

Cassini at Saturn

As Earth's next big interplanetary mission nears completion of its seven year voyage to its target planet, scientists and engineers have high hopes for discoveries on the scale of Galileo's reconnaissance of Jupiter and its moons, and the twin rovers hands-on examination of Mars. And one reason to expect such hopes to be fulfilled is the extreme level of insight and competence shown by the probe's operators, who have already diagnosed and fixed a fundamental design flaw in the communication system – all by remote control.

After spending half a year in preliminary orbits, Cassini will detach its European-built Huyghens entry probe and send it towards Titan and its mysterious atmosphere. The probe will relay data all the way down to the surface, and hopefully, from the surface as well – at least briefly.

But it almost wouldn't have worked, because a subtle design flaw in the European-provided receiver on Cassini would have locked out great swaths of incoming telemetry, perhaps all of it. But once the flaw was detected and diagnosed during meticulous in-flight test sequences soon after launch, flexible mission planners at NASA developed a way to 'work around the problem'.

The combination of Cassini's tremendous speed and the sharp air-drag deceleration of the Huyghens probe created a significant Doppler shift in the probe's signals. The frequency change was expected, but the compression of timing pulses – combined with a money-saving trick to use radio equipment from another European space mission – would have led the receiver to fail to synchronize the incoming bitstream, and so not retransmit it to Earth.

Three separate review panels, and an exhaustive testing program, had failed to find this problem before launch. But because of the years-long cruise out to Saturn, there was all sorts of time and opportunity for in-flight testing, and at the insistence of one suspicious communications engineer, included one special sequence of frequency-shifted pulses to simulate signals from the lander to the mother ship. Once a problem was uncovered, a new series of tests were conducted to verify that the precise failure mode was understood.

The team settled on a plan that reduced the Doppler shift adequately so the timing pulses would remain just within the recognition range of the receiver. This was accomplished deploying the probe not during the first approach but after orbiting Saturn for several months, and by raising Cassini's altitude as it flew past Titan while the probe was entering its atmosphere. As a result of this geometrical rearrangement, the probe's major deceleration component was normal to the Huyghens-Cassini line-of-sight rather than mostly along it.

The Huyghens probe still faces enormous engineering challenges to survive, but thanks to some very insightful worrying and inventive fixes, at least the deck isn't entirely stacked against it.