# Ramjet Propulsion for Single-Stage-to-Orbit Vehicles

James A. Martin*
*NASA Langley Research Center, Hampton, Va.*

## Abstract

SPACE flight is now a reality, and the space shuttle will soon allow routine flights to space. The growth in space utilization and resulting benefits will soon lead to the conclusion that even the space shuttle is not sufficient. New vehicles will be needed, and some of the goals for these vehicles should be reduced operating costs, reduced environmental impact, reduced loads on payloads, and increased flexibility. With these goals in mind, a program has been underway to analyze vehicle concepts and determine which advancements in technology should be pursued. One of the most attractive concepts from an operational viewpoint is a single-stage vehicle that can take off from a runway, fly into orbit with low thrust and acceleration levels, and return with a runway landing. Such a single-stage airbreathing vehicle is the subject of this paper.

## Contents

The first type of airbreathing engine considered was a fan ejector ramjet, as shown in Fig. 1. Data for several engines of this type were calculated, and the results are reported in Ref. 1. Parameters which were varied were the fan pressure ratio, the ratio of rocket to airbreather thrust, the fuel, and whether the fan was fixed or removable. The engine results were used in vehicle analyses; a typical vehicle is shown in Fig. 2. The results with these engines showed that the vehicle could not deliver a payload to orbit with the assumed gross mass. The analyses did show which engine variations were beneficial. The results of this initial work are reported in Ref. 2.

Figure 3 shows that the ejector rocket subsystem of the fan ejector ramjet engine has a lower specific impulse than the space shuttle main engine (SSME). Based on this and other information, a fan ramjet engine concept was considered which did not incorporate an ejector. Separate SSME's were used for rocket thrust. Figure 4 shows that with the fan ramjet engine a moderate payload could be delivered. Each engine was sized for a capture area of 11.566 $m^2$. Continuous use of the rocket engine was found to be detrimental.

Supersonic combustion ramjet engines were also considered. Separate SSME's were again used for rocket thrust. The results in Fig. 5 show that a significant payload can be delivered if the expected engine mass reductions are achieved. Some variable geometry is needed.

The major conclusions that can be drawn from this study of ramjet propulsion for single-stage-to-orbit vehicles are as

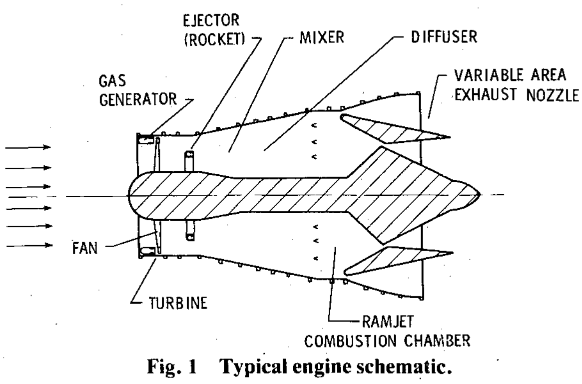


Fig. 1 Typical engine schematic.

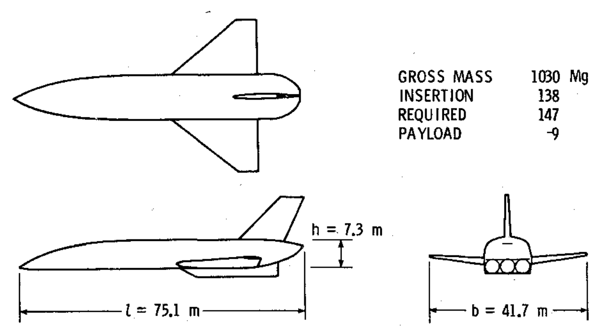


Fig. 2 Typical vehicle configuration.

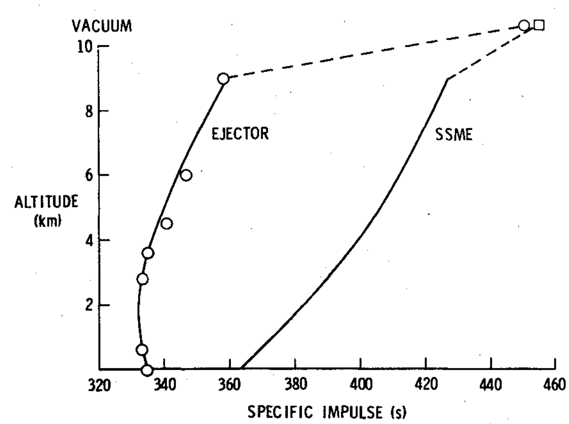


Fig. 3 Ejector performance compared to a separate rocket.

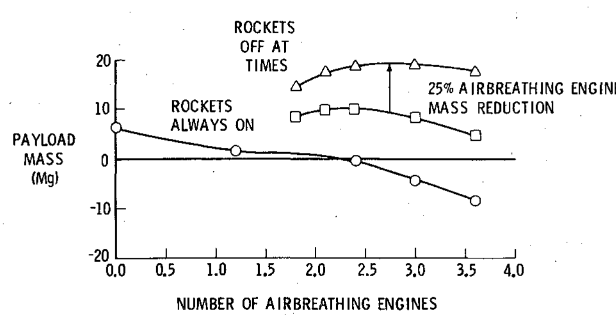


Fig. 4 Fan ramjet engine results.

Received Jan. 13, 1978; revision received May 12, 1978. Presented as Paper 77-1011 at the SAE Aerospace Meeting, Los Angeles, Calif., Nov. 14-17, 1977. Full paper is available from Society of Automotive Engineers, Inc., Department 206, 400 Commercial Drive, Warrendale, Pa. 15086. Price: $2.75. 

Index categories: Airbreathing Propulsion; Launch Vehicle Systems; Engine Performance.

*Aerospace Engineer, Space Systems Division. Member AIAA.

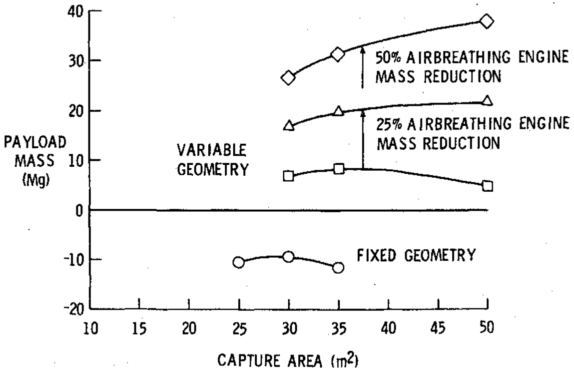


**Fig. 5 Supersonic combustion ramjet results.**

follows:

1) With advanced technology, single-stage ramjet vehicles can deliver reasonable payloads to orbit.

2) A fan ramjet engine incorporating a removable fan and used with separate rockets delivers more payload than engines with ejectors.

3) Supersonic combustion ramjet engines are desirable if the engine mass can be minimized.

## References

[1] Bendot, J.G., Brown, P.N., and Piercy, T.G., "Composite Engines for Application to a Single-Stage-to-Orbit Vehicle," NASA CR-2613, Marquardt Rept. 5-1325, Dec. 1975.

[2] Martin, J.A., "An Evaluation of Composite Propulsion for Single-Stage-to-Orbit Vehicles Designed for Horizontal Takeoff," NASA TM X-3554, 1977.