

## LS-DYNA Consulting Services

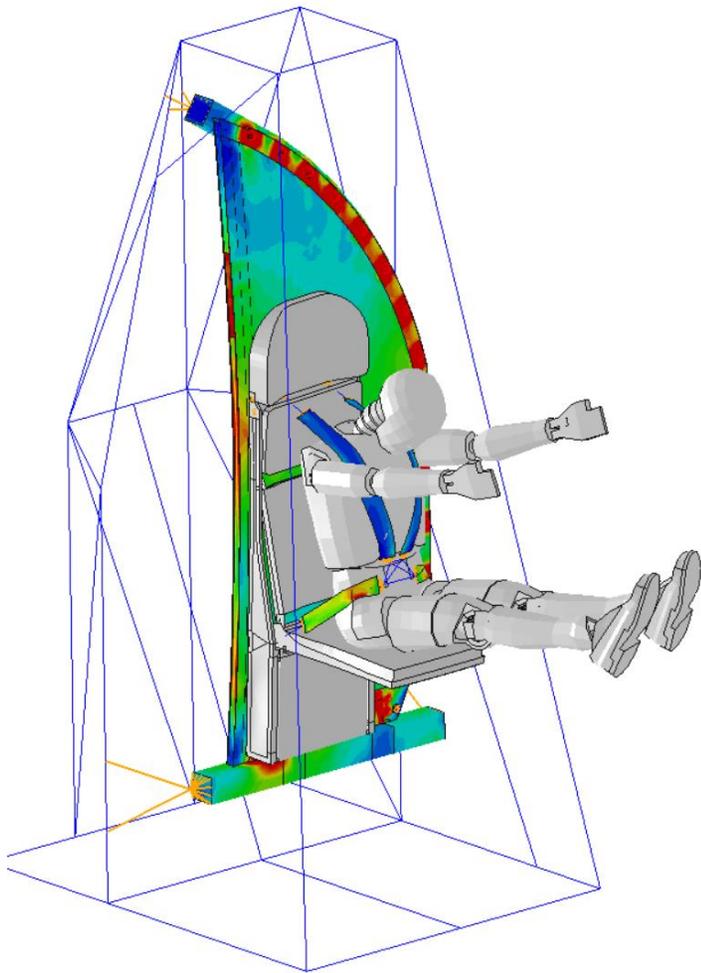
### 16g Sled Test Simulation of Airplane Lav Wall with Attendant's Seat

The engineering of airplane seats is quite complex due to competing demands for lightness and the ability to survive a 16g sled test. Experimentally, a 50% percentile dummy or anthropomorphic test device (ATD) is strapped into the chair and then subjected to a 16g acceleration pulse with a half-sine pulse width of 0.18 second. The test procedure is well defined under 14 CFR Part 25.562, Amendment 25-64 and JAR Part 25.562 with guidance given under SAE AS8049 Rev. A and for the ATD under 49 CFR 572.

In this LS-DYNA FEA consulting services work, the objective was to limit the design and schedule exposure of a new design. One can think of this as FEA insurance; that is, it is must less expensive and faster to virtually test than to destroy prototypes on a 16g sled test.

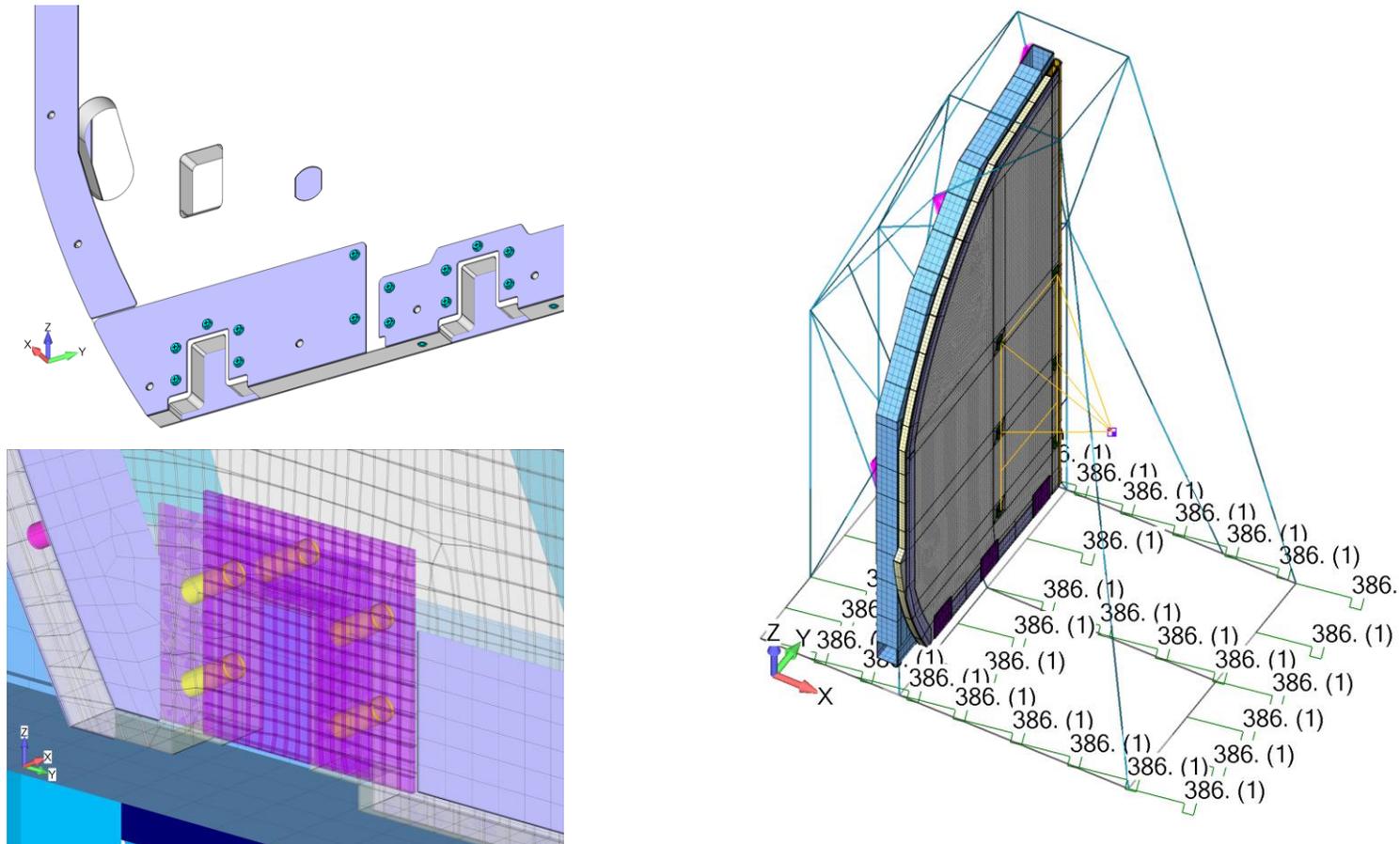
The LS-DYNA model was constructed from the client's CATIA geometry. The Nomex cored sandwich panel was idealized using a combination of solid elements for the core and laminate shell elements for the composite skins. This type of 3D modeling provides accurate simulation of the progressive failure of the composite skins (see 026\_Jensen,A\_PAPER Broad-Spectrum Stress and Vibration Analysis of Large Composite Container.pdf). Likewise, phenolic anchor blocks were modeled with solid elements and then integrated into the wall panel. As part of the virtual manufacturing process, key fasteners were preloaded prior to analysis to enable shear transfer across bolted interfaces.

The model was first proof tested without the ATD using LS-DYNA's implicit solver to ensure that the structure was tight and could withstand the 16g sled test environment. After this verification stage, the model was repurposed with an ATD for the full, nonlinear, transient explicit analysis. At the start of the transient analysis, bolts were preloaded and the ATD was allowed to settle onto the attendant's seat, once the model had stabilized, the sled's deceleration pulse was applied. Progressive composite failure was simulated using \*MAT\_54 with strain based failure criteria for tension, compression and shear. All metal components strength levels were based on MMPDS values. The complete transient, nonlinear simulation took about four hours to solve using 16 CPU-Cores. Results aligned well with the 16g sled test data.



## LS-DYNA FEA Simulation from CATIA to 16g Sled Frame

### MODEL CONSTRUCTION FROM CATIA GEOMETRY TO 16G SLED TEST

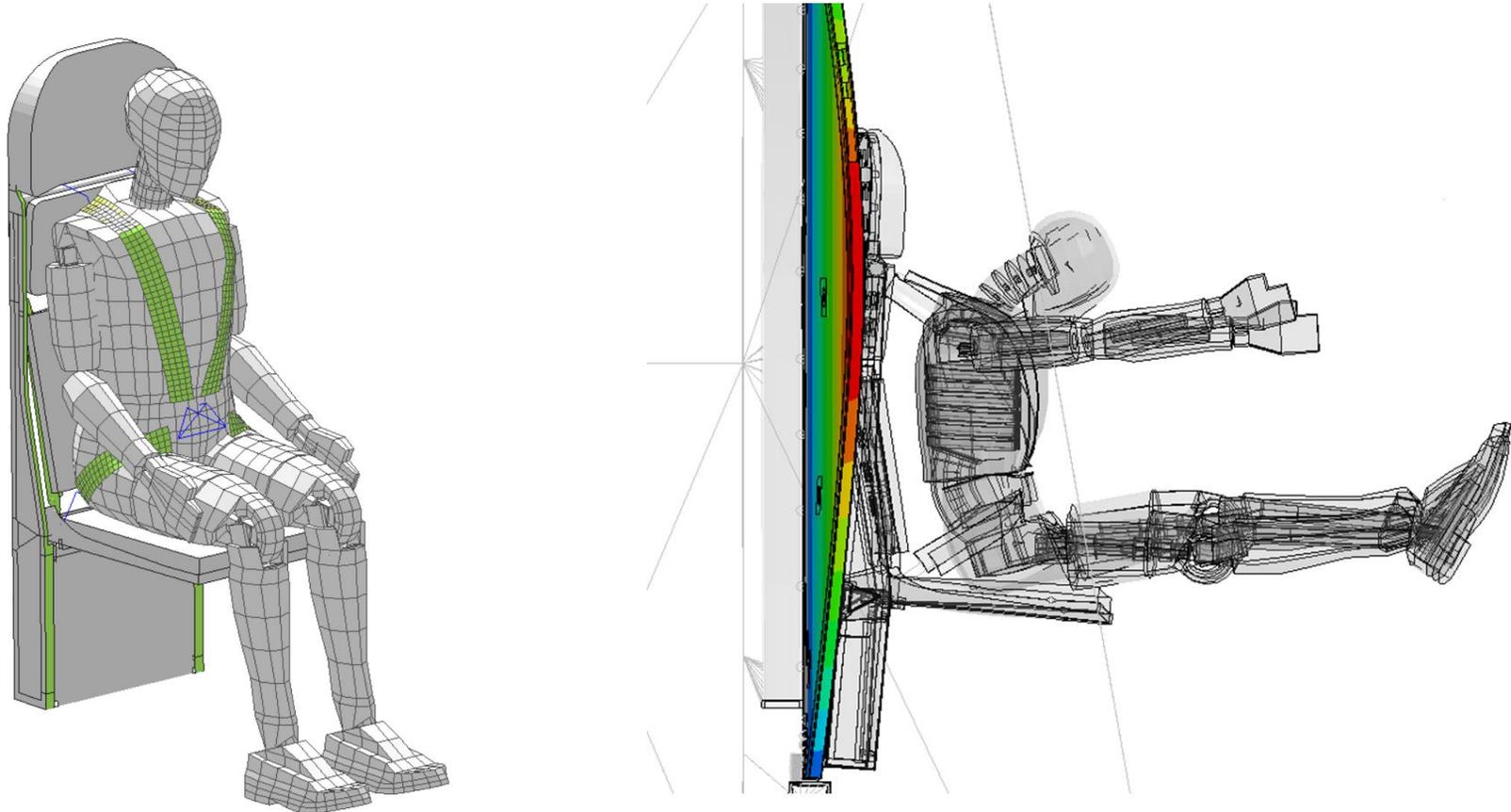


**Figure 1: The CATIA geometry was idealized into a FEA model using brick, beam, CNRB, spot-weld and shell elements**

A highly idealized FEA model was constructed from the base geometry. Phenolic anchoring blocks and the honeycomb panel core were modeled using solid elements. Bolts were modeled with a combination of beams and solid elements. The heads of the bolts were made with solid elements to allow compression and contact during preloading. All fasteners were preloaded at the start of the transient analysis. However, prior implicit work confirmed appropriate stress levels for all components.

## 50<sup>th</sup> Percentile Male Hybrid II as Specified by Federal Regulations 49, Part 572

### SEAT MODELING WITH ANTHROPOMORPHIC TEST DEVICE (ATD)

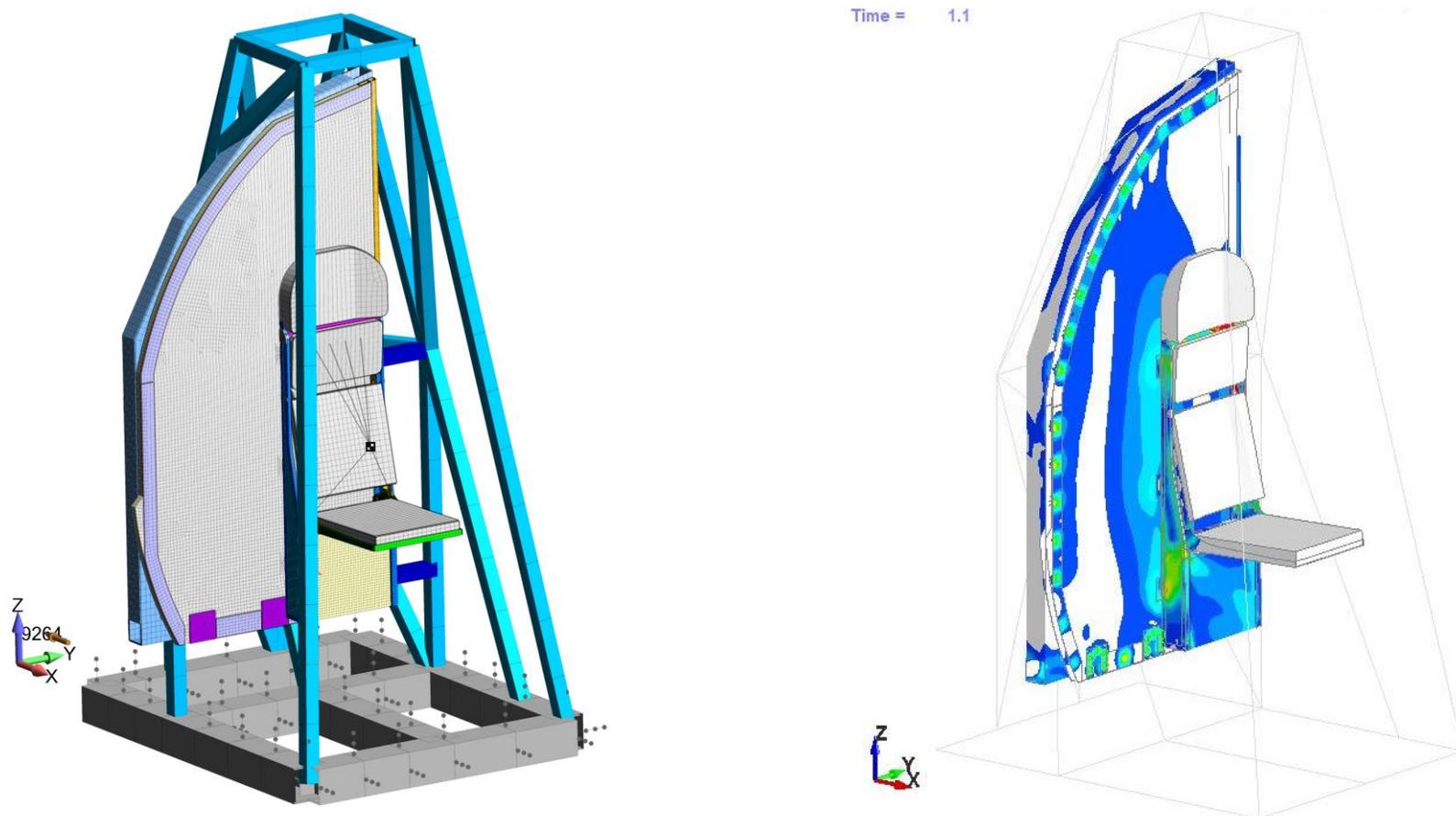


**Figure 2: Positioning and seat belt attachment to attendant's seat**

The hardest part about setting up the ATD was the seatbelt modeling. The ATD was very direct using LSTC's positioning tools but the modeling of the seatbelt fabric to obtain a clean response against the dummy was a whole another story. One of the tricks was to use `_MORTAR` contact between the seatbelt fabric and the ATD's foam shell. This avoiding spurious oscillations in the fabric yielded a much cleaner response.

## LS-DYNA FEA Implicit Verification of 16g Sled Test Model

### LS-DYNA FEA IMPLICIT MODEL SETUP

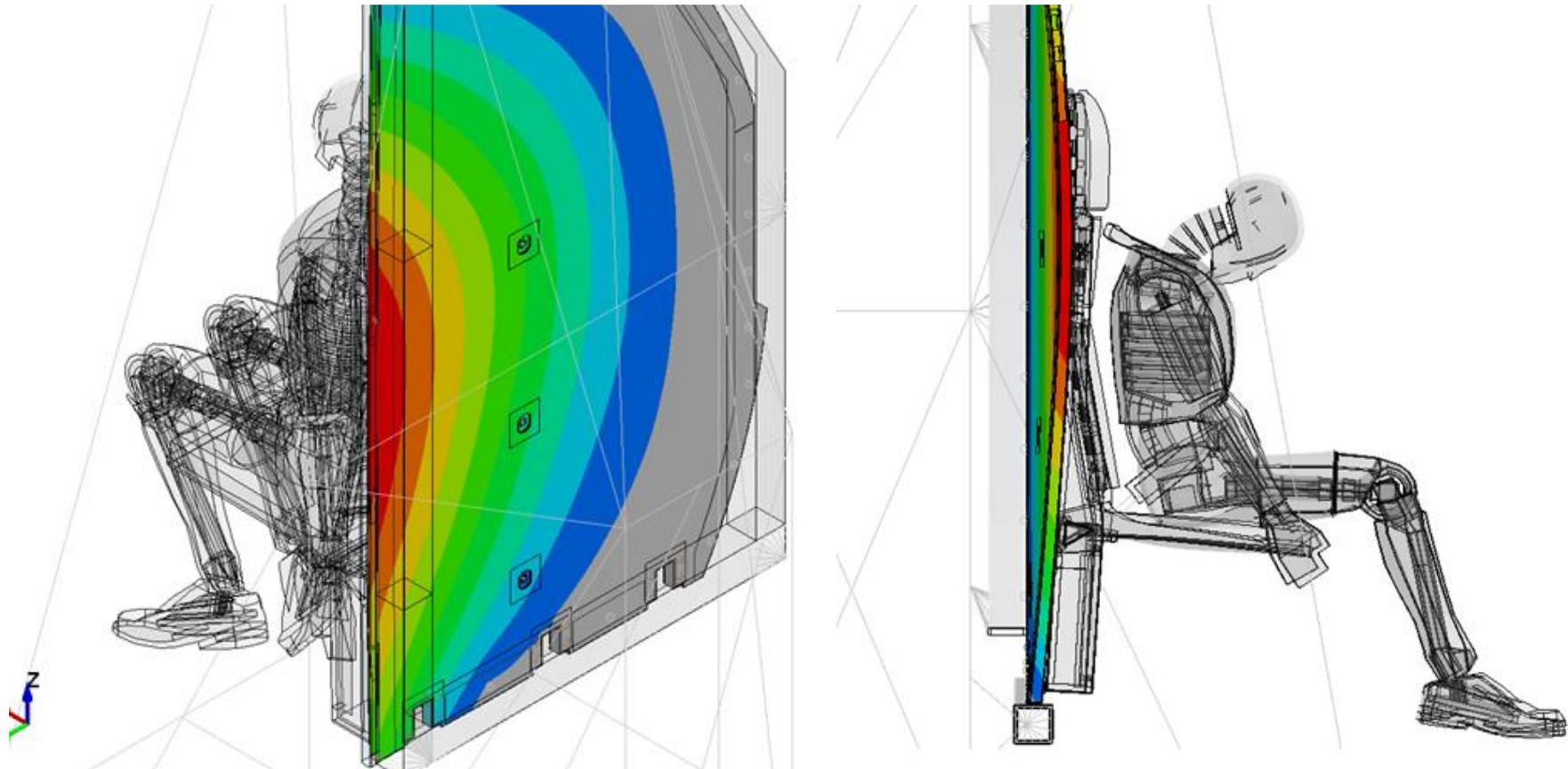


**Figure 3: LS-DYNA implicit verification analysis of 16g sled test model**

It can be difficult to verify a complex model using an explicit analysis due to transient inertia effects and a high level of background stresses that appear during a transient analysis. To avoid this complexity, the 16g sled model was analyzed using a static 20g static load. LS-DYNA’s solver robustly handled all the contact and material nonlinear behavior from bolt preload to progressive failure of the composite. This extra analysis work more than paid for itself in un-covering some limitations of the structure and some omissions in the idealization process.

## Why Transient, Nonlinear FEA Simulation is so Useful

10 SIMULATIONS FOR THE PRICE OF ONE 16G SLED TEST



**Figure 4: The full range of seat simulations were analyzed from 16g Forward to 14g Downward and at various angles**

The clear business case argument for Predictive Engineering’s LS-DYNA consulting services is the ability to quickly explore the complete sled test plan and gain assurance that when the test article is manufactured and installed on the test stand, one can have a high degree of confidence that it will pass on the first test. Given not only the costing but schedule impact of a test failure, the only difficult part is to assess your design’s risk-to-failure and your company’s tolerance for risk.