Letter to the Editor, September 2, 1993
SPACE NEWS

Sir,

What's wrong with the space program? William Harwood quotes an unidentified NASA manager, (Space News, August 30, 1993, p.1), "***Something isn't right, and I don't know what the heck it is.***" This is as spontaneous as it can get.

The article offers potential answers: ***"bad luck," "some generic management problem," the way the government manages critical contracts," "the nation's reluctance to accept risk," "sophisticated*** [though unidentified] ***failures," "putting all its*** [NASA] ***eggs in one basket," "the agency's ability to monitor the work of contractors."*** These are not causes of technical failures. Not even budgets can explain what's going on. The Congress will reconvene soon and ask: What's worng?

It was after midnight, in October 1986, when the first shuttle assembly [Atlantis] after the Challenger accident began the slow roll out to Pad 39B. Only a handful of people watched in the dark. Mr. William Harwood was one of them. Bill handed me binoculars to look at the heavily instrumented right booster. I declined. Earlier that day, I had detected and reported instruments completely missing from regions of maximum loads. That was why Bill brought the binoculars with him that night. Publicly, I was identified with the roll out loads. There was a more important issue that I discussed with NASA at the time. A first-order error in the design of the shuttle. That's what the data said. I almost told Bill about it then. I didn't. Though a pure engineering problem, it sounds like a riddle.

When a person steps suddenly on an old bathroom scale, the dial overshoots the actual weight. Two distinct entities are involved here, (1) the person, and (2) the scale. The parts of the scale (platform, springs, joints, etc.) experience greater loads than the weight. The loads on the scale overshoot. The person's weight does not. A person does not become instantly fat because he, or she, stepped suddenly on a scale. This is common knowledge. Next, the riddle.

When a rocket motor or engine starts, the pressure builds up rapidly to a maximum value. It has been a habitual practice to derive the maximum design loads from the maximum pressure; measured or calculated. This is where we went wrong. We have neglected the start-up overshoot. But, don't we know how to derive the overshoot? We do. The problem is subtle. The scale example is now handy.

The two factors involved here are, (1) the pressure, and (2) the rocket. Think carefully. The pressure is analogous to the person's weight in the scale example. The weight does not overshoot. Likewise, the pressure does not overshoot. The parts of the scale experience the overshoot to varying degrees. Likewise, the parts of the rocket experience greater loads. Throughout the short history of the space program, the start-up pressure has been measured carefully and accurately. But, the non-overshooting pressure is the wrong parameter to use for the design of launch vehicles and spacecraft and, even, aircraft and nuclear reactors.

The more we advanced, the farther we fell behind. As engines and motors produced greater thrust in shorter times, the start-up overshoot intensified, and our problems multiplied. For modern engines and motors, the overshoot is dramatic: some 70 to 100%. This alone can explain problems with different parts on the same system; electric, electronic, mechanical, structural, optical, hydraulic, etc. The start-up overshoot is like a speed bump in a parking lot. If you drive cars of different makes, carrying sensitive equipment and mirrors, at high speed over the speed bump, things will bend, buckle, jam, break, etc. It doesn't matter whether the car is cheap or expensive.

What do the experts say about this? What experts? In dynamics, we deal with a myriad of complex dynamic conditions encountered in each mission; after the first speed bump. In structural analysis, we consider everything; up to the first speed bump. The start-up dynamic overshoot occupies a niche that has not been adequately handled to date.

In 1990, I mounted a massive campaign to stop the launch of the Hubble. The launch was delayed, but eventually I was overruled. Spherical aberration is not caused by the start-up overshoot. But Hubble, like other payloads, encountered other problems: Solar arrays, gyroscopes, magnetic sensors, rate sensors, electronic control units, etc. These are not aberration problems, and they can be explained by driving fast over the first speed bump; the start-up dynamic overshoot. The problem is widespread. Just read about the Indian experiences, e.g., page 17 of same ***Space News*** issue, the explosion ***"occurred as soon as the engine was fired."*** If we are going to lead the world in space, we will need many experts in the **start-up transient dynamic overshoot effect.** The military engineers have been quick to recognize the problem. NASA engineers must. A problem of the nature and magnitude described above cannot be solved by the engineers alone. Officials in the Administration and the Congress must lead the way; even though they are not engineers.

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I am a senior expert on failure mechanisms in engineering systems.