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FUTURE OF V/STOL AIRCRAFT SYSTEMS: A SURVEY OF OPINIONS

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SUMMARY

The recent success of the British Harriers in the Falkland Islands conflict vividly underscored the potential of V/STOL aircraft in military operations in a difficult environment. Despite this apparent success of the Harrier, there has been a major decline of V/STOL funding in the research and development budgets of the U.S. government and industry. The recent funding history of V/STOL systems is examined. Responses to a questionnaire which asked the question, "Should there be an operational V/STOL aircraft other than the AV-8A and AV-8B in the military aircraft fleet of the U.S.A.?" are presented and discussed.

INTRODUCTION

Vertical/short takeoff and landing (V/STOL) aircraft have been the subject of much attention in the international aeronautical research and development (R&D) community over the past 30 yr. During this time a myriad of V/STOL concepts have been studied and tested, and in many cases demonstrator aircraft have been flown. The history of V/STOL and the lessons learned from past V/STOL development programs are well documented by Seth Anderson (refs. 1 and 2) and John Schneider (ref. 3) and will not be discussed further in this report. The important point is that of all V/STOL aircraft, only two fixed-wing V/STOL aircraft have reached operational status. One is the British Aerospace Harrier, a vectored-thrust V/STOL fighter/attack aircraft, versions of which are in service with the British Royal Air Force and Navy, the U.S. Marine Corps, and the Spanish Air Force; the other is the YAK-36 lift plus lift-cruise jet VTOL fighter in use by the U.S.S.R. These aircraft are shown in figure 1. An advanced version of the Harrier called the AV-8B Harrier II is now being introduced into service with the U.S. Marine Corps and, as the GR Mk 5, will join the Royal Air Force in the near future.

V/STOL aircraft provide the capability to operate from unprepared sites, damaged runways and flight decks, and small ships, while allowing shipboard operation without catapult and arresting gear. The recent success of the British Harriers in the Falkland Islands conflict vividly underscored the potential of V/STOL aircraft in military operations in a difficult environment. Despite this apparent success of the Harrier, there has been a major decline of V/STOL funding in the R&D budgets of the U.S. government and industry.

In light of the Harrier's success, the decline of V/STOL funding should be reconsidered. References 4-6 represent some recent attempts to address this issue. In December 1981, NASA and AIAA (American Institute of Aeronautics and Astronautics) cosponsored a major conference on V/STOL aircraft. This paper presents an examination of V/STOL funding in U.S. government and industry. It also presents a summary of results to a questionnaire regarding the future of V/STOL aircraft which was administered to a random sample group selected from the population of those who have been involved with some aspect of V/STOL research.

DEFINITION

Before addressing the future of V/STOL aircraft, it is appropriate to define more precisely what is meant by V/STOL in this report. A V/STOL aircraft is defined as an aircraft that is capable of vertical or short takeoff and vertical landing. It does not include STOL aircraft. To bound the question somewhat, we have chosen to eliminate rotorcraft from the definition. We fully recognize the XV-15 tilt rotor as a V/STOL aircraft and believe this concept, when embodied in the Navy-managed JVX program, will become an effective, operational V/STOL system. In fact, several responses to the questionnaire pointed out JVX as a V/STOL system of the future. Our intent is to look at the future of fixed-wing V/STOL aircraft capable of high subsonic and supersonic speeds typical of tactical combat aircraft. Figure 2 illustrates the altitude and speed ranges of three V/STOL aircraft categories, showing potential Navy missions for each category. Mission and performance overlaps exist among categories. The medium- and high-speed V/STOL aircraft are of most interest in this discussion. Rotorcraft such as JVX would fall into the low-speed V/STOL category. These categories were also suggested as possible future V/STOL systems by the questionnaire respondents.

FUNDING HISTORY

The U.S. Navy exploratory development and advanced development funding for V/STOL for FY-72 through FY-83 is plotted in figure 3. Funding is shown in then-year dollars. Funding peaked at about $65M in FY-78 and dropped to nearly zero by FY-82. Peaking funds correlate to the development of the AV-8B, the XFV-12A Thrust Augmented Wing, and the advent of the Navy's Type-A V/STOL aircraft. A similar trend is observed in the Independent R&D man-years expended by U.S. industry as seen

in figure 4. Independent R&D data were available beginning in FY-76. To further illustrate the current state of V/STOL R&D funding in the U.S., the NASA V/STOL funding history from FY-76 to the present is shown in figure 5. Funding of V/STOL aircraft by NASA also peaked in 1978, then dropped markedly until 1982 when the funding level began to rise slightly. This level of effort funding still exists within the NASA budget.

APPROACH

The questionnaire developed (fig. 6) was administered to a random-sample group of people who have been associated in some capacity with V/STOL aircraft. The population chosen for sampling was based on the assumption that the respondents could provide keen insight into past V/STOL research and a look into the future of V/STOL aircraft. Of the 80 individuals and/or organizations contacted, 51 did respond. Of this total, 32 submitted written responses and 19 gave oral responses either by telephone or personal interview. A breakdown of respondents is as follows:

Department of Defense	15
Other U.S. government	6
U.S. industry	17
Foreign government	1
Foreign industry	2
Other U.S. nongovernment	10
Total	51

The DOD responses consist of those from the Navy or Marine Corps only; no responses were received from the Air Force. All other U.S. government responses came from NASA. U.S. industry responses are composed of those from major airframe manufacturers and one response from an engine company. The 10 U.S. nongovernment responses came entirely from U.S. military and civilian government retirees, most of whom are working as consultants. Again, we stress the validity of the survey results based on the population represented by the respondents.

DISCUSSION OF QUESTIONNAIRE RESPONSES

Answers to the questionnaire are presented as follows:

Yes	33
Qualified yes	11
Noncommittal	2
Qualified no	2
No	2
"Nonresponsive"	1
Total	51

Two of the "yes" responses indicated there would be another V/STOL, but not for sea-based operations. The noncommittal responses were from persons who provided comments only on technologies. The "nonresponsive" respondent saw the future V/STOL being the AV-8B, and did not address the question asked here.

The type of V/STOL aircraft foreseen by the positive respondents are summarized as follows:

High-speed	14
Medium-speed	9
Both	13
Did not specify	8
Total	44

Of the 13 respondents that specified both medium- and high-speed, 7 indicated medium-speed should be developed first, 1 indicated high-speed should be developed first, and 5 did not specify the order of development. If we add the first choices of those who specified both to those who specified only one type, the results are 15 favoring high-speed first and 16 favoring medium-speed first. Obviously, there is no clear-cut choice among respondents as to which type of V/STOL aircraft should be developed first; however, there were 27 responses for high-speed compared to 21 for medium-speed. Clearly, a strong feeling exists that there will be V/STOL aircraft in the future. Both high- and medium-speed aircraft have strong support.

Several recurring thoughts emerged from the positive responses concerning the advantages of V/STOL systems and how they will be accepted in the future. The perceived advantages of V/STOL are dispersal of forces and flexibility of operations. Some points were

1. V/STOL aircraft will always be more expensive, but at some point the added flexibility will be worth the extra cost.

2. V/STOL capability should not be limited to a specific mission.

3. Introduction of V/STOL aircraft should be an evolutionary process with the AV-8B playing a key role in that process.

4. V/STOL must complement CTOL and large carrier operations.

5. V/STOL tactical support aircraft could be offloaded to smaller ships to allow more fighter and attack aircraft on the big decks.

6. Short takeoff and vertical landing (STOVL) is seen as the primary mode of operation, but vertical takeoff capability would also be advantageous.

7. Technology demonstrator aircraft are necessary before technologically advanced V/STOL systems will be accepted.

It is important to examine the negative responses to the questionnaire for insight into obstacles that V/STOL aircraft must overcome in order to be accepted. The key negative comments are not new, but are still germane today. These negative responses were

1. V/STOL aircraft will always be more expensive than CTOL aircraft.

2. The cost will always exceed the benefits because V/STOL technology will never sufficiently reduce the penalties.

3. A combination of CTOL and V/STOL aircraft is not affordable.

4. CTOL aircraft will be used as long as large carriers exist.

5. The rapidly expanding radius of sea warfare negates advantages afforded by V/STOL.

6. The past unsuccessful V/STOL efforts such as XFV-12A Thrust Augmented Wing and Type A V/STOL have significantly eroded the credibility of V/STOL aircraft.

The respondents were nearly unanimous in feeling that the technology exists for the development of medium-speed V/STOL aircraft. Given a requirement, medium-speed aircraft could be developed with current technology. It was felt that further advances in engine development were not necessary but would be advantageous for medium-speed V/STOL aircraft. Some respondents also indicated that the technology does not exist to develop high-speed V/STOL aircraft. Major engine development is necessary if the use of high-speed V/STOL aircraft is pursued. Ground effect of high-speed V/STOL aircraft is mentioned as another area of concern. The U.S. Marine Corps is a potential user of high-speed V/STOL aircraft, but other users would be necessary to justify the cost of developing new aircraft.

As might be expected, the respondents suggested all the Navy missions shown in figure 2 as potential missions for medium- and high-speed V/STOL aircraft. Many stated that V/STOL should not be linked to a particular mission or replace a specific aircraft. These aircraft represent an operational basing capability, not a mission. Therefore, V/STOL aircraft could feasibly be developed for all missions.

Propulsion concepts mentioned for high-speed V/STOL applications include vectored-thrust (with and without plenum chamber burning (PCB)), series-flow tandem-fan, hybrid-fan vectored-thrust, remote augmented lift system (RALS), augmentor/ejector, and lift plus lift-cruise. Propulsion concepts mentioned as possible medium-speed V/STOL candidates included tilt-nacelle, split-fan, parallel-flow tandem-fan, deflected-thrust, and tilt-rotor. There were no unexpected responses, and no new concepts were proposed.

CURRENT V/STOL ACTIVITIES

It seems appropriate to briefly review current activities in V/STOL research and development. For medium-speed V/STOL aircraft, the Office of Naval Technology has recently approved an exploratory development program to be managed by the Naval Air Systems Command. This program will concentrate on developing the technologies required for the transition of medium-speed V/STOL into an advanced development program with the intent of making V/STOL a competitor for future subsonic tactical support aircraft development programs. This new Navy program was initiated in FY-84 and may continue into FY-89.

Discussions have begun between the U.S. and the United Kingdom on a potential, joint high-speed V/STOL technology development program. The U.S. Navy, the Canadian government, and NASA are cooperating in a joint ejector technology development program for high-speed V/STOL, which includes generic ejector concepts. The program was initiated in FY-75. NASA and the Navy are continuing wind tunnel model tests of two single-engine V/STOL fighter concepts.

No V/STOL flight demonstrator programs are presently in progress, and none is currently approved in the budget plan for the next few years.

CONCLUSIONS

Based on the responses to the questionnaire, the following conclusions regarding the future of V/STOL aircraft are reached:

1. There will be future V/STOL aircraft.

2. A variety of obstacles must be overcome before V/STOL systems can exist.

3. V/STOL aircraft will complement CTOL and large carrier operations.

4. V/STOL aircraft will provide operational basing flexibility not available with CTOL aircraft.

5. Introduction of V/STOL aircraft will be evolutionary, with the AV-8B playing a key role in defining V/STOL scope of operations.

6. Technology demonstrator aircraft are necessary before technologically advanced V/STOL aircraft will be accepted.

7. Medium- and high-speed V/STOL aircraft have equally strong support.

8. The new aircraft will primarily operate in a STOVL mode, but will have vertical takeoff capability at reduced takeoff gross weights.

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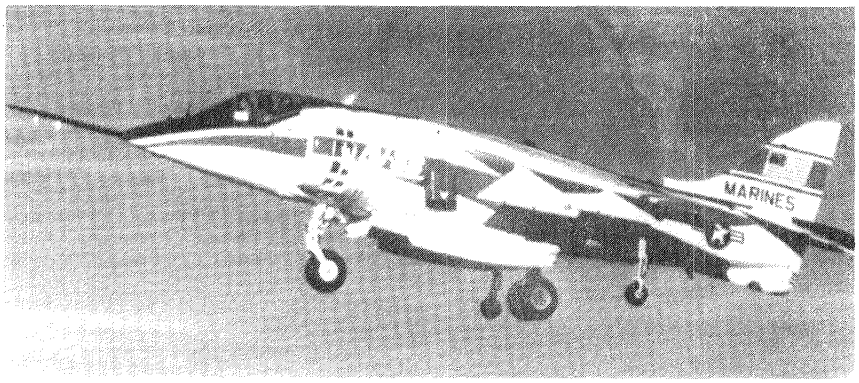
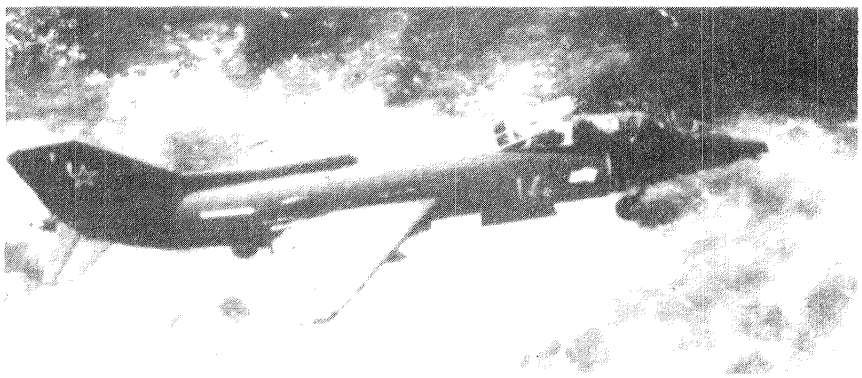


(a) British Aerospace Harrier.



(b) YAK-36.

Figure 1.- Current operational V/STOL aircraft.

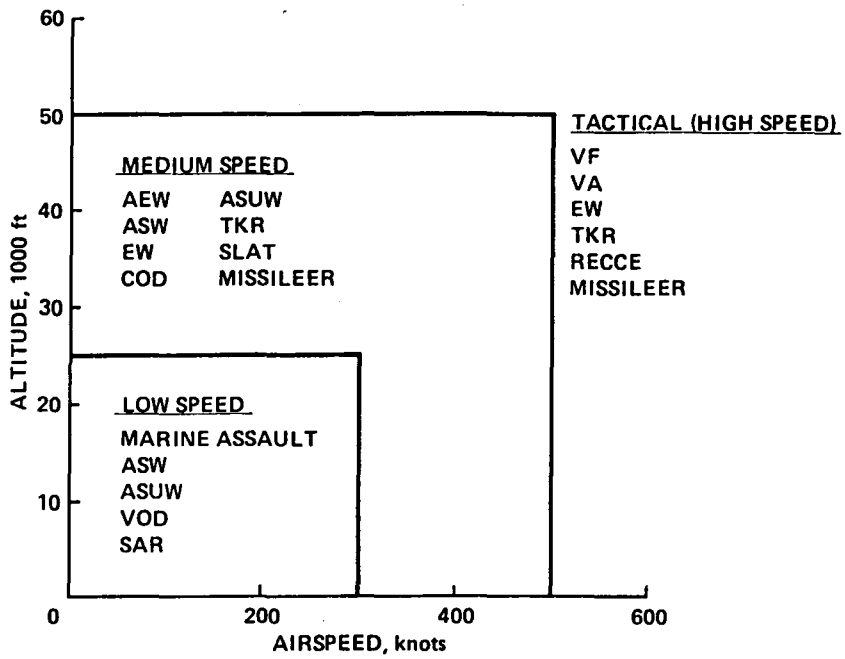


Figure 2.- V/STOL aircraft categories and potential missions.

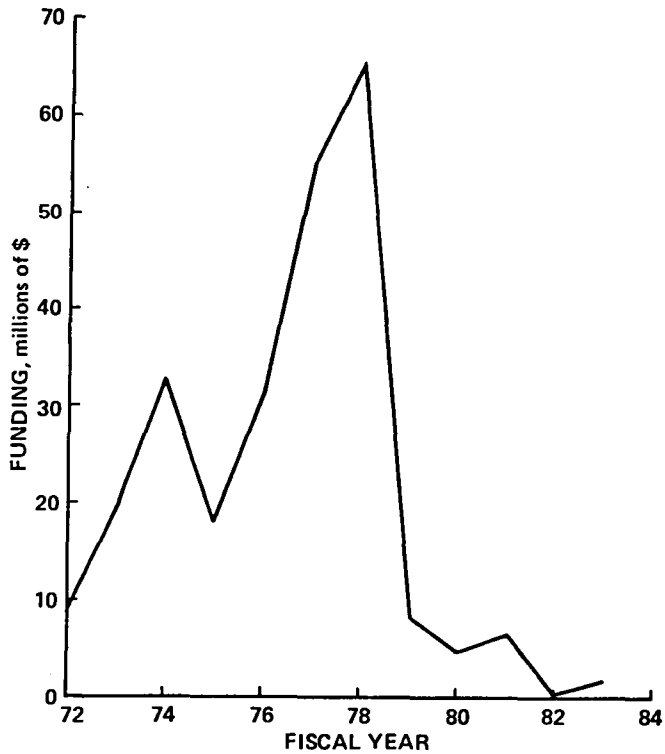


Figure 3.- Navy exploratory and advanced development funding (then-year dollars).

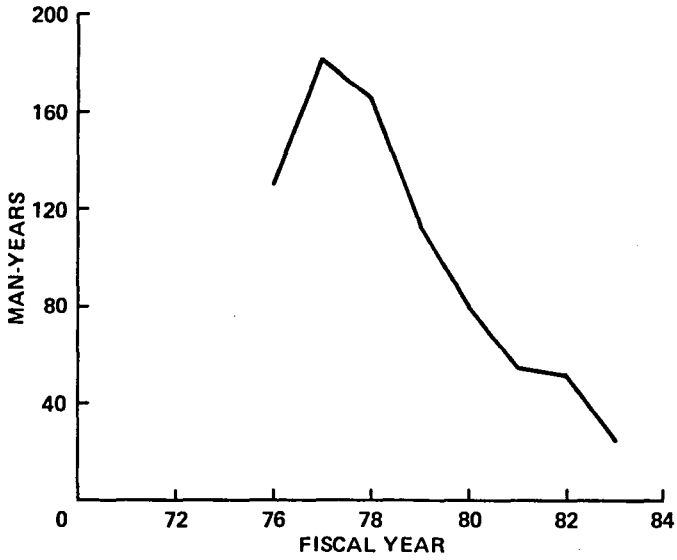


Figure 4.- V/STOL Independent R&D.

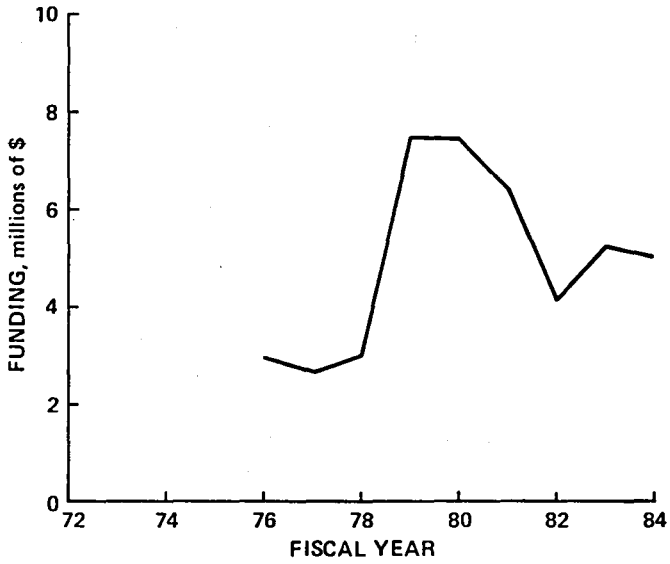


Figure 5.- NASA V/STOL funding (then-year dollars).

QUESTIONNAIRE

In your opinion, should there be an operational V/STOL aircraft other than the AV-8A and AV-8B in the fleet of military aircraft of the U.S.A.? That is, is there truly an essential military mission for a V/STOL aircraft that cannot be accomplished equally well or better by CTOL aircraft?

A. If the answer is yes, clearly define the essential mission or missions that would require a V/STOL aircraft, explain why the mission is essential, why V/STOL is necessary for that mission and in what timeframe V/STOL would be introduced. Include the following information:

(1) Which V/STOL concepts could accomplish the essential mission?

(a) What are the pros and cons of each concept?

1) Operational

2) Technological

3) Political

(b) Which concept can best accomplish the mission and why?

(2) What are the technological advancements, if any, that will be required in order to develop the concept?

(3) What aircraft, if any, will it replace?

B. If your answer is no, discuss why you answered no and include the following information:

(1) Do you feel new V/STOL aircraft will not become operational because they are not required by an essential mission and don't offer enough operational advantage over conventional aircraft? If so, why do you believe it offers insufficient operational advantage over CTOL?

(2) Are there technological reasons why you think new V/STOL aircraft will not become a part of the future operational fleet? If so, discuss what you feel the technological deficiencies are and why they can't be overcome.

(3) Do you think that new V/STOL aircraft will not be introduced for quasi-political reasons? That is, the resistance to change will be so great that the old way of conducting military operations will continue simply because it has always been done that way.

Figure 6.- Questionnaire.

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16. Abstract

The recent success of the British Harriers in the Falkland Islands conflict vividly underscored the potential of V/STOL aircraft in military operations in a difficult environment. Despite this apparent success of the Harrier, there has been a major decline of V/STOL funding in the research and development budgets of the U.S. government and industry. The recent funding history of V/STOL systems is examined. Responses to a questionnaire which asked the question, "Should there be an operational V/STOL aircraft other than the AV-8A and AV-8B in the military aircraft fleet of the U.S.A.?" are presented and discussed.

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