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SESSION 5 - SUBSONIC PROPULSION TECHNOLOGY

OVERVIEW OF THE SUBSONIC PROPULSION TECHNOLOGY SESSION

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INTRODUCTION

NASA is conducting aeronautical research over a broad range of Mach numbers. In addition to the generic and high-speed propulsion research described in separate sessions of this conference, the Lewis Research Center is continuing its substantial efforts towards propulsion technology for a broad range of subsonic flight applications. This session reviews some of the results from that program, including small engine technology, rotorcraft, icing research, hot section technology, and the Advanced Turboprop Project as major elements.

SUBSONIC PROPULSION TECHNOLOGY

Small Engine Technology Programs

Ongoing small engine programs are indicated in figure 1. The Automotive Gas Turbine (AGT) program is sponsored by the Department of Energy (DOE), and the Compound Cycle Turbine Diesel (CCTD) program is sponsored by the Army. There is a strong element of synergism between the various programs in several respects.

All the programs include research in high-temperature structural ceramics. This research tends to be generic in nature and has broad applications. The rotary technology and the CCTD programs are examining approaches to minimum heat rejection, or "adiabatic" systems employing advanced materials. The AGT program is also directed toward applications of ceramics to gas turbine hot-section components.

Turbomachinery advances in the gas turbine programs will benefit advanced turbochargers and turbocompounders for the internal combustion (IC) system, and the fundamental understandings and analytical codes developed in the research and technology (R&T) programs will be directly applicable to the system projects.

The chart in figure 2 shows opportunities for future major thrusts in small engine technology. Advanced cycles will be examined which offer the potential of large reductions in specific fuel consumption (SFC). New and enhanced computational tools will be developed, verified, and applied to advanced concepts to provide highly advanced, efficient, durable components. Advanced materials, such as ceramics and metal-matrix composites, will be applied to achieve maximum performance and life from the advanced engine concepts.

Rotorcraft Transmissions

Ongoing efforts involve computer code development and validation as well as analysis and optimization of components and full-scale transmissions (fig. 3). New tooth forms and gear materials are being investigated for operation at higher temperatures and loads. Advanced transmission concepts (split-torque, bearingless planetary) are being explored for reduced weight and noise as well as increased life and reliability.

Aircraft Icing Research Program

The NASA aircraft icing research program (fig. 4) has two major technology thrusts: (1) development of advanced ice protection concepts and (2) development and validation of icing simulation techniques (both analytical and experimental). Technology is being developed that is applicable to both fixed and rotary wing aircraft.

Engine Hot Section Technology

The activities of the NASA Turbine Engine Hot Section Technology (HOST) Project (fig. 5) are directed toward durability needs, as defined in industry, and a more balanced approach to engine design. The HOST efforts will improve the understanding and prediction of thermal environments, thermal loads, structural responses, and life by focused experimental and analytical research activities. The overall approach is to assess existing analysis methods for strengths and deficiencies, to incorporate state-of-the-art improvements into the analysis methods, and finally to verify the improvements by benchmark quality experiments.

Advanced Turboprop Project

Figure 6 shows the overall content of the Advanced Turboprop Project in the areas of single rotation, gearless counterrotation, and geared counterrotation, and the flow into the area of advanced concepts. Figure 7 shows the major contractual elements of the Advanced Turboprop Project: the Large-Scale Advanced Propeller Project, the Propfan Test Assessment Project, the Unducted Fan Project, and the Advanced Gearbox Technology Project.

The four current flight test programs with advanced turboprops are shown in figure 8, and an artist's conception of potential near-term applications in commercial and military aircraft is shown in figure 9.

Propeller Research

Figure 10 shows the ongoing propeller research program of analysis and scale-model wind tunnel test verification leading to aerodynamic, acoustic, and structural code development. Advanced concepts of a single-rotation propfan with stator vane swirl recovery and a high-bypass-ratio ducted-fan configuration are illustrated.

High-Bypass Engines

Figure 11 shows the potential reduction of SFC for propulsion systems using ducted props and propfans as compared to high-bypass turbofans. Although the ducted props will not have the efficiency of unducted propfans, they are more suitable for "packaging" on large aircraft such as the B-747.

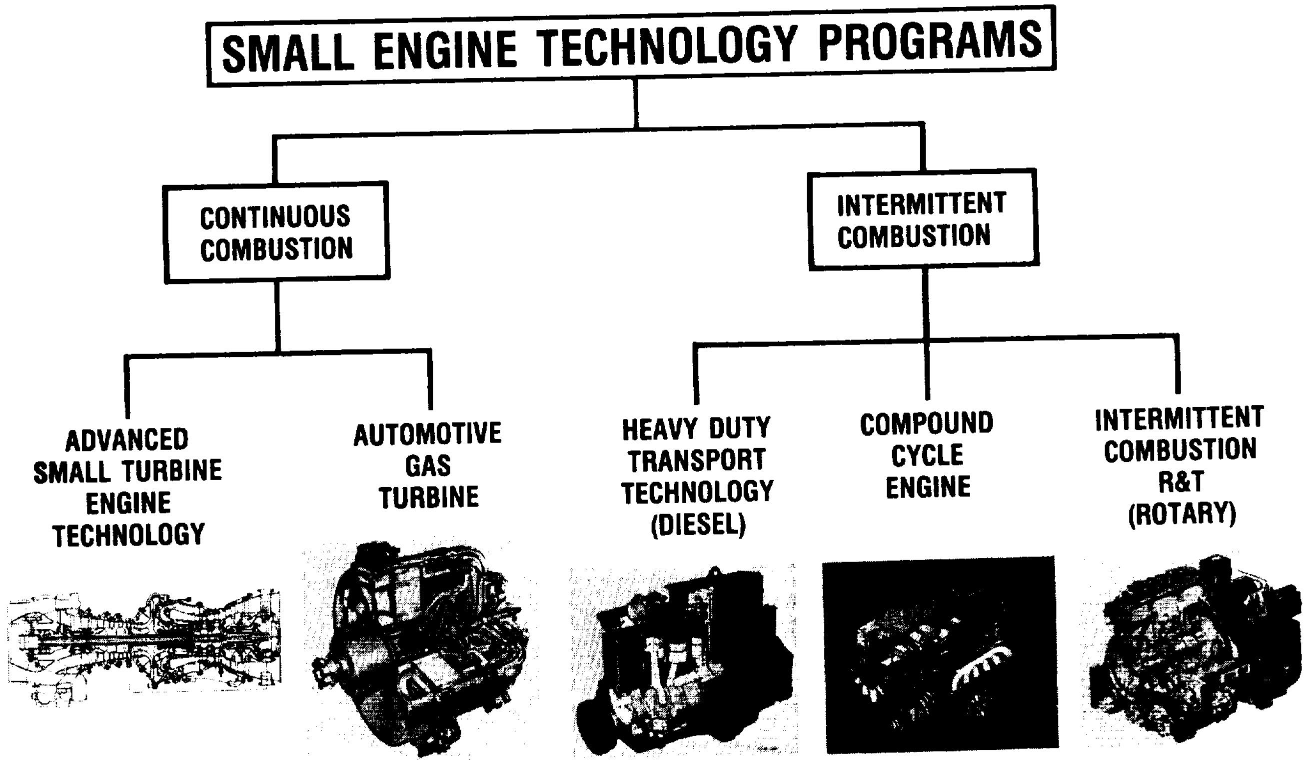

Figure 1. - Small engine technology programs.

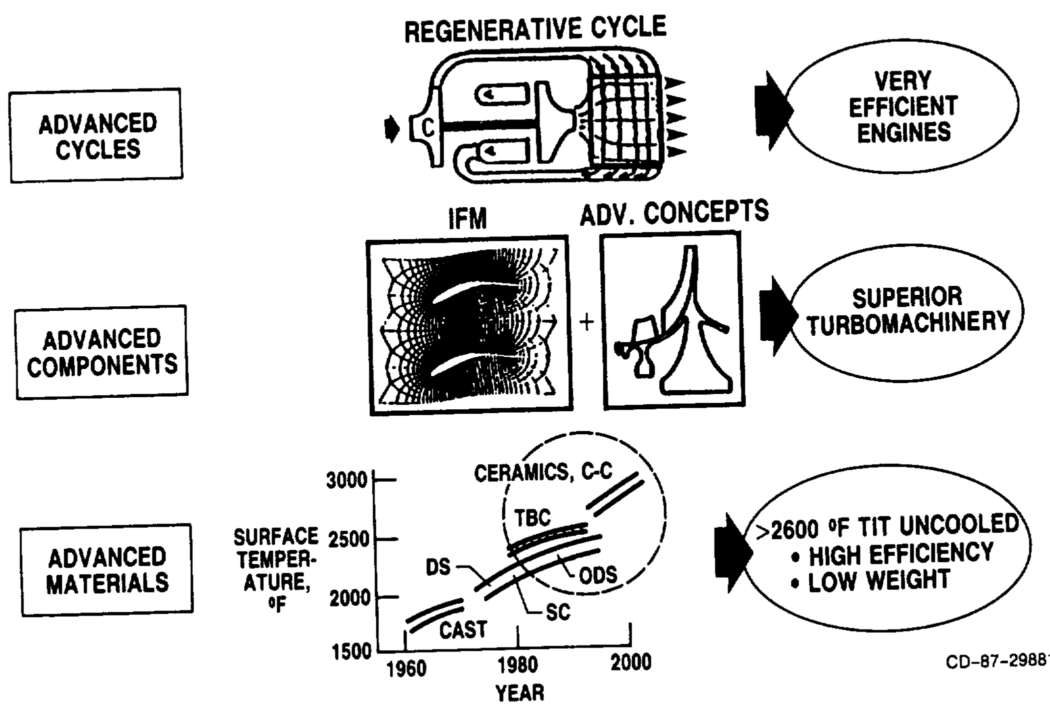

Figure 2. - Small engine technology thrusts.

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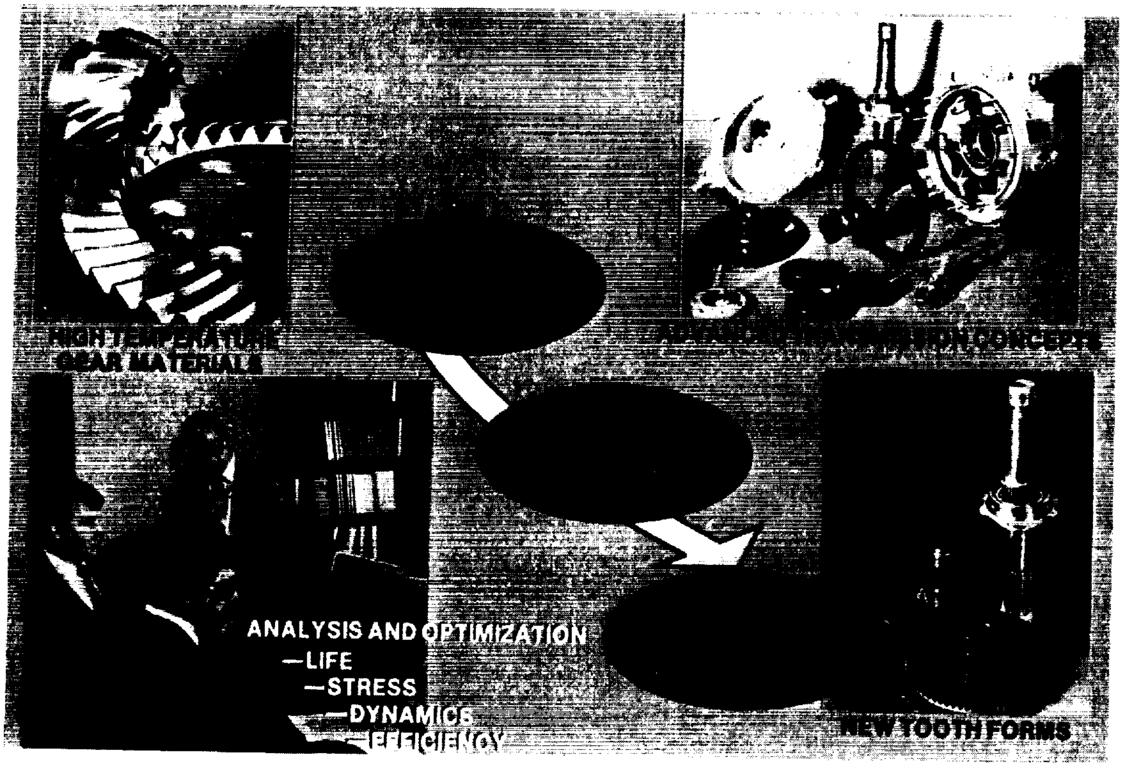

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Figure 3. - Rotorcraft transmissions.

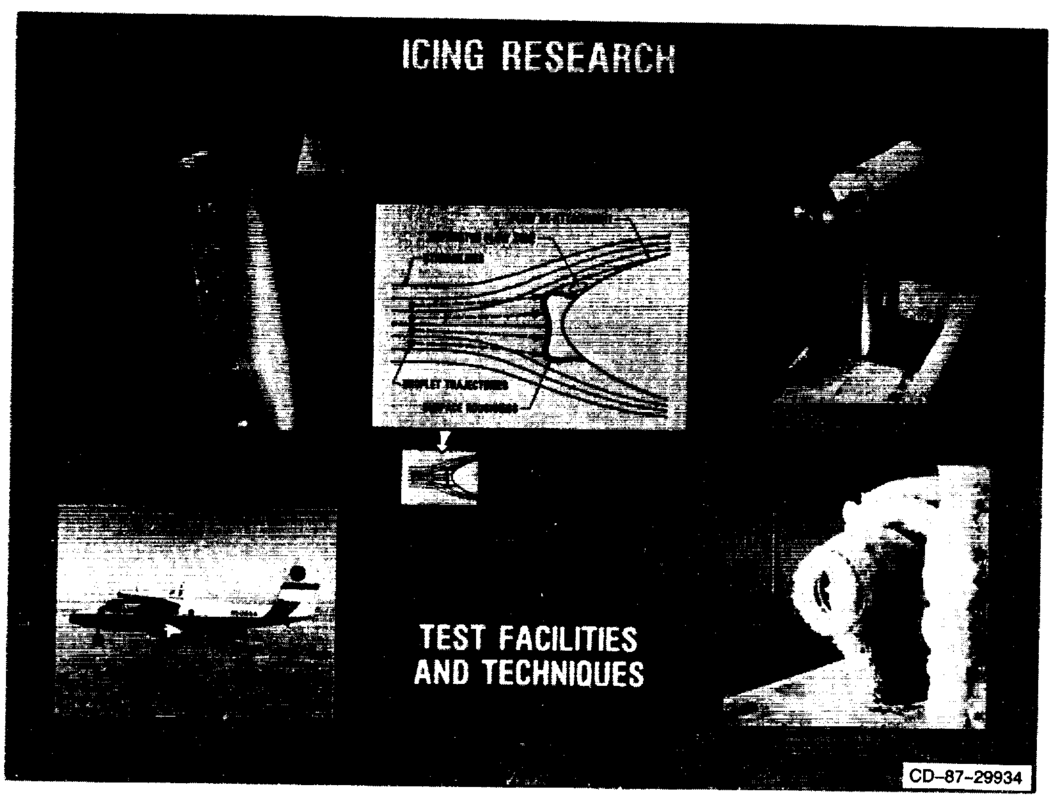

Figure 4. - Aircraft icing research program.

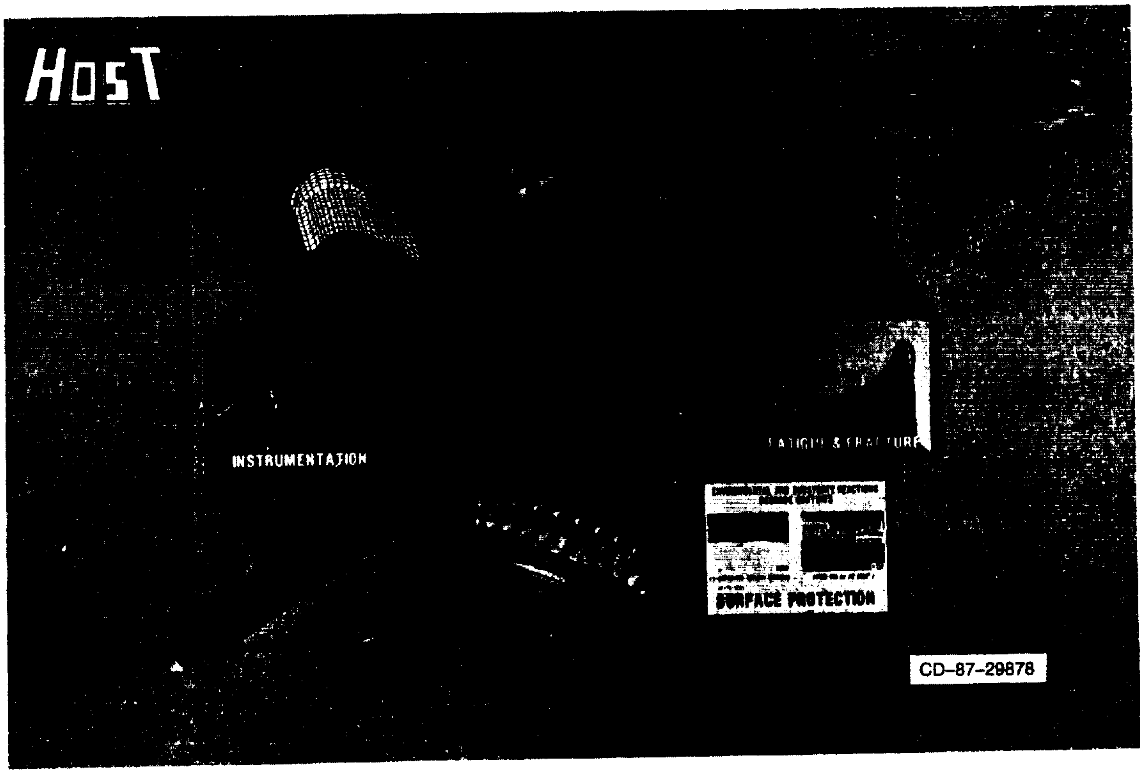

Figure 5. - Engine hot section technology.

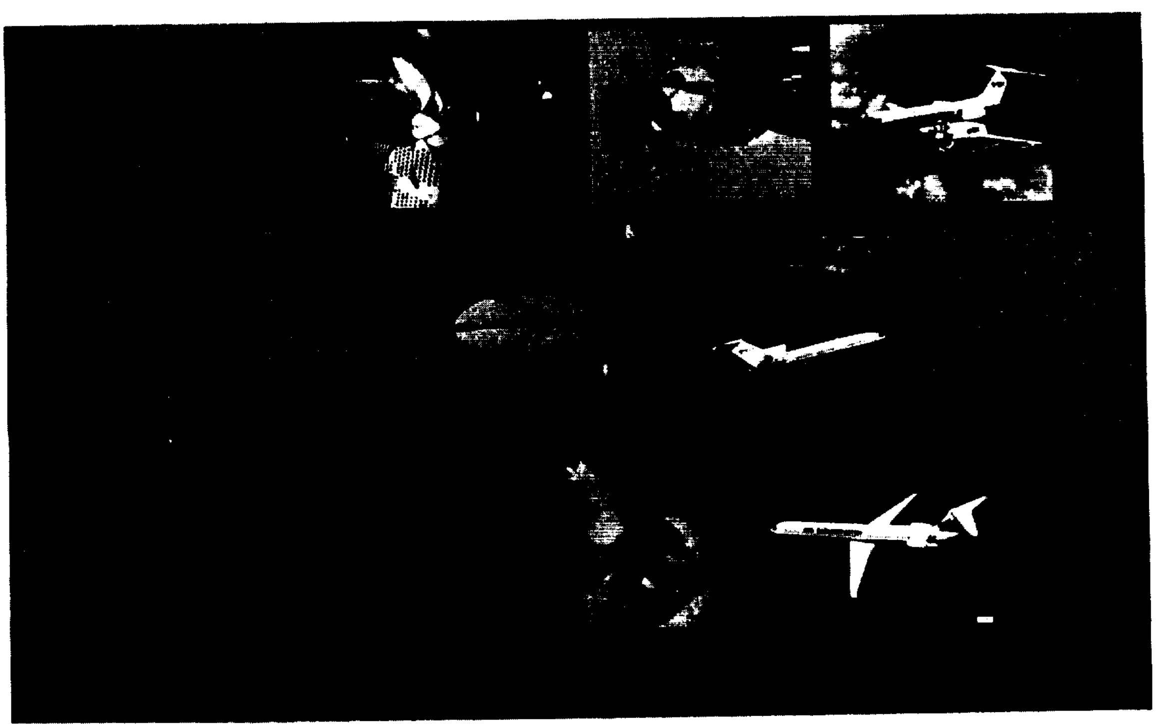

Figure 6. - Advanced Turboprop Project.

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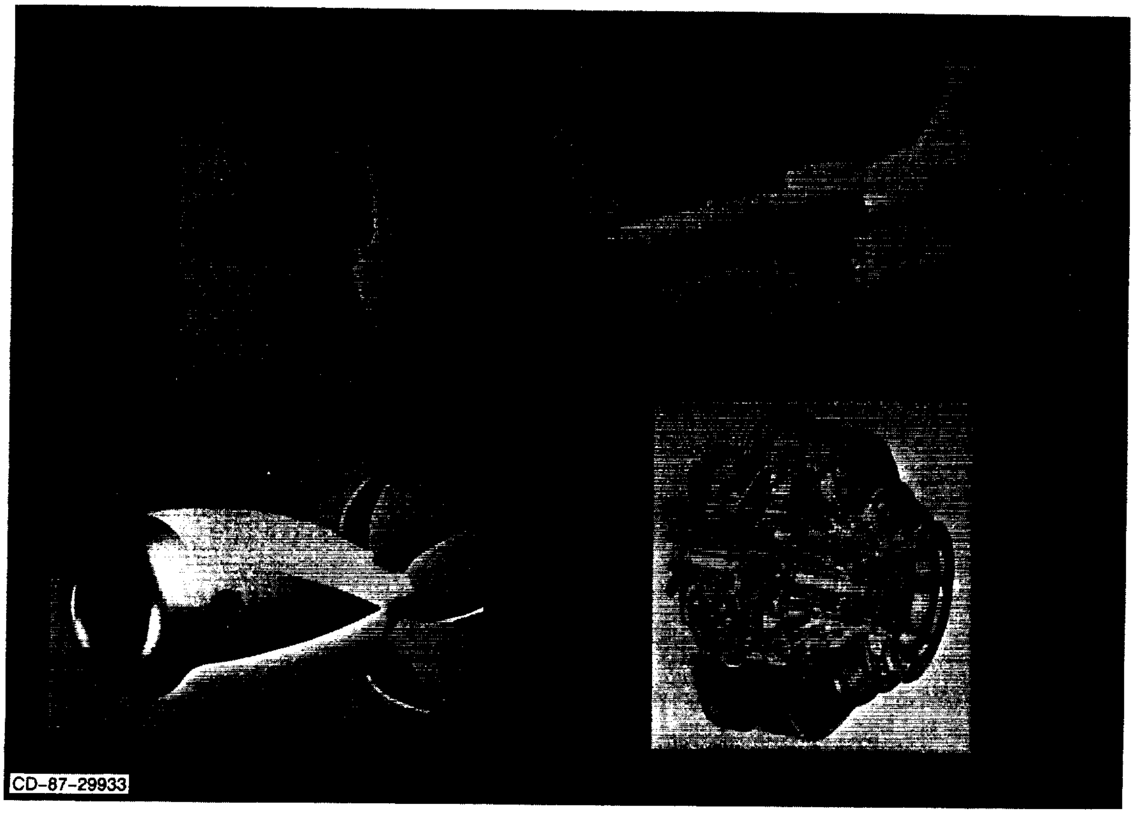
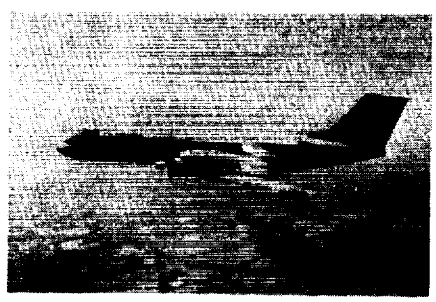


Figure 7. - Major contractual elements of the Advanced Turboprop Project.



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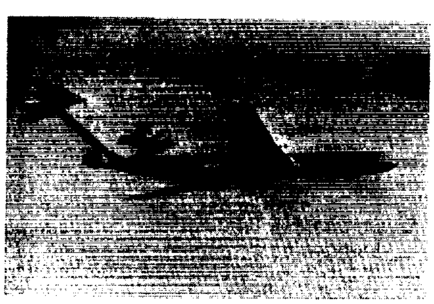

UDF/BOEING 727

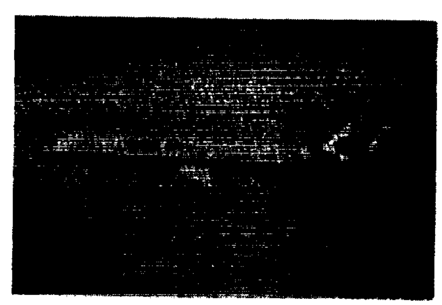

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Figure 8. - Flight testing of advanced turboprops. CD-87-29932

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Figure 9. - Advanced turboprop applications.

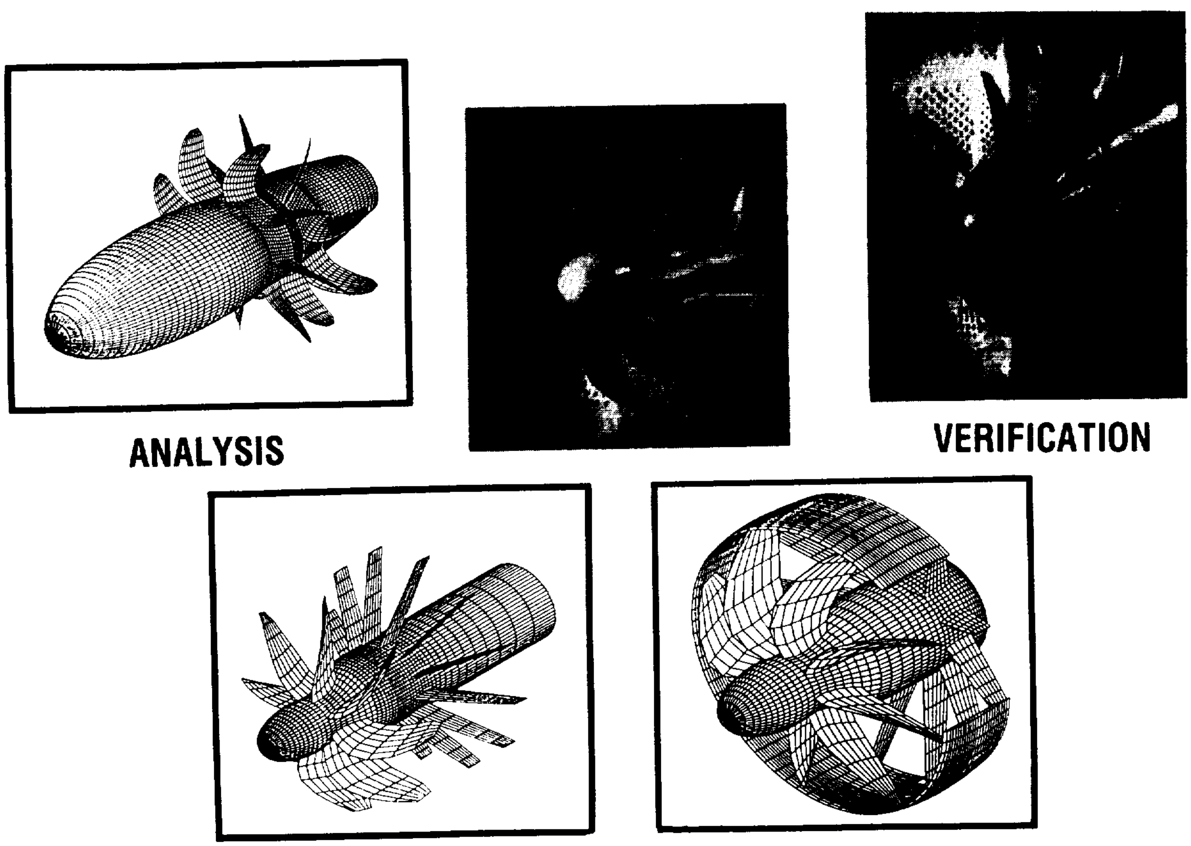

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Figure 10. - Propeller research.

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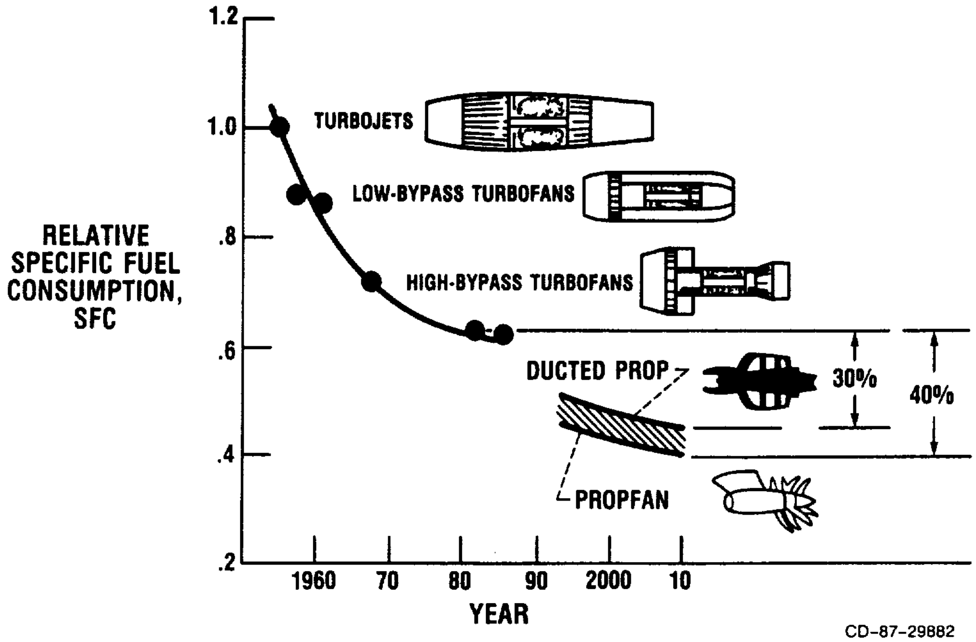

Figure 11. - Specific fuel consumption for various propulsion systems.