Reply to Yousef Butt in 'Bulletin of the Atomic Scientists'
James Oberg   August 25, 2008

Perhaps there is less to these apparent contradictions than meets the eye. For the first shuttle missions I served on the 'Propulsion Officer' team overseeing the auxiliary engines and their support plumbing, and I recall that even at launch the tanks had a significant 'empty space' filled with pressurization gas. It was this ullage volume that provided the 'push' to transfer liquid propellant into the lines leading to the engines, and this ullage volume is clearly seen in the drawing of the tank on the first page of the linked NASA document. As a result of such mass asymmetry, given enough time the USA-193 tank might indeed have settled with the forward end – exposed to highest temperatures – coated inside with cold hydrazine, in frozen or slush form, a very efficient heat sink.

But the steering force would be relatively weak since the center-of-mass offset wasn't large, and the tank could be expected to be rapidly tumbling once it tore loose from encapsulating structure midway through entry. A tumbling tank is not an arbitrary assumption, it is the characteristic of actual tanks that have survived entry and been examined.

In any case, according to Johnson, there were numerous other studies at classified levels, using a wide variety of initial conditions, and, according to Johnson, "They all survived." I have every reason to believe that this statement is true and is reliable.

More seriously flawed is Butt's contention that the tank nearly melted simply because the outside temperature rose higher than the melting point of the tank material. This is a problem in fundamental thermodynamics. The fate of the exposed material in question is not dependent on the exterior temperature but on the amount of heat that exterior can transfer into it. If the exterior heat is very high but is also materially very tenuous (as in the near-vacuum conditions of 100 kilometers up), the amount of HEATING it induces in the skin may be minor, especially if the skin is in contact with a very cold mass behind it – as in this case. And at orbital entry speeds, the heat transfer is primarily by conduction, not radiation from the off-standing plasma shock wave.

As to how cold that mass would have become in space (the number that was mysteriously "dictated" to the NASA team), the experts competent to calculate it would be those with full knowledge of the satellite's mechanical structure and flight profile – its owners, operating at a classification level higher than needed by the NASA analysts. We know that derelict satellites even in near-Earth orbit fall well below 0º C, from experience. In theory, the 'black body' temperature at 1 AU is below 0º C, for an object in continuous sunlight – and cumulative factors even beyond being in Earth's shadow almost half the time would account for much less solar energy absorption, and consequently a much lower temperature.

From my own spaceflight operations experience and familiarity with actual atmospheric entries and fallen object recoveries, I find the analysis that shows a tank with cold hydrazine is very likely to survive to ground impact to be eminently plausible. While Dr. Butt argues that the opposite is "certainly" true, it seems that this is the conclusion that he has always wanted to reach from the beginning, as shown in his earlier writings on the subject, and strikes me as independent of competent engineering analysis of the type that has been used successfully in the real space programs undertaken by professional space experts.