

HAPTION

Physics simulation applied to assembly and maintenance

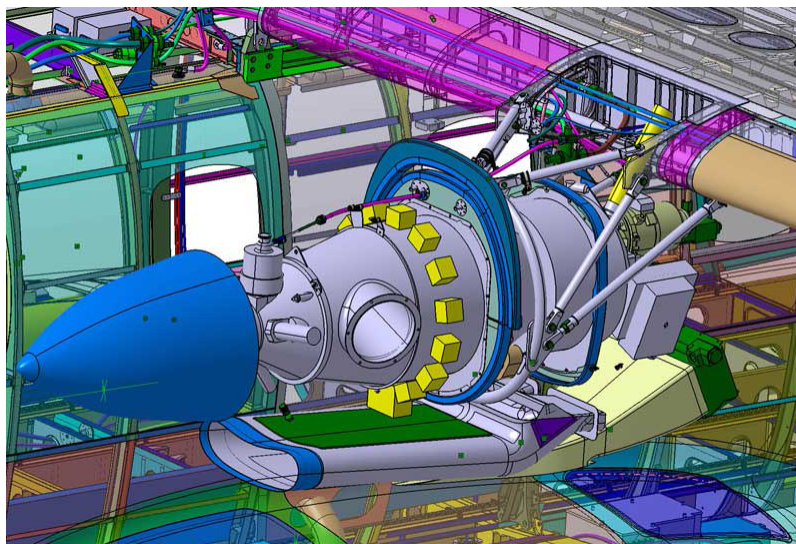


A revolution: the Digital Mock-Up becomes interactive!

Every day, manufacturing industries design complex products consisting in the assembly of many different parts. Engineers must plan and optimize the necessary assembly operations, which represent as much as 30% of the total cost of the products when leaving the factory. In many cases, as for example when mounting a steering wheel, there is no problem of accessibility and the only optimization necessary is the choice of the right moment and the right tool. But some operations turn out to be very difficult, such as setting a window inside a car door.

Until the 1990s, difficult assembly operations were always tested on a real prototype or mock-up. For example, a plastic model of the car door would be manufactured, with a Plexiglas window; such a prototype could be ready within three weeks and cost the equivalent of 65,000 US\$. During the last twenty years, increased competition has forced industry to modify the design processes so as to reduce their duration and cost. 3D CAD (Computer Aided Design) followed by the “Digital Mock-Up” allowed a higher integration of components, at the cost of an even higher complexity. At the same time, physical prototypes have almost disappeared.

The same issues are faced by engineers for maintenance operations. In the aerospace business, they are even more acute. Indeed, the maintenance costs of a commercial airplane represent more than twice the purchase price. As a consequence, a good knowledge and optimization of those costs is a strong sales argument.



Integration of a complex product inside Catia V5™

3D CAD platforms propose tools for the validation of assembly tasks. They range from the simple movement of parts with highlighting of interferences, to automatic collision-free path planning. However, those tools do not fulfil the needs of engineers very well: firstly, they take a long time to process (several hours for a complex movement); secondly, their usage is frustrating because non-intuitive. Therefore, the results are often unacceptable and the users must repeat the same operations several times in order to converge towards a good solution.

This is where HAPTION comes into play, with the technology called “interactive physics simulation”. The technology is developed by CEA LIST (French Atomic Energy Commission) and integrated by HAPTION into Dassault Systemes’ industrial software products. Its role is to create a physical interaction with the Digital Mock-Up. Using a force-feedback device (also called “haptic interface”), engineers can manipulate individual parts and feel their collisions with other elements of the assembly, just as if they were working on a real prototype.

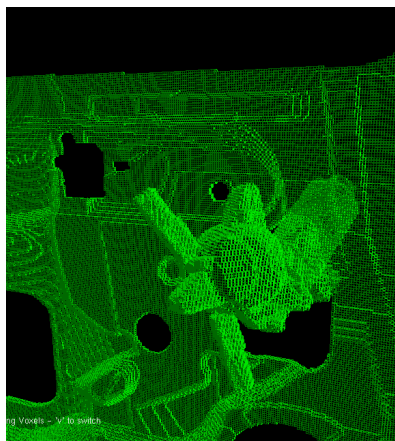
Operating principle

The IPSI technology (IPSI stands for “Interactive Physics Simulation Interface”) proposed by HAPTION belongs to the software category of real-time “Physics Engines”. Real-time physics engines have known a very fast development in the last few years, driven by the video games industry. The specific characteristics of IPSI are its ability to handle very complex 3D geometry, and to guarantee that 3D objects don’t interpenetrate at all during the simulation.

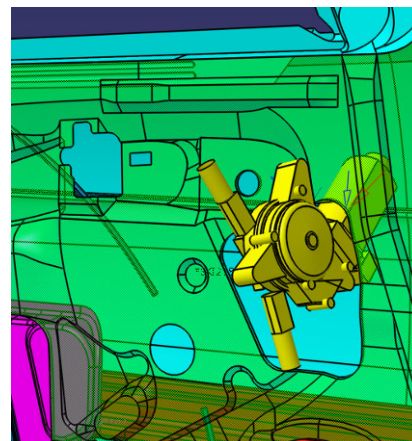
The operating principle is the following: starting from the CAD definition of the objects, IPSI builds an optimized internal representation; after the simulation is started, it solves a system of equations which includes the contact constraints between objects and the user’s intentions transmitted by the haptic interface. It obtains a collision-free movement for the manipulated part, which is then updated in CATIA™.



*Haptic interface
operated by the user*



*Physical model
solved by IPSI*



*Visual representation
inside CATIA*

In case of a contact with an obstacle, the haptic interface resists the movement of the user, who feels like he is actually holding the part with his own hand. The contact information is precise enough to detect surface asperities of millimetre size. It's also very rich, so that it's possible to detect directions of free movement, in translation as well as in rotation. Finally, the contact feeling is clear and final, and the user knows that there is no way through.

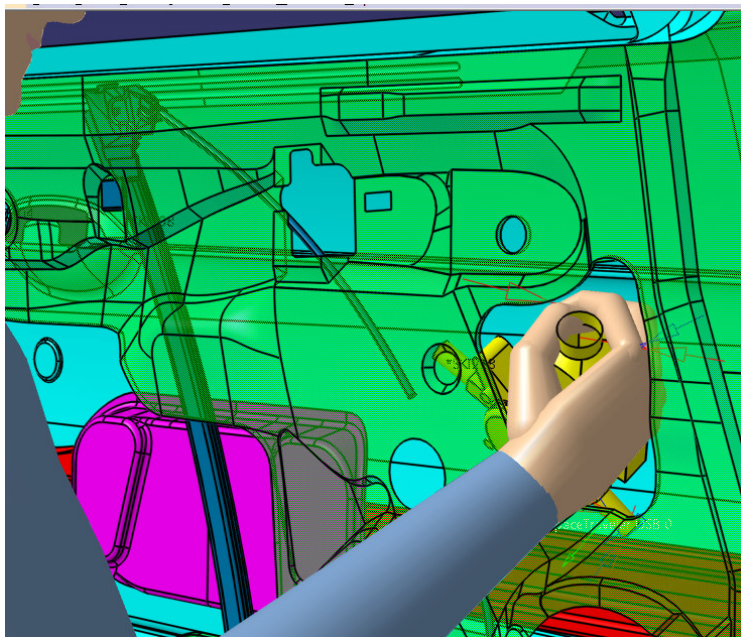
In the field of assembly and maintenance simulation, the perfect control of object dimensions is critical. Indeed, it must be possible to have a reliable guarantee that each operation which is feasible in simulation will also be feasible in reality. For that purpose, IPSI always works with a minimum distance to contact, also called safety gap. By setting the value of that gap adequately with respect to the tessellation parameters of CATIA, the user can demonstrate that the exact geometry of objects will never interpenetrate.

For an even more natural experience, it is possible to combine the haptic-driven interactive physics simulation with a scale 1:1 stereoscopic display. HAPTION provides solutions for implementing force-feedback devices in all sorts of immersive systems (CAVE™, Workbench™, Powerwall™, HMD, etc).



*Assembly simulation inside a CAVE™
(picture © PSA Peugeot Citroën, France)*

Finally, it is also possible to add a model of the operator, in the form of a virtual manikin. It enables the validation of assembly and maintenance activities in an operational context, by taking into account the accessibility constraints for the operator, as well as the ergonomic aspects.



Assembly simulation with a virtual manikin

Benefits of HAPTION technology

With the technology proposed by HAPTION, assembly and maintenance operation can be validated very early during the design process of a new product. Its added value is multiple:

1. Thanks to the force-feedback device, the user experiences a physical contact with the Digital Mock-Up; he has a better perception of the dimensions, volume, and spatial structure of the 3D objects.
2. The use of the technology calls for manual expertise; after a few minutes' training, an operator from the assembly line is able to handle the simulation himself, thus bringing in his practical experience.
3. Contrary to automatic path planning, interactive simulation places the human operator at the center of the system; the user guides the simulation in the directions he feels promising, while taking into account external constraints which are not in the model.
4. The contact management is comprehensive, meaning that movement is still possible in other directions, which is not the case with most CAD tools; the user can benefit from the contact information to guide his movement, and thus find the solution in shorter time.
5. More generally, the work sessions become much more productive, as they achieve better solutions in a shorter time, and also because the participants reach a better understanding of the issues and complexity of the operations to be performed; therefore, when compromises are necessary between different departments, they are found faster and with a better consensus.



*Assembly simulation of fuel lines inside a helicopter
(picture © Sikorsky Aircraft, Stratford, CT, USA)*

Technical implementation

The proposed technology is available for the software platforms CATIA V5™ and DELMIA V5™ by Dassault Systemes. HAPTION supports all versions from R18 to R21, for Microsoft Windows 32 and 64 bits. The typical configuration of the workstation is given here below:

- CPU Quad-Core @ 3GHz
- 16 GByte RAM
- Graphic board NVidia QuadroFX™ 3800 or ATI FirePro™ 7800
- Microsoft Windows XP/7 64 bits

For very complex models (high resolution, large workspace, large number of triangles), it is advisable to relocate the IPSI component on a dedicated workstation.

About HAPTION

Since its creation in 2001, HAPTION has been developing and selling hardware and software solutions based on force-feedback. HAPTION uses patented technologies developed by CEA LIST (French Atomic Energy Commission), for which it has an exclusive worldwide license. Its activities span the sectors of research laboratories and universities (CNRS/INRIA, University of Karlsruhe, Iowa State University, Politecnico di Milano), transport industries (PSA Peugeot Citroën, Airbus, BMW, Volkswagen, Boeing, Lockheed Martin, Sikorsky) and nuclear operations (CEA, AREVA, Cybernetix, ITER).

HAPTIONS employs 15 people in its facilities near Laval, France. In 2010, the turnover was 1.6 M€, 48% of which outside of France.

