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SESSION 6 - HIGH-SPEED PROPULSION TECHNOLOGY

NASA THRUSTS IN HIGH-SPEED AEROPROPULSION RESEARCH AND DEVELOPMENT - AN OVERVIEW

Joseph A. Ziemianski

INTRODUCTION

NASA is conducting aeronautical research over a broad range of Mach numbers. In addition to the advanced conventional takeoff or landing (CTOL) propulsion research described in a separate session at this conference, the Lewis Research Center has intensified its efforts towards propulsion technology for selected high-speed flight applications. In a companion program, the Langley Research Center has also accomplished significant research in supersonic combustion ramjet (SCRAM) propulsion. What will be presented in this session is an unclassified review of some of the propulsion research results that are applicable for supersonic to hypersonic vehicles. This overview not only provides a preview of the more detailed presentations which follow, it also presents a viewpoint on future research directions by calling attention to the unique cycles, components, and facilities involved in this expanding area of work.

NASA THRUSTS IN AERONAUTICAL RESEARCH AND DEVELOPMENT

The Lewis Research Center is conducting high-speed propulsion research over a broad range of Mach numbers. In addition, the Langley Research Center has accomplished related research in supersonic combustion ramjet (SCRAM) propulsion. What will be presented here is an overview of some of the propulsion research results that are applicable to the classes of supersonic/hypersonic vehicles shown in figure 1. The research program associated with the National Aerospace Plane (NASP) will not be discussed because of classification, but the final paper of this session describes hypersonic propulsion research at Langley Research Center.

Session 5 of this conference described the advanced conventional takeoff or landing (CTOL) propulsion research results.

NASA THRUSTS IN AEROPROPULSION

The propulsion concepts that NASA has identified with the vehicle classes shown in figure 1 are illustrated in figure 2. The papers presented in this session describe the following:

(1) An evaluation of the merits of a high-speed transport and the associated propulsion technology barriers

(2) A further exposition of a propulsion research concept that may have applicability to the high-speed transport - a supersonic throughflow fan

(3) High-speed inlet studies in the Mach 5 range

(4) Propulsion research results associated with a supersonic short takeoff and vertical landing (SSTOVL) vehicle

(5) A summary of hypersonic propulsion research at the Langley Research Center

FUTURE DIRECTIONS IN HIGH-SPEED PROPULSION RESEARCH AND DEVELOPMENT

The future of NASA's propulsion research will shift towards the higher Mach propulsion concepts because of the renewed emphasis on such challenging programs as SSTOVL, high-speed civil transports, and NASP. What is required is the identification of propulsion unique cycles and associated components that could lead to new vehicle capabilities in the high Mach regimes. Because of the complexity and limited data base at high Mach numbers, considerable discipline research must first be accomplished before any component program can begin. Integration of the propulsion system is complex; because of the high Mach numbers, the propulsion and airframe become an integral system.

UNIQUE TECHNOLOGIES FOR HIGH-SPEED PROPULSION

Unique technologies required for high-speed propulsion are shown in figure 3. They range from high-speed inlets and the associated computational fluid dynamic codes needed to address the complex flows to high-temperature materials/structures needed in the hot section of the engines. For application such as the high-speed civil transport, unique nozzles and suppressors are required for performance and community noise considerations.

Supersonic compression is an identified technology that can lead to more fuel-efficient propulsion concepts, in the Mach 2 to 4 range. Supersonic combustion is needed around Mach 6 for a scram propulsion mode but may have promise at lower speeds in a complete supersonic throughflow machine. How all these technologies are brought together in a viable propulsion concept is the challenge of today's researchers.

PUTTING IT ALL TOGETHER

One configuration that shows considerable promise is the supersonic throughflow engine (fig. 4), but it will require major progress in a variety of discipline and component research areas and careful matching of those elements. If successful, our analyses indicate for a high-speed civil application that this concept will be 10 percent more efficient and that the weight will be 25 percent less than that of a variable cycle engine.

HIGH-SPEED AEROPROPULSION RESEARCH WIND TUNNEL FACILITIES

NASA Lewis Research Center has positioned itself in the high-speed regime by developing additional capabilities in our complex of wind tunnel testing facilities, which are listed in table I. The Propulsion Systems Laboratory (PSL) now has the capability to run turbomachinery to Mach 6 with gaseous hydrogen and oxygen. In addition, heaters have been added in our 1- by 1-ft tunnel to eliminate condensation shocks to Mach 6. These additions, together with the current 10- by 10-ft supersonic (Mach 3.5) and 8- by 6-ft transonic tunnels, give NASA the capability to test over a broad Mach range.

In addition, we are investigating reopening our Hypersonic Test Facility (HTF) at Plum Brook, which if successful will have capabilities to test at Mach numbers of 5, 6, and 7 in a nonvitiated mode. In addition, if heaters are added, the facility capabilities can be expanded substantially.

TABLE I. - HIGH-SPEED AEROPROPULSION RESEARCH WIND TUNNEL FACILITIES

Facility	Speed capability, Mach number
10- by 10-Foot Supersonic Wind Tunnel	≤3.5
Propulsion Systems Laboratory 4	[a]≤6
1- by 1-Foot Supersonic Wind Tunnel	[a]≤6
8- by 6-Foot Supersonic Wind Tunnel	Transonic
Plum Brook Hypersonic Test Facility[b]	
Nonvitiated	5, 6, and 7
Vitiated	≤6

[a]New capability.
[b]Proposed for NASP testing.

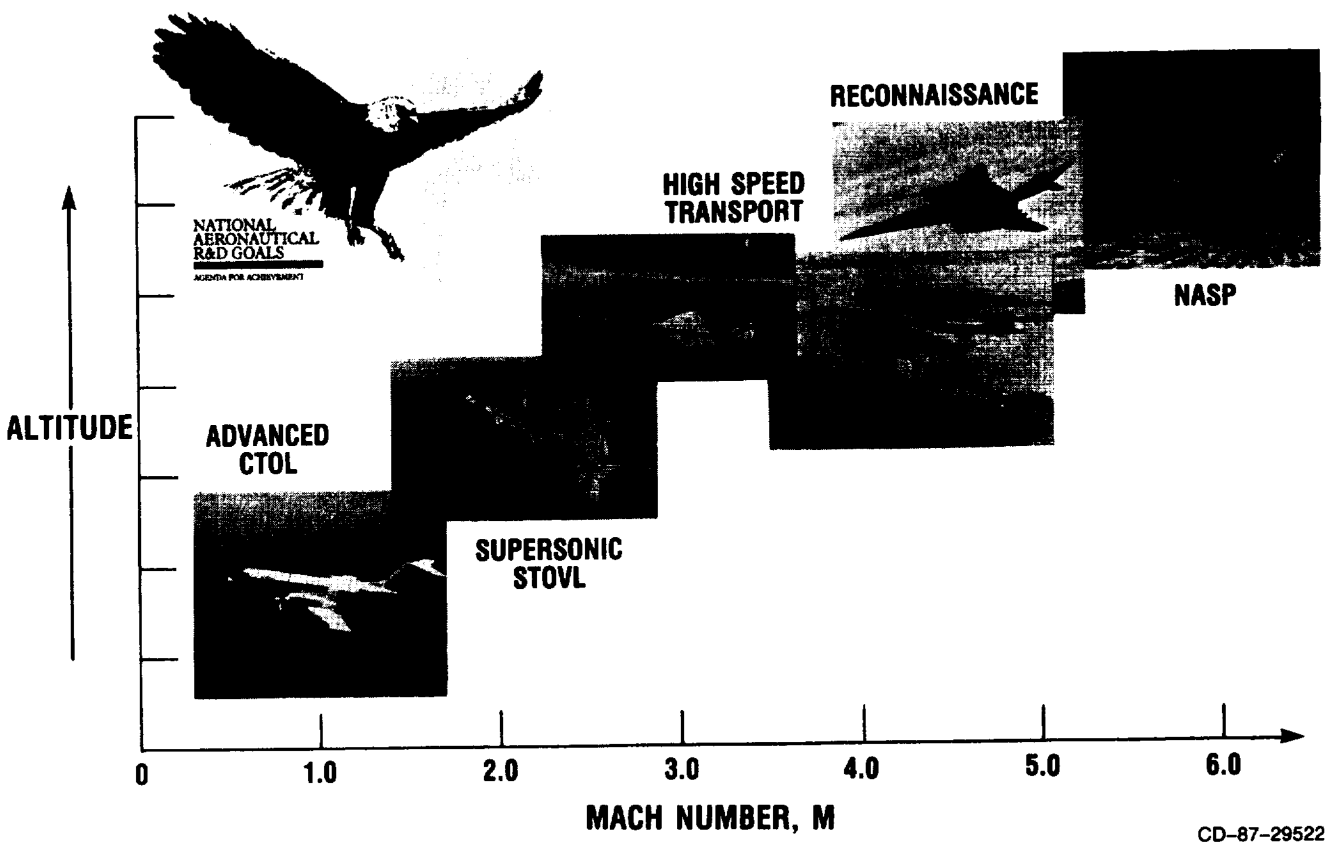

Figure 1. - NASA thrusts in aeronautical research and development.

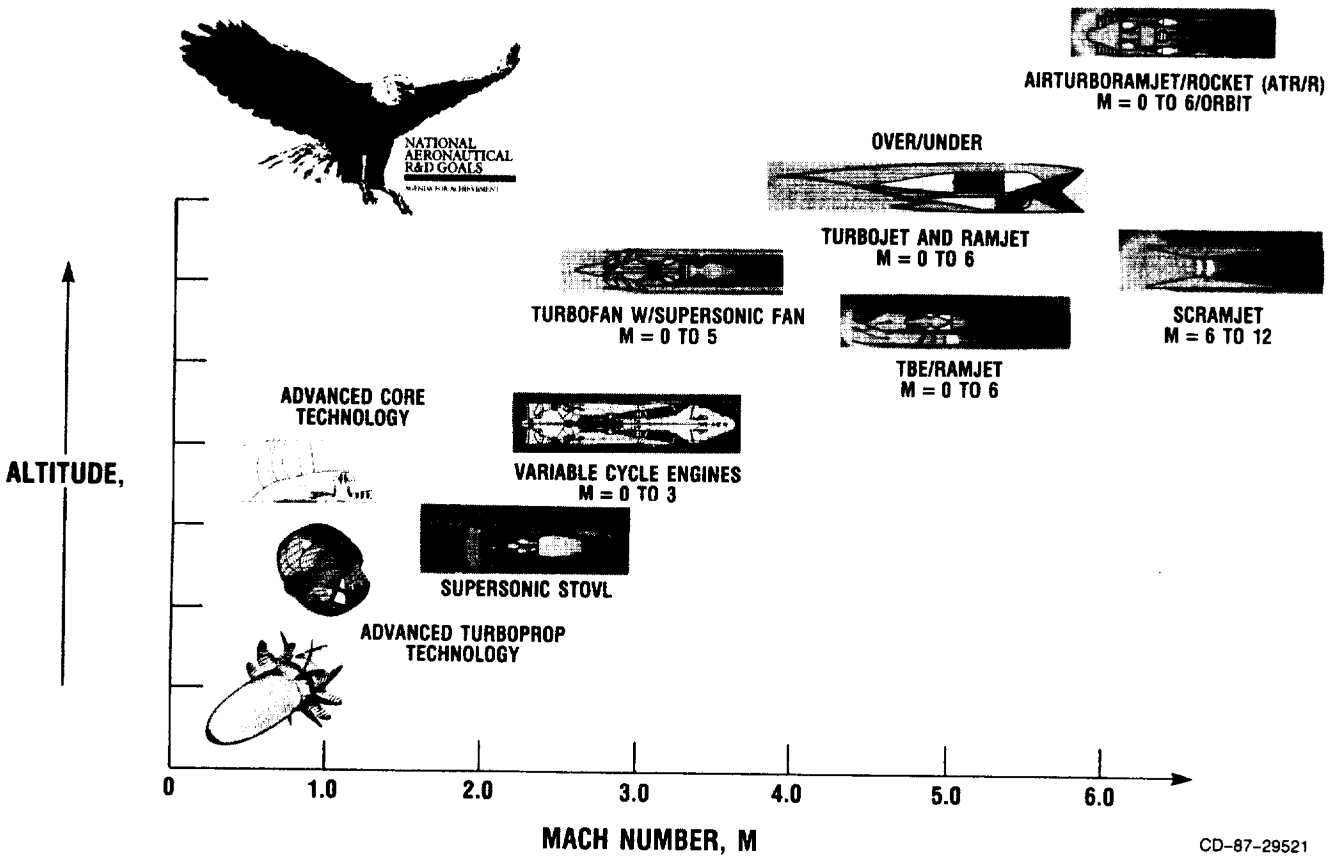

Figure 2. - NASA thrusts in aeropropulsion.

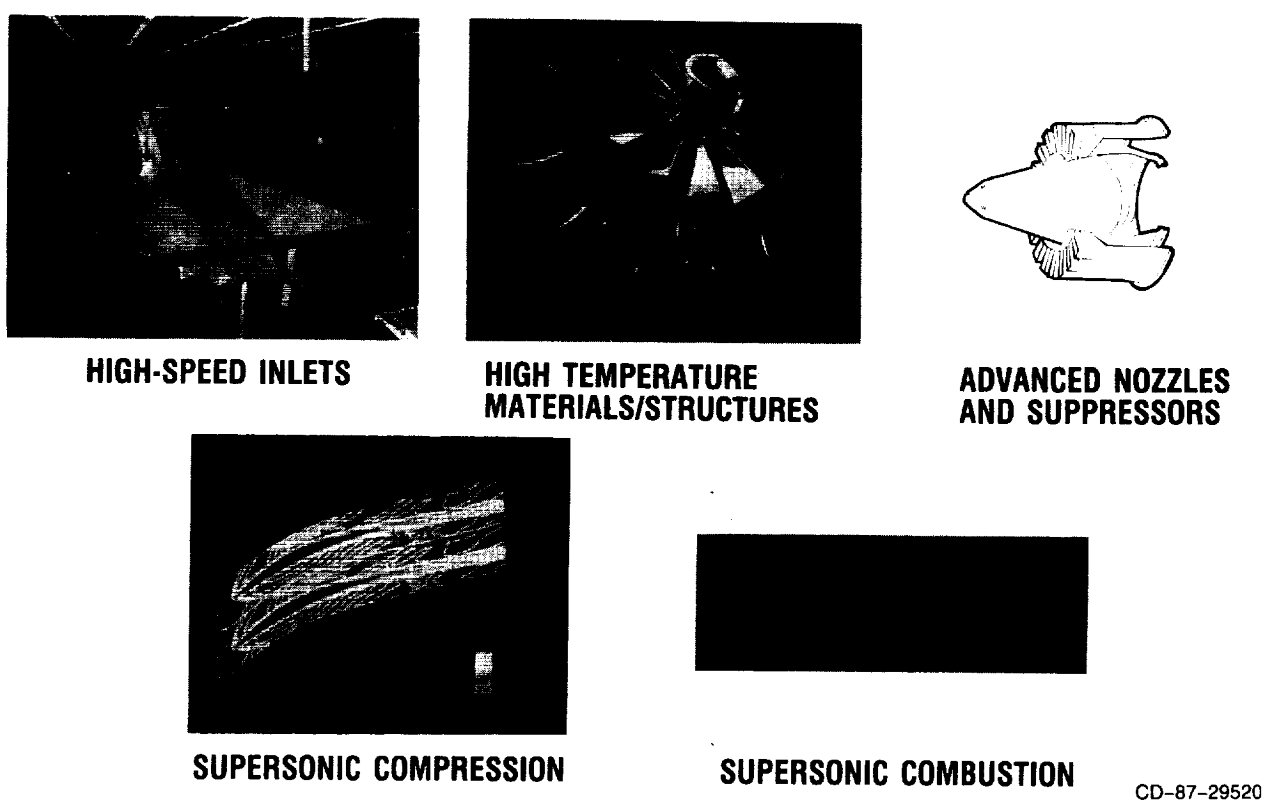

Figure 3. - Unique technologies for high-speed propulsion.

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Figure 4. - Supersonic throughflow engine.