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Sirs,

The Two-Stage-To-Orbit (TSTO) (AW&ST, May 17, 1993, p. 31) is another hoped-for major launch vehicle. Reading between the lines, the TSTO, like its predecessors, is destined to face the same old problems. According to the "BOEING MANAGERS," TSTO will have "a substantial performance margin to offset weight gains typically experienced…" Why start with a performance margin only to offset inevitable weight gains? Why the habitual practice: design it, construct it, test it to find out what will fail, redesign it, reconstruct it, redesign, reconstruct, etc.? Why not design it right the first time? Why not construct it right the first time?

For nearly seven years now, I have cautioned that if we continue on the above path, then we are not going to Mars, we are not going back to the moon, and we will hardly make it to low earth orbit; which is where we are today. Harbingers of bad tidings used to be killed. Today, they are ignored. The former NASA administrator, Richard Truly, and some of his associates were skillful at dodging a serious engineering blunder that has caught up with us good. The error has impoverished our aerospace programs and industries, and the economy. The following description should be of immediate interest to your technical readers, and, especially, to policy makers.

Suppose that instead of TSTO, we want to design a weight scale. We know that if a person stepped suddenly on the scale, then the dial will overshoot. The scale must then be designed to withstand the person's weight plus the overshoot. If the scale is made of aerospace materials (high stiffness to weight ratio), then the overshoot can be as much as 100%. This is to say that for a 100-lb person, some parts of the scale will experience forces of up to 200 lb. If we start with the 100-lb as a design baseline, add a safety margin, say 40 lb (e.g., the 40% margin used for the shuttle), and construct the parts of the scale to withstand 140 lb; we will have a lightweight scale that will fail when tested, and it will require redesign and reconstruction. How is this relevant?

When we stand on a scale, our weight imposes a pressure (weight divided by the area of the feet) on the platform. "Pressure" is the key word. Our weight, or its equivalent pressure, does not overshoot. A person does not become instantly fat because he or she stepped suddenly on a scale. But, the parts of the scale (springs, platform, joints, etc.) will surely experience the overshoot.

By analogy, the sudden pressure build-up in a combustion chamber is like stepping suddenly on a scale. The pressure itself does not overshoot, but its effect on the parts does. It has been the habitual practice to design pressure-activated systems to only the maximum pressure values. Hence, the vicious cycle of redesign and reconstruction; and premature fatigue, early cracking, accelerated corrosion and unexpected accidents.

How did this happen? Simple. A rocket is made up of thousands of parts. It is more practical to make a few pressure measurements in the engine than to make thousands of force measurements in all the parts. It has not been clearly recognized before that the pressure does not overshoot.

Nor has it been noted that pressure transducers do not, and cannot, measure, nor detect, the magnified effect. The Shuttle, for example, was designed in the early 1970's without any consideration whatsoever to the overshoot effects. If you remember, the shuttle was nearly ready in 1977. But when tested, the vehicle required strengthening, and it gained weight before it finally flew in 1981 (just look up Aviation Week during that period). The redesign and reconstruction cycle did not stop there. I had actually left an attractive aerospace job in 1978 primarily because of the shuttle's difficulties. The space program looked grim to some of us then.

What is the primary measurement that has been used to analyze the safety of nuclear reactor vessels under sudden pressure build-up? The non-overshooting pressure. The overshoot effect does not show up in pressure measurements, and the effect has been completely overlooked in transient conditions. The same error that has haunted the space program is widespread in all pressure-activated systems, and it must be corrected immediately.

Some agencies I recently briefed on the above situation now recognize it, and future procurements will inevitably require the overshoot analysis up front, and not as part of a redesign and reconstruct cycle. Excellent analytical and experimental tools are readily available. The "weight gains typically ***experienced***" should become a thing of the past. Future systems, including the TSTO, should be designed optimally the first time around.

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