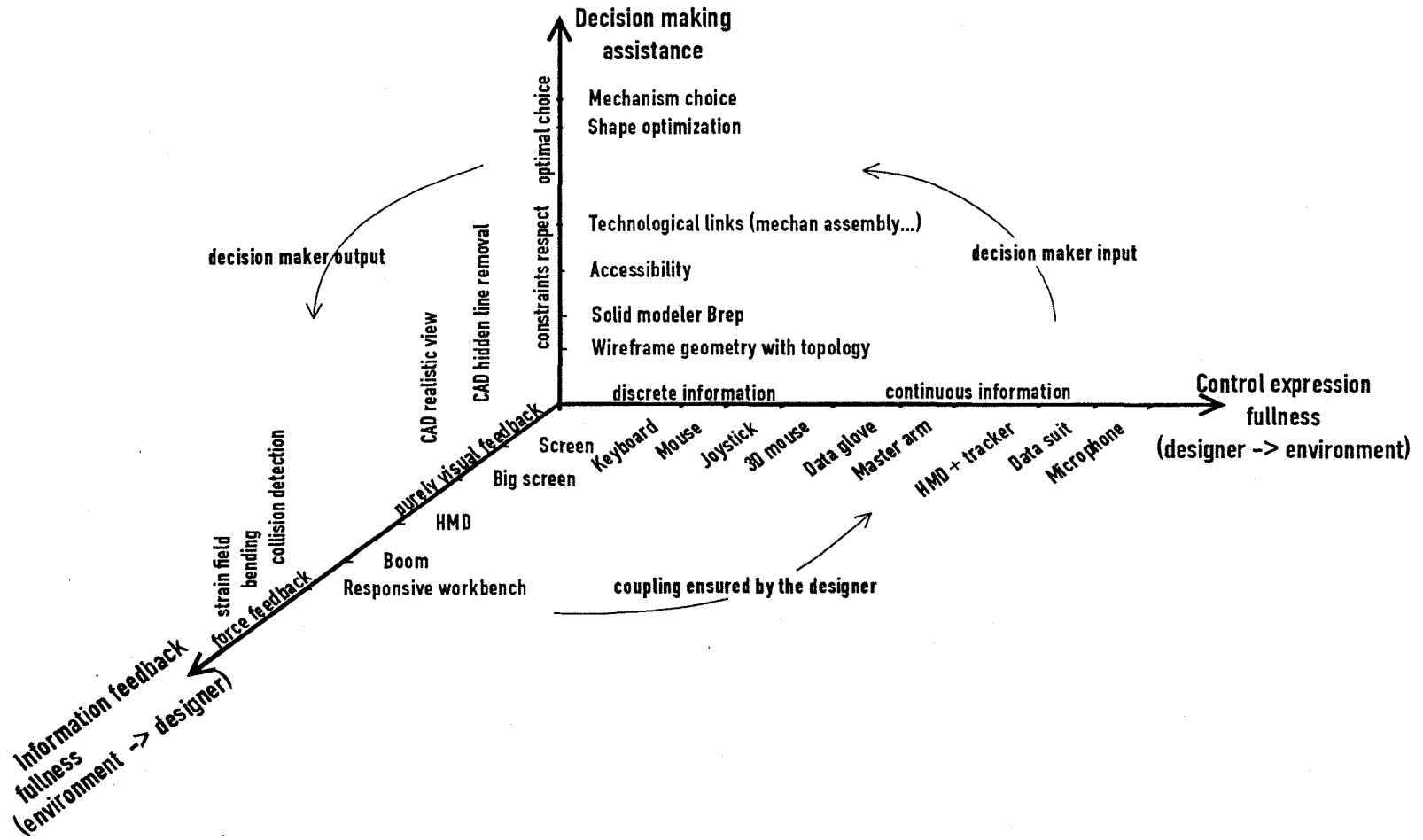


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FIGURE 3

Virtual reality - Characteristic axes and coupling



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FIGURE 4