APR Corner

Aerospace Projects Review

Aerospace Projects Review (APR) is presented by Scott Lowther, whose unique electronic publication is described as a "journal devoted to the untold tales of aero-spacecraft design."

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Inflatable Spaceplane

Scott Lowther, Aerospace Projects Review

Getting back safely from orbit involves one of the most challenging environments Man has yet tackled: the aerothermal heating involved in using the atmosphere to brake from orbital velocity. The math is simple: if you use the atmosphere to slow your spacecraft from orbital velocity, then all the kinetic energy that went into putting the spacecraft up there in the first place must be transformed into another form of energy… in this case, heat. It is **almost** as if the spacecraft needs to be parked directly behind the rocket engine that launched it, and the engines run for as long as they did during launch, for the same throttle settings.

A note: unlike ever science fiction movie that has ever mentioned it, the heating on re-entry does **not** come from friction with the air. Instead, it comes from the compression of the air. As the spacecraft plows into the air at many times the speed of sound, the air simply cannot easily get out of the way, and "piles up" in front of the craft. The pressure is far greater than the local static air pressure, and thus the compressed air heats up. This cannot be avoided. However, it can be dealt with in a number of ways. The ways generally used have been either refractory materials such as carbon structures or silica tiles that can withstand the heat, or ablative heat shields that melt or vaporize and take the heat away. But another approach is to use very large, but very light, heat shields.

If two spacecraft enter on the same trajectory and same speed, and have the same shape and mass, they will have similar heating issues. If, however, one of the spacecraft has a much larger surface area, then to first order the heating rates will be much reduced. A simple thought experiment will illustrate this: a one kilogram rock, and a one kilogram balloon several meters in diameter. The rock will enter as a meteor, decelerating slowly while glowing white hot. The balloon, on the other hand, will virtually slam to a stop. The acceleration will be immense, but the heating rates will be vastly lower compared to the rock. The same **total** amount of thermal energy will be converted from kinetic energy, but it will be spread over a far greater surface area. Thus the balloon might get a little warmer, but not white hot.

Several spacecraft have been designed to take advantage of the milder heating properties associated with inflatable reentry vehicles. One such design was studied at NASA-Langley in 1960 and found to be practical. While the nose cap would be made of a high temperature solid metal, structure, the bulk of the craft would be an inflatable structure using tubes inflated to 75 psi as the primary structural elements. A two-man capsule was suspended within the inflated structure. The leading edge temperatures were held to around 1500° F; while conventional balloon materials could not withstand this, a

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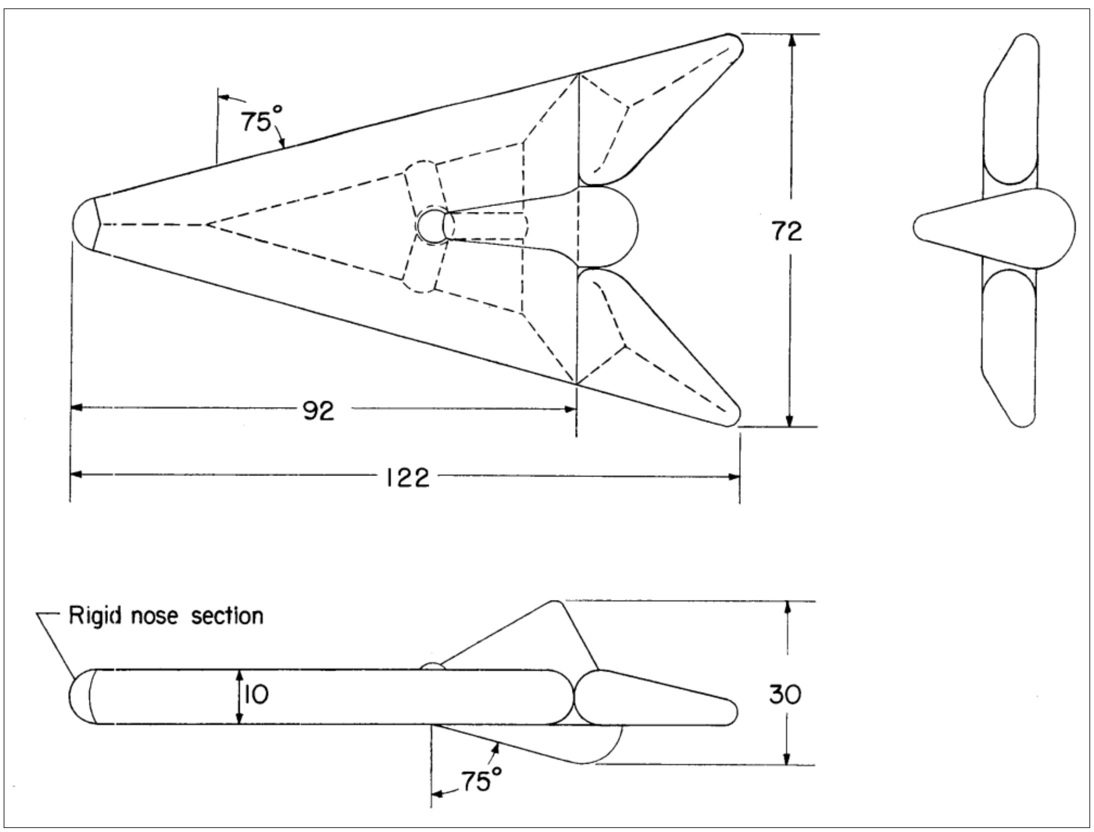

Above: Inflatable spaceplane. Dimensions in feet (NASA, 1960). Image credit: Scott Lowther.

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fine steel mesh cloth impregnated with a gas-tight elastomeric material could. The inflatable structure would be folded and stored during launch and while in orbit; inflation would occur just prior to re-entry. The ability to be folded for launch solved a major problem inherent with many spaceplane designs: the pitching moment produced by larger wings at the forward end of the launch vehicle. The X–20 Dyna Soar dealt with the pitching moment by adding very large fins to the tail ends of the initial Titan I and Titan II launch vehicles; a similar launch vehicle with an inflatable spaceplane would not need such fins, as the spaceplane would be packed into a non-lifting configuration.

It's not clear if the design analyzed by NASA was an in-house design or a contractor design. Several companies, such as General Electric, had devoted considerable effort to the study of inflatable manned entry vehicles.

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Weight breakdown:
Structure (Wings, elevon, tail): 2,400 lbs
Pressurization system: 400 lbs
Capsule structure: 1000 lbs
Crew: 400 lbs
Escape system: 600 lbs
Power system: 800 lbs
Total: 6,000 lbs

Reference: NASA TN D-538, "A STUDY OF THE FEASIBILITY OF INFLATABLE REENTRY GLIDERS," Walter Olstad, Langley Research Center, October 1960.