

Oberg-Fobos-Nov14-Is Cross-coupling-Raising-the-Orbit

From blog on Fobos-Grunt mission problems

Re: LIVE: Fobos-Grunt Troubleshooting Latest (Part 2)

JimO nov 14 at 01:17 AM // <http://forum.nasaspaceflight.com/index.php?topic=27289.0>

Let me add my 2 kopecks to the mystery of the orbit rise and its hypothetical connection with attitude control firings.

The effect that is being postulated was called 'cross-coupling' in the MCC when I worked there, and reflects the fact that small thrusters which are dedicated to specific translational or rotational modes are rarely 'pure' in their force. Along with major intended contribution to specific roll/pitch/yaw and X/Y/Z translation, they induce forces in other modes as well, sometimes minor, but not always so.

Best example: attitude hold for the Orbiter using vernier jets. Since the verniers used are all down-firing, an attitude deadband is maintained by the autopilot alternately firing nose down jets, then tail down jets. The result was a 'creep' in the +X direction, in translation. Such an unexpected creep, overlooked by some consoles, was actually at the root of a major navigation crisis while I was on duty on a mission I am not yet at liberty to disclose -- a crisis I'm happy to brag that I solved as the lead 'Rendezvous and Guidance Procedures Officer'.

Translational cross-coupling was also at the heart of the loss of Mars Climate Orbiter in 1999, when the outbound cruise experienced higher-than-planned effects due to the asymmetry of the solar array, requiring frequent rotational correction burns that added up to a significant translational deviation. It was THAT deviation, which was mis-entered into cruise navigation based on the tables being in the wrong units, that created the navigation error that [together with management's refusal to listen to the navigators' intuitive concern based on their DETECTION of the cumulative error but their inability to spend enough manpower to chase down its root cause] that led to flying the perfectly-good spacecraft into the martian atmosphere.

Now, here's how this reflects on Phobos-Grunt. Translational cross-coupling is most in evidence when the spacecraft attitude profile is such that the series of small extraneous forces are cumulative -- that is, adding up in the effectively same direction.

For orbital altitude effects, that direction is prograde [or retrograde], along the velocity vector. That was the case for STS-[oops, almost typed it in!], and for MCO.

But we are given to understand that Phobos-Grunt may be holding attitude in solar inertial orientation, to maximize power. This is NOT the LVLH [local vertical local horizontal] attitude of the shuttle, or for that matter, ISS.

In practice, solar inertial pointing clocks completely around the sky once every rev.

This suggests to me that any translational cross coupling from such repeated burns would for the most part cancel out. Those that fell far off the velocity vector would not alter orbital energy and hence not affect altitude/period.

Or at least they would cancel if the sun were nearly in the probe parking orbital plane. If the probe-sun vector is significantly out of plane, some asymmetry could indeed be occurring.

Does anybody have the 'beta angle' for the probe -- the angle of the line-of-sight to the sun based on the orbital plane [with time tag]? An easier question -- what's the delta RAAN between PhG and ISS, since we know the beta angle of the latter.