THE ROYAL SOCIETY

Introduction

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Since the 1960s and the exploits of the X-15, the most public hypersonic flights have been those of the Space Shuttle orbiter. In both aircraft, technical risk was held to challenging but realistic levels by limiting the engine design to rocket propulsion. Published consideration of airbreathing propulsion, with its promise of much reduced propellant consumption, was restricted during the 1960s and 1970s to experiments and design studies of, for example, hypersonic airliners (which offered global ranges at colossal cost), and to vehicles for military application; in addition, studies made of space launch systems were of great diversity but usually replaced the ballistic rocket launch by horizontal take-off and conventional flight up to hypersonic Mach numbers. This extended the pioneering work on reusable launchers by Sanger and Bredt until, in the early 1980s, 'post-Shuttle' studies led to such projects as Sanger, Skylon and the National Aerospaceplane (NASP, X-30), all of these being airbreathers up to Mach 5, and some of them considerably beyond. These in turn have been exposed to assessments of technical risk and of the costs of complication, and have resulted during the 1990s in less ambitious specifications. In particular, vehicle sizes have drawn back from the 300 ft aeroplane, airbreathing propulsion is rarely envisaged for Mach numbers beyond about 10 or 12, and the relative utility of hydrogen fuel and hydrocarbons has been reassessed but, for the longer term at least, they remain reusable airbreathers.

If the future space launcher is to be economically reusable, then re-entry of a single stage to orbit (SSTO) (or a two stages to orbit (TSTO) second stage) must comprise a controlled and readily survivable flight, with no need for substantial vehicle refurbishment. Cost and complexity may dictate a long gestation period for any such launcher, but nonetheless, new re-entry craft need to be built because of the imminent construction of the International Space Station. This calls for the ability to rescue and evacuate as many as eight astronauts at a time, and for this task, the X-38 is being developed. But neither the X-38 nor the Space Shuttle are well suited to the task of carrying the injured because they involve substantial g-forces in re-entry.

The intention of this Theme Issue is to isolate two projects that are technically and economically feasible during the next two or three decades, and to indicate research which might attract funding. These projects form focal points for Topic I and Topic II. They are, respectively, for lifting re-entry (Topic I) a small simple re-entry glider offering very low g-forces so that an injured astronaut can survive a return to Earth for treatment without risking an embolism due to blood clots shifting under re-entry loads, and for airbreathing propulsion (Topic II), a demonstrator for future reusable space launchers or a small aerospaceplane offering hypersonic cruise or space access carrying minimal payload. The re-entry glider is complementary (and not a competitor) to the X-38. The airbreathing vehicle is a logical extension to

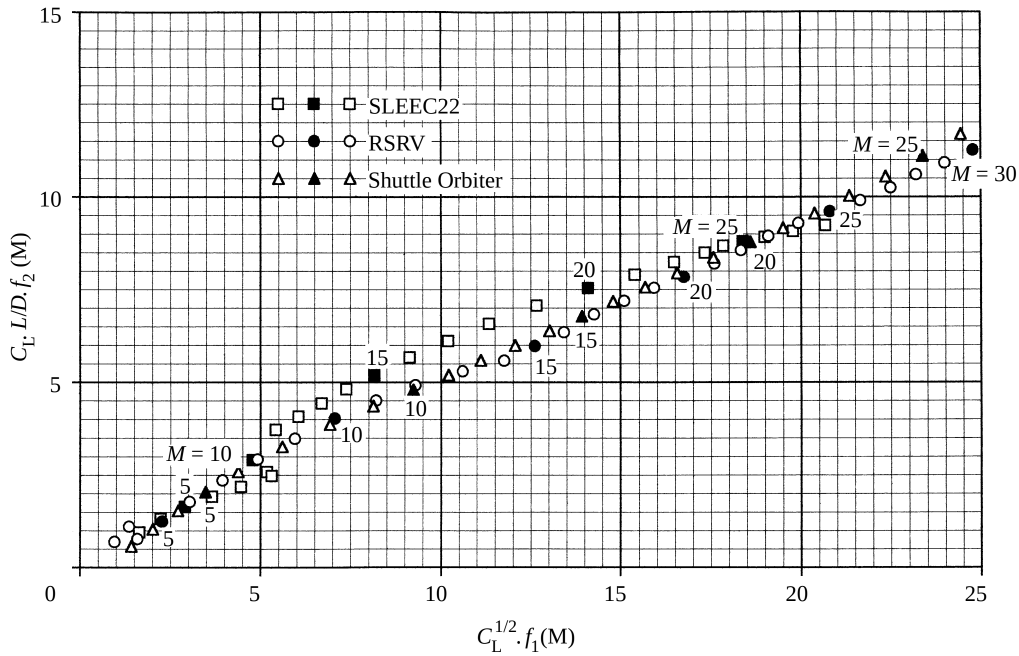

Figure 1. Data correlation for lifting re-entry gliders.

such projects as the Hyper-X. Both vehicles are compatible with civilian and USAF interests, but they are radically different in type.

The two vehicles proposed above have at least one feature in common. Unlike Concorde, the projected High Speed Civil Transport or a hypersonic airliner, they do not have a 'design' Mach number. Thus the designer has little opportunity to concentrate on lift, drag and thrust at one dominant flight speed. The aerodynamics of both lift generation and vehicle propulsion must be assessed over a Mach number range of 0.3 to (say) 10 or more, and for re-entry the Mach number range is trebled.

In the opening paper, Pike derives two basic aerodynamic parameters that allow the lifting effectiveness of hypersonic wings (and their lifting efficiency) to be correlated and compared over a wide range of Mach number. The parameters can also show the performance of complete engines (such as the scramjet which, as confirmed by Broadbent, readily provides a lift force as well as a thrust), and of wings using 'external heat addition' to modify their lift and drag characteristics (again as confirmed by Broadbent). An example of their use to correlate the performance of three different re-entry gliders is shown in figure 1.