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Problem Solved.

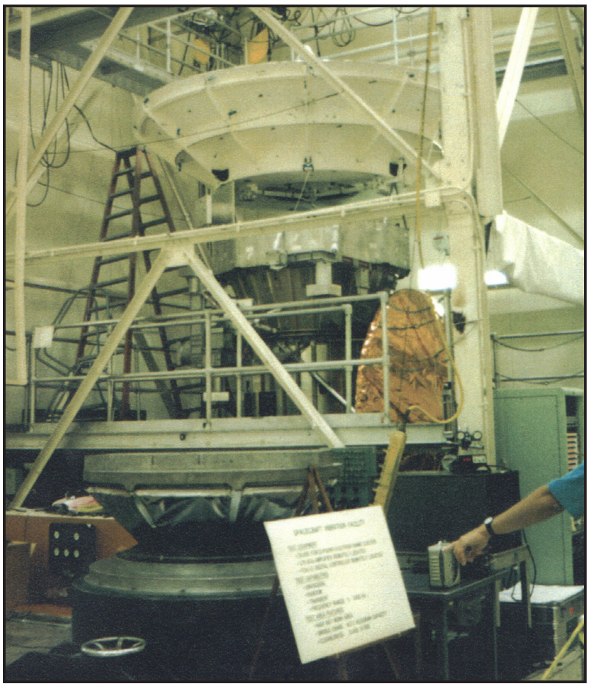
CASE STUDY | Probing Saturn and her Moons

A joint effort of NASA and the European and Italian space agencies, the Cassini orbiter and Huygens probe were launched In 1997 to make a 934 million mile trip (10 times the distance to the sun) to visit Saturn, its majestic rings and 31 known moons. Having traveled 2.2 billion real miles to enter orbit around Saturn in 2004, Cassini is the most highly instrumented and scientifically capable planetary spacecraft ever flown.

Since its arrival in 2004, the spacecraft has sent a constant stream of images and data back to earth, where more than 250 Cassini scientists strive to answer fundamental questions about our universe and ourselves. Before the end of its prime mission in 2008, Cassini will have orbited Saturn 76 times, 52 of which it will have executed close encounters with seven of Saturn's moons.

Among the many Cassini space mission problems requiring innovative solutions was a technical contradiction related to keeping harmful radiation from damaging on-board instrumentation and digital electronics components. If too much radiation gets through to the equipment and electronics, they fail.

CASSINI ON THE SHOCK AND VIBRATION TABLE AT THE JET PROPULSION LABORATORY IN PASADENA, CA



The details of the technical contradiction were that the improving feature was a reduction in radiation density (parameter 7), while the degrading feature was an increase in system complexity (parameter 39). Cross-referencing these two parameters, the contradiction matrix produced principles number 26 (copying) and 1 (segmentation) as generic solution principles.

Mainly the idea of segmentation provided the impetus for a solution. The design team segmented equipment and components into two distinct layers: outer and inner. Less radiation-susceptible components were re-allocated to the outside of the Cassini structure, where they served their mission purpose while, at the same time, helped shield more sensitive components inside the spacecraft. In some cases, outer-layer equipment was located directly behind structural elements of the spacecraft, thereby adding increased radiation protection.

As well, instead of co-locating all the inner components in a single module, they were spatially distributed throughout the vessel to further minimize saturation risk by virtue of their physical non-proximity.

The overall new design did not add significant complexity to the system, and it also reduced the need for very expensive radiation hardening materials formerly used to protect at-risk components.

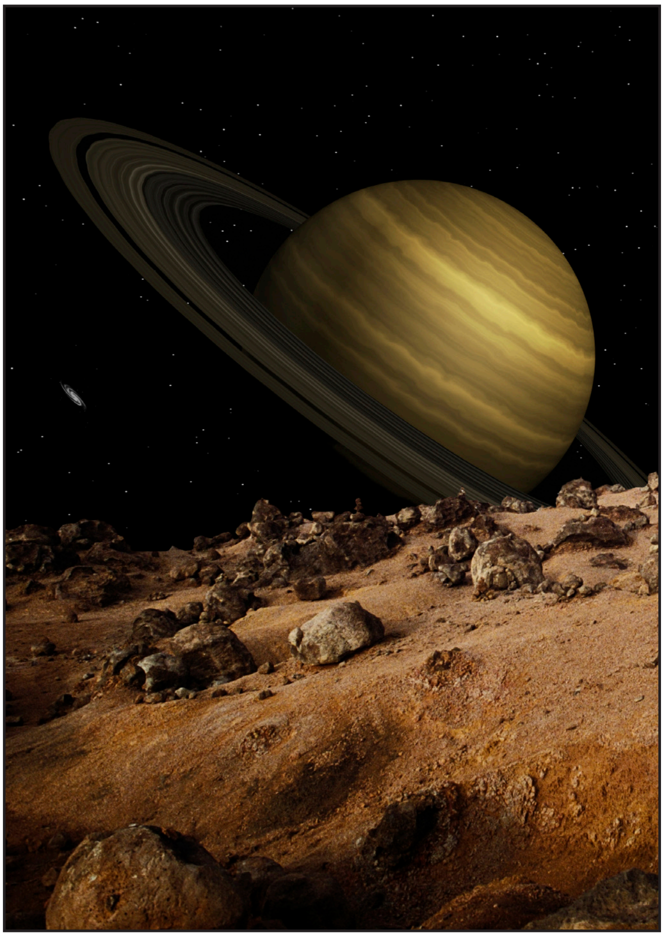
Another problem was the need to isolate the main engines and thrusters from spacecraft instrumentation, as heat, shock and vibration can interrupt or cause instruments to fail. At the same time, all components of Cassini had to be as small and compact as possible, so they could fit into the cone of the launch vehicle on which Cassini would leave earth and enter space.

The associated technical contradiction involved improving parameter #8 (volume of a stationary object) and its degrading counterpart, parameter #31 (harmful effect). All Cassini components had to be close and compact (volume of object), but such closeness put instrumentation at risk of damage (harmful effect).

Looking in the contradiction matrix, the team encountered inventive principles 30 (flexible thin films), 18 (mechanical vibration), 35 (parameter change) and 4 (asymmetry).

Using the mechanical vibration principle, the engineers reduced vibration frequency by dampening the instrument cases. Instead of mounting instrument cases directly on the Cassini structure, they used rubber mechanisms to isolate each case from the structure - and elegant solution that protected the cases from heat, shock and vibration without expanding their size. Having done this, Cassini's engines and thrusters remained fully effective, yet risk to instrumentation is greatly minimized.

HUYGENS PROBE MOUNTED IN THE CENTER SECTION OF CASSINI AT THE JET PROPULSION LABORATORY IN PASADENA, CA



TRIZ was further applied on the Cassini frontier by identifying a physical contradiction related to the Huygens probe, which successfully landed on Titan, the largest of Saturn's moons, early in 2005. In the big picture, the probe was desired for its role sending 90-minutes-worth of valuable scientific data to the Cassini orbiter, which in turned relayed that data to earth. Now the Huygens probe sits battery-dead on Titan.

To simplify, the probe was also undesired because it took up space on the orbiter, and this constituted a physical contradiction at the macro-systems level. On the one hand the lander was needed, but on the other it impinged on space constraints.

Therefore, the separation in space principle was employed to develop the "center void" that was ultimately used to house the Huygens probe. How could engineers rearrange space to accommodate all the instrumentation and functionality of the Cassini orbiter and the probe without having one impinge on the limited space of the other?

The solution was to move some components on the orbiter, thereby creating some space into which part of the probe could fill, while the rest of the probe protruded outside of Cassini (see picture). This more effective utilization of space was sufficient to overcome the contradictory requirement of wanting but not wanting the Huygens probe and all its components, instruments and functionality.

This case study was excerpted with permission from Insourcing Innovation, an Auerbach Publications book, the lead author of which is BMGI's CEO David Silverstein.