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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

DOD's Use Of Remotely Piloted Vehicle Technology Offers Opportunities For Saving Lives And Dollars

Remotely piloted vehicles are unmanned aircraft which can be controlled from distant locations. These vehicles were used extensively in Vietnam for photographic, reconnaissance, electronic listening, and other missions. Advantages attributed to the vehicles include eliminating pilot and crew losses, lowering operating costs, and, in some cases, better performance. There are some technological limitations to their widespread use, but experts agree that the problems could be overcome if a real interest in them were to develop.

Remotely piloted vehicle technology has been given only limited use by DOD in recent years. The majority of experts GAO contacted traced this to a reluctance on the part of users and the ensuing lack of funds for development. GAO, while recognizing that DOD is making some use of remotely piloted vehicle technology, believes a need exists to assure maximum use of this technology where its use can save lives and money.



MASAD-81-20
APRIL 3, 1981



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-202379

To the President of the Senate and the
Speaker of the House of Representatives

This is our report examining the status of remotely piloted vehicle technology, reasons for its limited application by the Department of Defense, and the potential for applying this technology to nonmilitary uses. This study was made as part of our efforts to examine the Government's research and technology activities and provide the Congress with information to help it exercise its legislative and oversight functions.

We are sending copies of this report to the Director, Office of Management and Budget, and to the Secretary of Defense.

A handwritten signature in black ink that reads "Milton J. Auslan".

Acting Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

DOD'S USE OF REMOTELY PILOTED
VEHICLE TECHNOLOGY OFFERS
OPPORTUNITIES FOR SAVING LIVES
AND DOLLARS

D I G E S T

Remotely piloted vehicles were extensively used throughout the Vietnam conflict for photographic, reconnaissance, electronic listening, and other missions. These unmanned aircraft, controlled from a distant location, have been credited with eliminating pilot and crew losses and lowering operating costs. They have also been said to increase vehicle survivability and performance because of their increased maneuverability and detection avoidance. (See pp. 1 to 3.)

GAO reviewed the status of remotely piloted vehicle technology to see if it could have wider application in the military and civil sectors and found that:

- While some technological limitations to widespread use of the vehicles exist, experts agree that problems could be overcome if a real interest in them were to develop. (See pp. 6 to 9.)
- Because the military services have been reluctant to take advantage of the promise demonstrated by unmanned aircraft in Vietnam, funding support has diminished. (See pp. 10 to 23.)
- No civil programs for using remotely piloted vehicles exist and unless they are developed for military use, which would make them affordable, they will not find widespread use in civil applications. (See pp. 24 and 25.)

STUDY METHODOLOGY

GAO's study included a review of the literature on remotely piloted vehicles obtained from a number of Government and private information systems, interviews with representatives of

the military, industrial, and civil communities, and a comprehensive questionnaire sent to persons experienced in remotely piloted vehicle technology. While the 77 persons who responded may not necessarily be unbiased and may not be representative of the entire remotely piloted vehicle community, they constituted the most knowledgeable source of information GAO could identify. Most of these individuals were identified through their membership in the Association for Unmanned Vehicle Systems, whose members have worked with these systems for years. (See pp. 4 and 5.)

TECHNOLOGY NOT A MAJOR BARRIER TO WIDER USE

Experts do not believe that the state of the art is a major hindrance to the use of remotely piloted vehicles as an alternative for manned systems in many situations. Present limitations such as recovery of a vehicle during the night or adverse weather and other technology related areas were seen as surmountable problems, which could be overcome if a real interest in the vehicles were to develop. Also for certain applications, technology is currently not available.

The principal reason for the lack of use of the vehicles, primarily by the military, was user apathy--the reluctance to replace a manned aircraft with an unmanned vehicle. Barriers most often cited by the experts as constraints were Government regulations and airspace safety, especially for civil operations. (See pp. 6 to 9.)

REMOTELY PILOTED VEHICLES NOT POPULAR WITH THE MILITARY

The Department of Defense (DOD) has no operational remotely piloted vehicles. It has only two development programs and limited plans for future applications. In 1978 the Congress noted DOD's lack of success in deploying new unmanned vehicles and reduced funding for development programs.

Experts identified several missions, for example, harassment, decoy, surveillance/reconnaissance, and electronic warfare support, for which a remotely piloted vehicle is held to be better suited than a manned aircraft. (See p. 17.) The greatest advantage of these aircraft, according to the experts, is for missions which entail great risk to pilots. Other major advantages relate to cost savings--the vehicles are considered to be cheaper than multimillion dollar manned aircraft, the cost and training of a ground controller is substantially less than for a pilot, they save fuel, and their smaller size enhances survivability and reduces replacement costs. (See pp. 3 and 18.)

The most widely perceived disadvantages to military unmanned systems were their performance under emergency or unforeseen conditions and recovery difficulties. These vehicles cannot duplicate all of the abilities a pilot brings to the aircraft. Better data links to bring the remotely piloted vehicle operator's skill to the immediate situation may lessen this problem, but it may never be entirely eliminated. However, the gravity and frequency of these situations must be weighed against life-saving and cost advantages. (See p. 19.)

DOD has made only limited use of remotely piloted vehicle technology. The majority of experts traced the low level of use of these aircraft to the interrelated factors of reluctance on the part of users and the ensuing lack of funds for development. (See pp. 20 and 21.)

CIVIL USE WOULD ONLY FOLLOW MILITARY DEVELOPMENT

Remotely piloted vehicles present an effective alternative for some civil sector missions, for example, meteorological data gathering, atmospheric sampling, and surveillance. Because of the low number that would be employed in the civil sector, the system cost savings would not be as significant a factor as they would for the military.

The predominate factor against widespread civil use is the lack of development funds and the market potential to attract industry developers. Widespread use of unmanned vehicles in civil aviation is, therefore, not likely in the near future. Unless they are developed by the military, which could bring costs down, they will not be affordable. (See p. 24.)

DOD COMMENTS AND GAO EVALUATION

In commenting on this report, DOD agreed that technologies are now sufficiently mature to support a variety of remotely piloted vehicle applications and pointed out that there had been some technical problems in using this technology, resulting in higher costs than initially projected, a factor relevant to comparing cost effectiveness of unmanned aircraft with alternative systems.

GAO has noted that technical problems and cost increases occur in both unmanned and manned aircraft programs. Thus, these should not be reasons for not considering remotely piloted vehicles as viable alternatives when mission requirements permit their use.

DOD did not agree that career advancement limitations and occupational drabness were hindering military acceptance of the remotely piloted systems and said that this finding came principally from a survey of experts, a source which does not necessarily constitute an unbiased forum of views.

GAO recognizes that the experts surveyed did not necessarily constitute an unbiased forum of views. Their general views on user reluctance, however, are compatible with other evidence developed. For example, a lack of operational remotely piloted vehicles, only two development programs, limited plans for future applications, and reduced funding and support by DOD (see pp. 10 to 16) also suggest that remotely piloted vehicle technology has not been vigorously pursued by the military.

DOD said users have been willing to objectively compare the merits of the vehicles with other

ways of providing required operational capabilities. They noted that technologies are currently being applied to several systems now in development. DOD also said that it will continue to consider application of the remotely piloted vehicle technology and support remotely piloted vehicle acquisition programs when they merit it. (See app. I, p. 26.)

RECOMMENDATION TO THE CONGRESS

Experts have cited various advantages of unmanned vehicles over manned aircraft for certain military missions and have identified user reluctance and lack of support as hindering the greater use of remotely piloted vehicles by DOD. The Congress has taken notice of DOD's inability to field new unmanned vehicles.

In view of the information GAO developed and DOD's position, the Congress should scrutinize proposed manned aircraft developments to assure that DOD gives adequate consideration to the use of the remotely piloted vehicle technology for some missions. While DOD is making some use of the technology, there is a need to assure that its use maximized where suited to save lives and money.

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ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office
LOCUST	low cost expendable harassment vehicle
RPV	remotely piloted vehicle
SAC	Strategic Air Command
TAC	Tactical Air Command

CHAPTER 1

INTRODUCTION

A remotely piloted vehicle (RPV) is an unmanned aircraft piloted by remote control. Like a drone, it can be preprogrammed and recovered. The major difference is that an RPV can also be controlled from a remote location once it is in operation, whereas a drone cannot. The most advantageous military use would be in a hostile environment or on a mission which could be boring or fatiguing for the pilot, such as reconnaissance or surveillance. RPVs would be able to perform a mission that would be too costly to be performed by a manned aircraft.

RPVS USED SUCCESSFULLY IN THE 1960S AND EARLY '70S

In 1959 the Ryan Aeronautical Company (now Teledyne Ryan Aeronautical) put into production its Firebee drone. The Firebee was a subsonic jet-propelled unmanned aircraft, remotely controlled from either another aircraft or a ground station.

Evolution of this target drone into an operational RPV dates from the time of the Cuban missile crisis in 1962. An American U-2 spy plane was shot down during a vital reconnaissance flight over Cuba. Because only two more U-2s were immediately available and their missions over Cuba could be performed as efficiently by a remotely controlled unmanned aircraft, the U.S. Government initiated an urgent program to develop RPVs capable of supplementing them.

Within 90 days Teledyne Ryan produced its first model 147 RPV, based on the Firebee. It was first tested against America's own sophisticated air defense and was able to make repeated penetrations without detection. The 147 became the first member of a family of RPVs that now numbers more than 20 identifiable variants.

The first public disclosure that RPVs had superseded U-2s for certain missions came in 1965 when the People's Republic of China displayed the remains of unmanned reconnaissance aircraft that had been intercepted during overflights of that country.

RPVs were extensively used throughout the Vietnam conflict. Flying over 3,000 sorties, with an attrition rate of less than 10 percent, they were primarily used for

photographing targets for air attack, recording damage after bombing, and even discovering unsuspected key targets like the huge North Vietnamese fuel storage areas in a suburb of Hanoi. Some of the most valuable "bonus" discoveries resulted from RPVs wandering off course.

The RPVs flew over North Vietnam at both high and low levels, relying on their speed and small size to elude the heavy and effective North Vietnamese defenses.

Specially funded programs during the Vietnam conflict extended the usefulness of RPVs beyond photographic missions. Other military applications included dispensing American propaganda leaflets over North Vietnam and carrying electronic listening transceivers to pick up and relay enemy broadcasts. However, due to the shortage of RPV equipment, many of these applications were severely handicapped.

During the Yom Kippur War of 1973, the Israelis used pilotless aircraft in advance of some waves of piloted attack aircraft. According to "Jane's Pocket Book of Remotely Piloted Vehicles," the pilotless vehicles saved many lives. By appearing as a much larger aircraft on enemy radar screens, they caused the Arab forces to fire their missiles at them, thus allowing the main attack formations to slip through the defense while the missile launchers were being reloaded. Even though a high proportion of the RPVs were shot down, the Israelis developed a high regard for them.

ADVANTAGES OF RPVS

There are important advantages that can be realized when circumstances allow the employment of RPVs instead of manned aircraft systems. These include eliminating pilot and crew losses, lowering operating costs, and increasing vehicle survivability and performance capabilities.

Eliminating pilot and crew losses

During the Second World War, the United States lost about 40,000 aircraft and twice as many pilots and airmen. Three decades later, the Vietnam conflict demonstrated that technological achievements had not diminished the vulnerability or risk of manned aircraft. Of the American prisoners of war held in Southeast Asia, almost 90 percent were downed pilots and crewmen and over 5,000 Americans lost their lives in hostile and nonhostile aircraft incidents during the war. Increased employment of RPVs in high risk and political situations could greatly reduce losses in future conflicts.

Lower operating costs

An RPV can be cheaper than a manned aircraft fulfilling the same mission requirements as a result of

- elimination of crew support systems, for example, ejection seats, oxygen systems, air-conditioning, and armor plating;
- cost reductions in design and construction (cheaper materials, such as fiberglass, plastic, foam, fabric, and cardboard can be used);
- cheaper and easier maintenance; and
- highly efficient fuel consumption (a Rand study estimated the annual peacetime fuel consumption of a F-4 fighter plane to be 460,000 gallons, while an RPV performing the same mission requirements would use 2,280 gallons).

In addition to savings in the cost of the vehicle and operating and maintenance expenses, personnel expenses may be drastically reduced. Cost and training of a ground controller is substantially less than a pilot. Disregarding humanitarian considerations, the capital investment lost when a pilot is killed or incapacitated is sufficient to make the use of RPVs a logical alternative whenever possible.

Increased vehicle survivability and performance capabilities

For some missions, an RPV offers the user increased mission capabilities over manned systems. The smaller RPV is more difficult to detect on radar and if detected is more difficult to hit with combat fire. Therefore, it can survive and stay on station longer. Vehicle maneuverability is enhanced by removing the pilot; the aircraft can endure much greater "g" forces than the human body. Also because of its lower cost, an RPV can be employed in great numbers to increase air power. This could become an important factor, for example, in a European theatre war against the numerical superiority of the Warsaw Pact forces.

CONGRESSIONAL CONCERN OVER DOD'S LACK OF FIELDING RPVS

The Department of Defense (DOD) did not continue to pursue the potential uses of RPVs demonstrated in Vietnam. By

1978 the House Armed Services Committee found it necessary to report that:

"The committee has strongly supported the development of remotely piloted vehicles. However, the significant investment in development and the lack of success in deploying new vehicles have highlighted the Department of Defense's inefficient management in this area.

"The committee finds little rationale to support base technology programs for the remotely piloted vehicles due to the Department of Defense's inability to field new vehicles. The committee can continue to support full scale development programs only if the Department can demonstrate its ability to transition these programs into fielded hardware. The committee would also like to convey support for the requirement to have RPVs in our military inventory in view of their demonstrated performance in actual combat. The committee has been concerned over the decline of Service support for these necessary systems that not only serve as force multipliers, but could in many instances perform those missions that greatly endanger our pilots."

OBJECTIVES, SCOPE, AND METHODOLOGY

Because there seemed to be a variety of situations in which RPVs could be used to advantage, and yet DOD was criticized for its inability to field them, we undertook a study to learn the (1) status of RPV technology, (2) reasons for its limited application within DOD, and (3) potential for application of RPV capabilities for nonmilitary uses.

Our study consisted of a number of major tasks. A literature search of major Government data bases and other sources was made. We followed up our literature review with a combination of interviews and questionnaires.

A questionnaire was sent to 85 people experienced in the RPV technology field to obtain their opinions and views on the advantages, drawbacks, and feasibility of more widespread use of RPVs. Most of these individuals were identified through their membership in the Association for Unmanned Vehicle Systems. Seventy-seven persons, or 90 percent, responded. Eighty-seven percent of those responding had at least 5 years of experience in the field of RPVs and 38 percent had 11 or more years. Their views are not necessarily

representative of the entire RPV community and may not be an unbiased forum of views on RPVs but, it constituted the most knowledgeable source of information that we could identify. (See app. III, p. 28, for copy of questionnaire used.)

Military and industrial experts were interviewed, some from the Association for Unmanned Vehicle Systems membership and some identified through other sources. We asked the interviewees the same kinds of questions as were in the questionnaire and were able to obtain more detailed responses and clarification of the issues.

Meetings were held with DOD officials, including the Army, the Navy, and the Air Force, in the Washington, D.C., area, Wright-Patterson Air Force Base, Ohio, and Langley Air Force Base, Virginia; the National Aeronautics and Space Administration; the Customs Service; the Law Enforcement Assistance Administration; and the Association for Unmanned Vehicle Systems.

To achieve as wide a knowledge base as possible, we also solicited the opinions of a number of aviation organizations, such as the Air Line Pilots Association, the Air Transport Association, and the Aircraft Owners and Pilots Association on the effect that increased use of RPVs would have on their organizations.

In our opinion, the extensive backgrounds and experiences of these experts collectively give us a reliable body of information on the available RPV technology and the barriers to RPV use.

CHAPTER 2

THE STATUS OF RPV TECHNOLOGY:

PROVEN, AVAILABLE, AND LITTLE USED

While some technological limitations exist to widespread RPV usage, such as recovery during night and adverse weather, and, to a lesser extent, remote sensing and data link technologies, those who have worked with RPVs agreed that these problems could be overcome if a real interest in the market for RPVs were to develop.

The technology exists to make RPVs practical alternatives for many missions, but the reluctance of the potential users have prevented it. This is not to imply that the technology is available for all possible applications of RPVs. There are certain applications for which RPV technology is currently not available.

BARRIERS TO USING RPVS NOT RELATED TO TECHNOLOGY

The RPV experts did not believe that the state of the art is a major hindrance to using RPVs as an alternative for manned systems in many situations. Several responded that the technical problems that do exist could be solved.

Because insurmountable technical obstacles to RPV usage would negate their cost and operational advantages, we asked the experts to classify technological and other barriers as to their relative seriousness. As shown by figure 1, recovery was the only technology considered to be more than a moderate technological barrier. Nontechnological constraints stemming from Government regulation and airspace safety were considered barriers to a moderate extent. This is especially true for civil operations. Remote sensing and data link technologies were considered less of a problem.

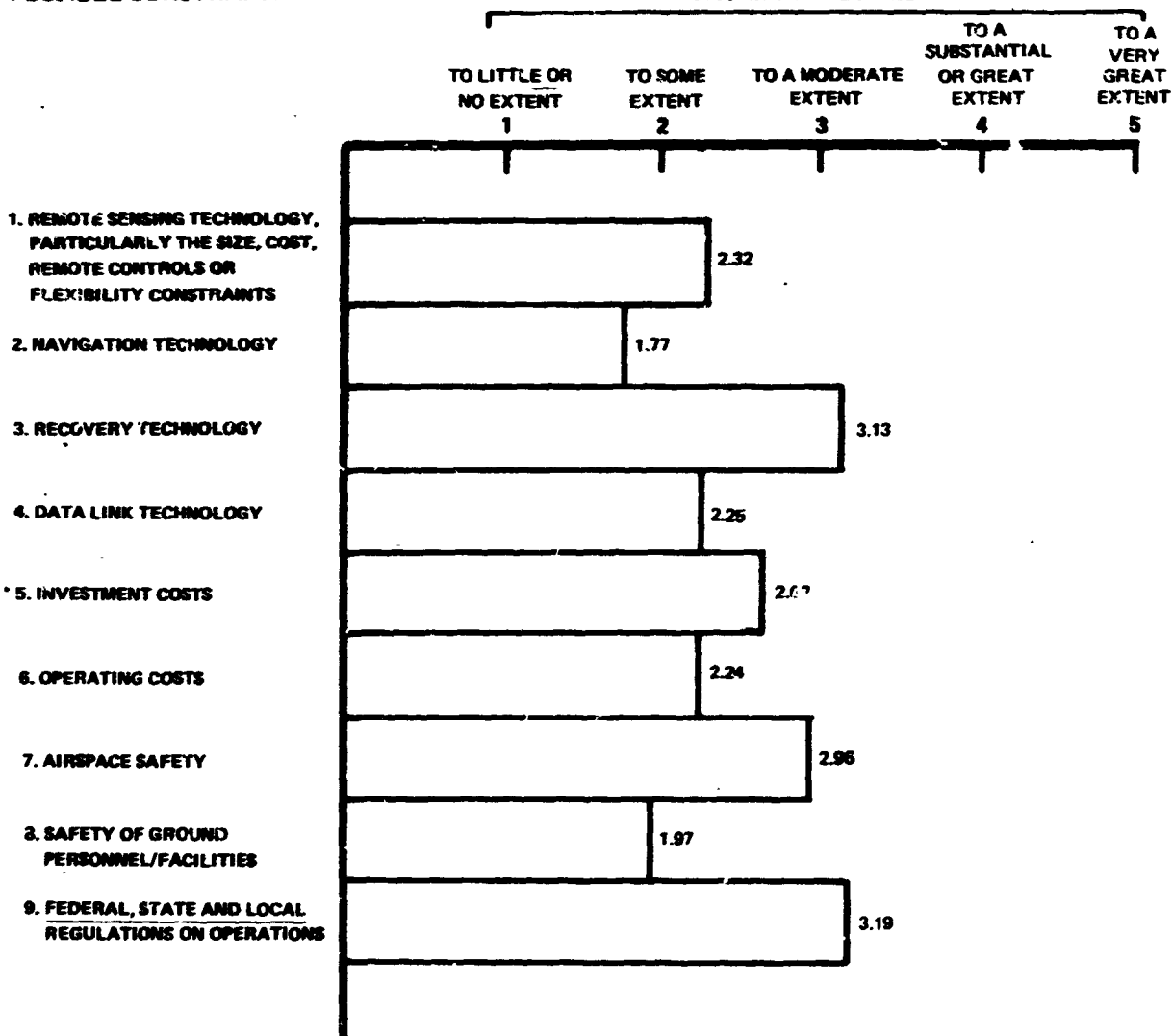
From the user's point of view, data linkage should be of the highest capability for the RPV to be used in battle. Less than the most effective linkage could require more manpower to effect recovery and could cause the RPV to lead the enemy back to its base of operations.

Recovery technology was acknowledged to be one of the biggest drawbacks to RPV systems in Southeast Asia. The Mid-Air Retrieval System employed in Vietnam used helicopters to capture parachuting unmanned vehicles after use. However, post-Vietnam systems, using specialized equipment on the RPV

Figure 1
BARRIERS TO THE USE OF RPVS

POSSIBLE CONSTRAINTS

EXTENT HINDERED



and command control equipment on the ground, have demonstrated airstrip takeoff and landing capabilities. According to DOD officials, the recovery technology has matured considerably since the systems used in Southeast Asia. Today's problems are related to recovering the vehicles at night and in adverse weather.

In a 1974 Air Force study on potential RPV applications (see pp. 10 and 11) launch and recovery were investigated. The study concluded that solutions to the problems appeared feasible and required no major technological breakthroughs.

Federal, State, and local regulations on operations may be a barrier at present, especially for civil operations, but it is believed that licenses could be obtained once the operational safety of RPVs had been demonstrated to the Federal Aviation Administration.

Guaranteeing airspace safety was considered essential before RPVs could be used in civil aviation. Some experts felt that this could only be done by using RPVs outside of controlled airspace or under control of the Federal Aviation Administration.

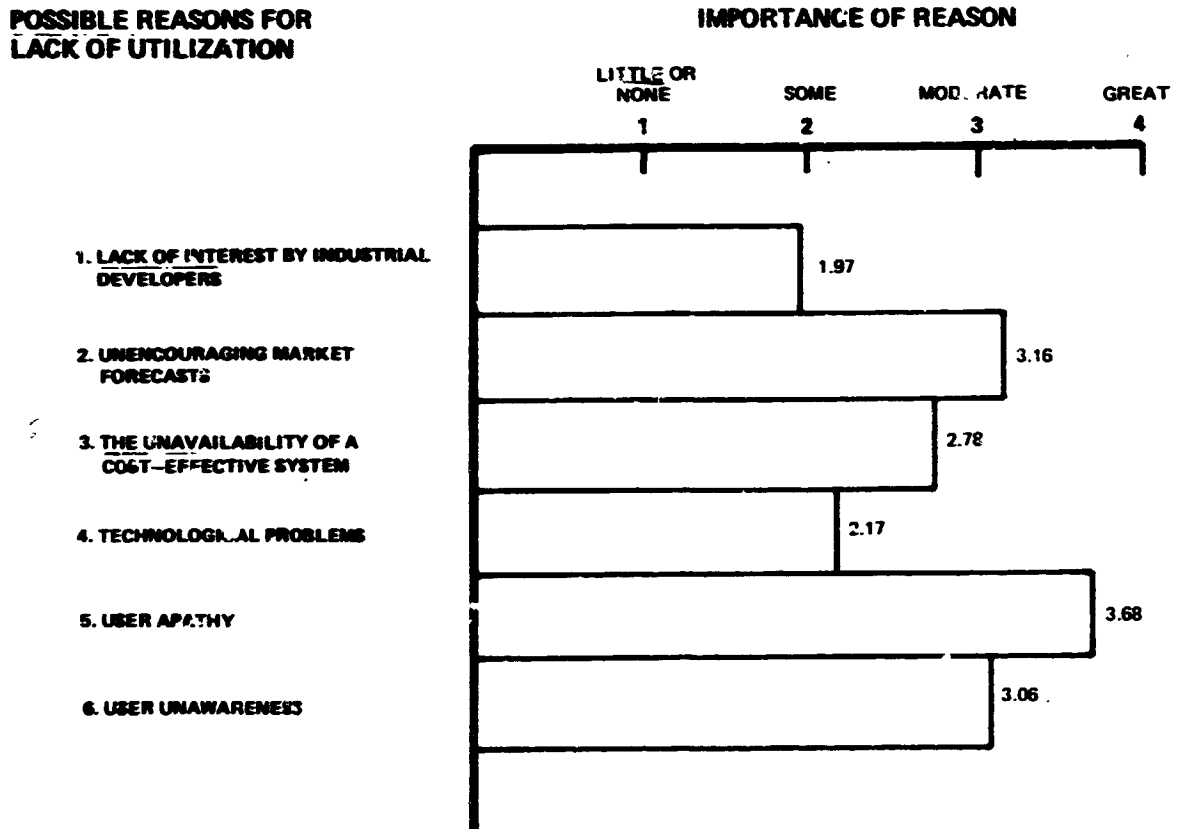
RPV USE HAMPERED BY USER RELUCTANCE AND LACK OF SUPPORT

Experts in the RPV community attributed the lack of widespread use of RPV technology to user reluctance and insufficient Government support and interest and not to insufficient advancement in the state of the art. (See p. 20.) Past Federal support has been concentrated in DOD and most past users have been military. The inability of the military to develop and demonstrate a cost-effective unmanned vehicle has led to eliminating funds for further refining and developing RPV technology. This decline in interest and support in DOD is discussed more fully in chapter 3.

Most experts ranked user apathy as the most important reason for the lack of RPV use. Perceive as being of moderate importance were the related factors of user unawareness of the technology that is available and weak market forecasts. Technological problems, lack of interest by industrial developers, and the unavailability of a cost-effective system were not considered to have contributed as much to RPV's limited use. Thus, RPVs appear to suffer from the attitude of the users and not from technological drawbacks or infeasible systems. (See fig. 2.) One of the conditions which may be the cause of the user apathy and user unawareness is the fact that the missions flown by the RPVs in Southeast Asia were for the

most part classified. As a result, not very many people, including military, were aware of the role they played at that time. Also, when the Tactical Air Command (TAC) assumed control of the RPVs, they were not given a supportable package. (See p. 16.)

Figure 2
REASONS FOR LACK OF RPV UTILIZATION



CHAPTER 3

RPVS NOT POPULAR WITH THE MILITARY

Even though RPVs demonstrated their performance capabilities in combat during the Vietnam conflict, the military has no operational RPVs, only two programs in development, and limited plans for future applications. According to the experts, the most important factors behind the limited use of RPVs in the military services are user reluctance and the lack of funding support.

AIR FORCE IDENTIFIES RPV MISSIONS

An Air Force study identified 11 missions with potential for RPV applications. The study recognized, however, that a system for each application could not be supported. It concluded that success in Southeast Asia had helped to make drones/RPVs serious system candidates, but little had been done subsequently to either promote their development or to dismiss them from Air Force consideration.

Early in 1973, the Air Force established a Drone/RPV Mission Analysis Group to produce a management plan for RPV development, identify Air Force mission applications where drone/RPVs could offer promise, and provide increased visibility into operational concepts, technological needs, development problems, and costs.

The analysis group reviewed mission areas to identify potentially viable drone/RPV applications, postulated and checked a number of operating concepts, extensively surveyed the technology base, and made RPV-related technology projections. The results of the study were dated February 1974

Fourteen mission areas generally used by the Air Force and the Air Force Systems Command were reviewed for possible drone/RPV applications. Eleven different applications were identified as having potential for RPVs: intelligence collection, communications relay, reconnaissance, search and rescue, atmospheric sampling, electronic warfare, dispensing or dispersal, air-to-air, interception, surveillance, and airlift.

According to the analysis group, it was readily apparent that operational and resources considerations would never support development and acquisition of a drone/RPV system optimized for each of the promising applications. They also concluded that it was equally obvious that all of these

applications could not be efficiently accomplished by a single drone/RPV system.

One of the factors brought out in the study was that the application of traditional air power requires extensive airfield and ground facilities within the operational range of the air vehicle being used. However, an airborne launch control and recovery system for drone/RPVs would enable their employment on a worldwide basis independent of forward operating bases and prepositioned ground bases. Range limitations would disappear and very rapid reaction to remote events would be possible.

Most of the Air Force's operational drone/RPV missions had used the technique of airborne launch and midair retrieval. These launch and recovery operations had been relatively successful, but generally were considered expensive in terms of equipment and manpower and could be limited by the availability of the launch aircraft and recovery helicopters. The study identified a number of options for launch and recovery systems and stated that all of the systems appeared technically feasible and should be technologically achievable.

The report stated that, historically, the drone/RPV program had been characterized by quick reaction to urgent national priorities and needs; specialized management procedures had been the rule; and capability advancement by improvement and modification to existing vehicles and equipment had been the norm. The emergence of drone/RPVs as serious weapon system candidates in our defense posture had been brought on by their successful use in Southeast Asia, an advanced technology base, dramatic improvements in Soviet defenses, and a coincident search for less costly systems.

The study found that the concept of air combat drone/RPV systems was formulated in 1970, but little had been done subsequently to either promote the development of these systems or to dismiss them as viable systems for Air Force consideration.

We were unable to identify any action taken because of the 1973-74 study. However, at that time, the Air Force was working on two RPV programs which were subsequently terminated.

CURRENT DOD PROGRAMS

DOD has no RPVs in its operating inventory. Two RPV programs are currently under full-scale or engineering

development--the Air Force's Low Cost Expendable Harassment Vehicle, called LOCUST, and the Army's RPV program.

The Air Force had an Advanced RPV program, but its continuation was not approved by the Congress for fiscal year 1980. We were informed by DOD that the reason the program was canceled was because the Air Force could not come up with the necessary requirements documentation to support further development of the program. The program was at the point in its development cycle where a need or a user had to be identified. None were forthcoming, so the program was terminated.

The LOCUST, strictly defined, is an expendable drone rather than an RPV. But it is generally referred to as an RPV. The LOCUST program management plan, March 5, 1979, states that the program is to provide an effective weapon system to suppress enemy air defenses at a minimum life-cycle cost.

The system is to be ground launchable by a small team and is to be accurate enough to give a high probability of disabling a radar by detonating within the target area. Because it is a single system to fulfill a common requirement, it is to contribute to the North Atlantic Treaty Organization's weapon standardization. The harassment vehicle concept is shown on page 13.

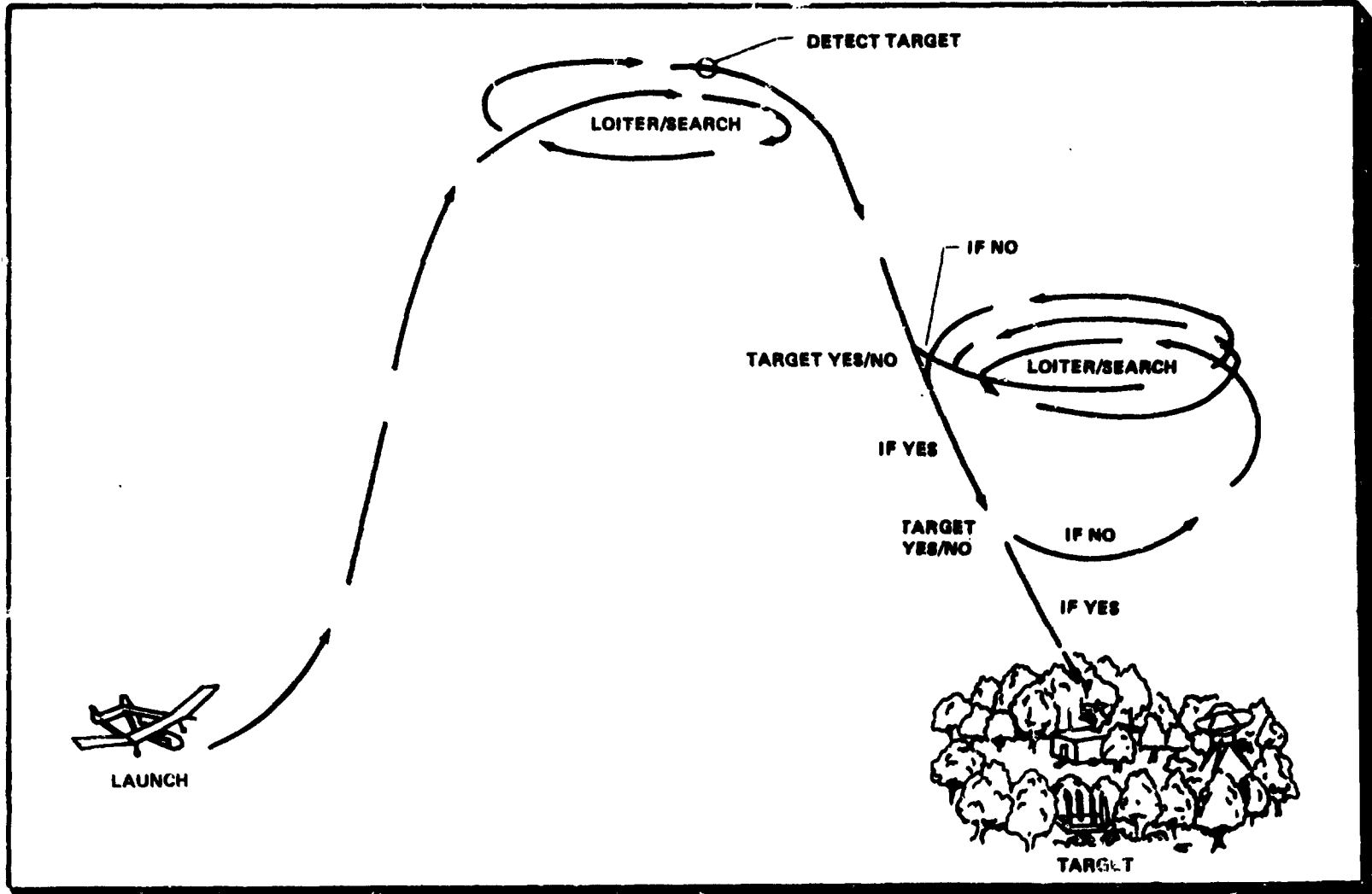
On March 23, 1980, the United States signed a Memorandum of Agreement with the Federal Republic of Germany for development of the LOCUST system. The acquisition program will include full-scale development (phase I) and production (phase II). The phase I funding is estimated to be \$30 million. The joint agreement calls for approximately equal development of the system by both countries, with the cost sharing based on the amount of work done by each country.

A request for proposal has been released and plans call for competing the two best systems. The LOCUST development work is scheduled for completion about May 1983.

The current Army RPV program provides for full-scale engineering development of an RPV system to fill a requirement for unmanned aerial target acquisition, designation, and location. The system is to extend the eyes of the brigade and division elements during combat to as far as the range of their artillery weapons. At the present time, ground-based systems cannot detect distant targets and manned observation aircraft cannot survive for a long period of time with acceptable attrition rates. The RPV has a small silhouette, is less vulnerable, and can perform low-level

HARASSMENT VEHICLE CONCEPT

13



HARASSMENT VEHICLE CONCEPT FURNISHED BY U.S. AIR FORCE

surveillance or target designation. It will multiply the effectiveness of field artillery and assist the commander to optimally employ his forces by providing artillery adjustment and laser designation on targets within the full range of the field artillery.

In hearings before a subcommittee, House Committee on Appropriations, on fiscal year 1981 appropriations, the Assistant Secretary of the Army for Research, Development, and Acquisition said:

"While the RPV is not exactly cheap, it is reasonable and costs a pittance compared to a full-sized aircraft or helicopter and pilot. It is extremely survivable by virtue of its size. In a test, thousands of rounds of radar-directed fire from a sophisticated air defense gun, as well as hundreds of rounds of fifty-caliber, were expended on an RPV flying well within range. The RPV flew on without a scratch. This system will * * * enable the Army to gain realtime TV data on the enemy when his air defense concentrations are too severe to risk sending a manned aircraft."

The Army RPV program is a continuation of the Aquila system which was started in 1974. It is based on the Aquila technology, but with more stringent requirements. Aquila was originally intended as a reconnaissance and surveillance vehicle. However, the present mission is target designation for the artillery with a secondary reconnaissance/surveillance use. This approach is designed for the Army with possible use by the Marine Corps.

The principal reason given by the Army for this shift in mission orientation is the discovery during development that its application to target acquisition/designation was slightly more effective than to reconnaissance and surveillance. However, reconnaissance/surveillance is still a very significant role for the RPV. The RPVs require mission preplanning and cueing from other sensors to perform both target acquisition/designation and reconnaissance/surveillance in an acceptable manner.

The current RPV program entered engineering development in August 1979 and the system's initial operational capability date is estimated to be the third or fourth quarter of fiscal year 1985. According to Army officials, the RPV is high on the artillery's list of priorities--about 25th of 500 items.

DOD'S PLANS FOR FUTURE
APPLICATIONS ARE LIMITED

We inquired about possible future uses of RPVs within each of the military services. The Air Force is considering an advanced reconnaissance system and one of the alternative ways of accomplishing the mission is with an RPV. This reconnaissance system is still in the planning stage and a Mission Element Needs Statement is being drafted.

The Mission Element Needs Statement is a requirement document used within DOD to justify initiation of a new major weapon systems acquisition. It should identify the mission and state the need in terms of the mission/task to be performed rather than in terms of capabilities and characteristics of a weapon system.

For an RPV to be the successful candidate for the reconnaissance mission, it must compete with other systems capable of performing the same requirement. According to some officials within the defense establishment, an RPV will be unable to compete successfully as a system because no RPV exists that can be used for comparative purposes.

The Navy informed us that it had no funded development programs and has nothing specifically planned for RPVs in the future, although it has studied possible applications for RPVs.

RPV COMMUNITY SEES POTENTIAL
FOR GREATER MILITARY USE

The judgments of the experts showed a marked degree of consensus that military missions exist for RPVs, but the reluctance of potential users to consider something other than manned aircraft has led to stagnation of RPV programs, a resulting lack of funding support, and, in some cases, eventual cancellation.

We asked the experts for their views on such questions as:

- What events brought about the decline in favor of RPVs with the military after Vietnam?
- Are there military missions for RPVs?
- Do the advantages of RPVs outweigh the disadvantages?

--What are the causes for the limited use of RPV technology?

--What are the reasons behind the lack of RPV use?

Nearly all the respondents had worked with military RPV systems, both in the military and industry--in most cases for 5 or more years. The views expressed on the following subjects are those of this group.

Military user interest, funding decline after Vietnam

After the Vietnam conflict, RPV use decreased. In 1976 the TAC assumed control of the RPV operations from the Strategic Air Command (SAC). Some of the experts felt that this marked the beginning of the downturn in enthusiasm for RPVs within the Air Force, that TAC never really wanted the RPV, seeing them as competing for funds with manned aircraft.

We considered TAC to be a potential user of RPVs. Therefore, we contacted TAC officials to determine their current interest. Their awareness of RPV technology principally went back to the Vietnam period and the subsequent transfer from SAC. They said that when TAC first began operating RPVs in 1976 they experienced a number of vehicle losses. According to one individual, the losses were mainly due to operator error caused by the lack of proper training.

However, some officials who were involved in RPV operations in SAC and TAC felt that SAC did not transfer a supportable package to TAC. These officials said that, at the time of the transfer, the funding and manpower allocated for RPV operations had decreased. The intelligence community support for RPVs had decreased or been eliminated. Also, TAC was left with an operationally cumbersome program which required considerable support staff to function. TAC wanted an organically supported RPV system. Interest waned when the cost of supporting one became evident. At that time, a constrained budget situation existed and RPVs for electronic and reconnaissance missions became expendable.

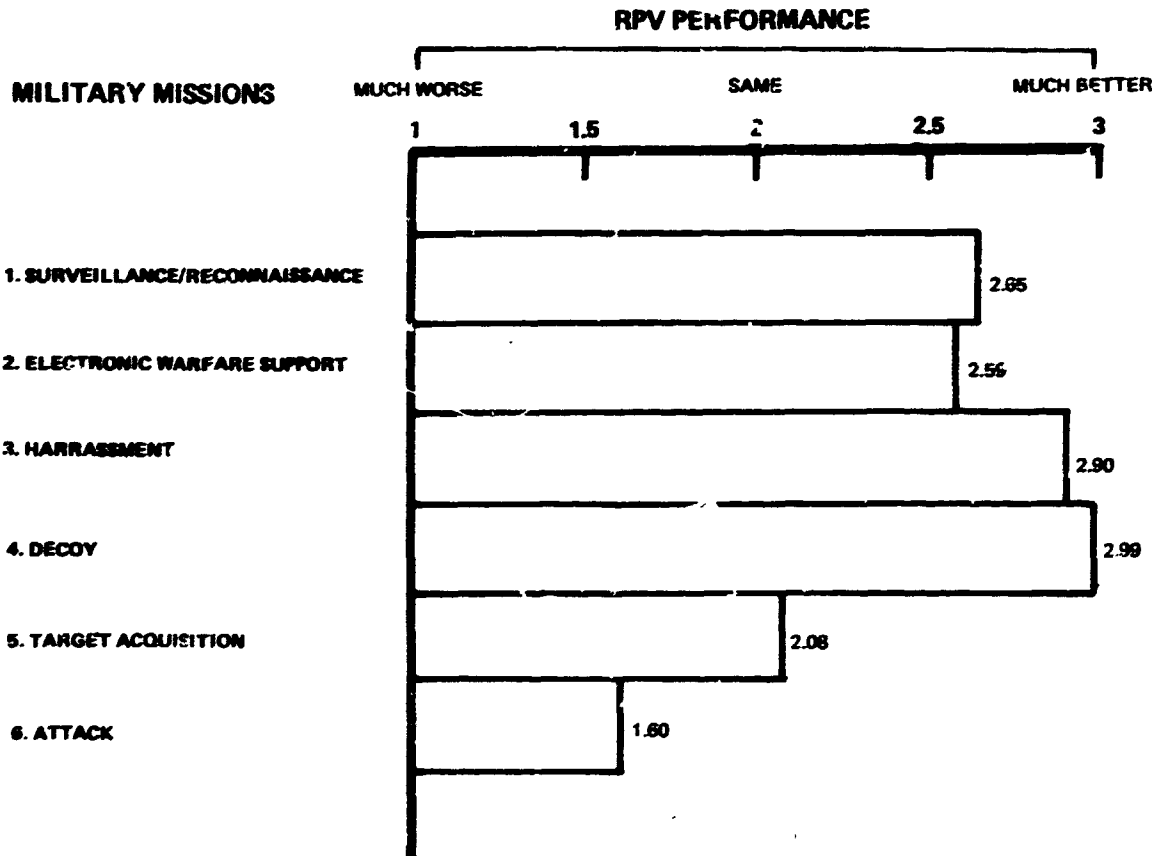
RPV systems at the time included the vehicle itself, the launch and control aircraft, and a recovery helicopter. The massive force required to put the RPVs into action decreased their usefulness to TAC, causing more resistance and resulting in even less funding. This lack of funds for development of new methods made it necessary to continue to use the outdated technology. Regardless of the reasons, RPV

support within TAC deteriorated. Eventually, all operational RPV programs were cut from TAC's budget.

RPVs rated excellent for selected military missions

The experts were nearly unanimous that RPVs would be much better than manned aircraft for harassment and decoy missions. To a slightly lesser degree, RPVs were considered much better than manned aircraft for surveillance/reconnaissance and electronic warfare support missions. Figure 3 shows their responses when asked to make comparisons considering 1980 technology. Some of these mission areas are presently being supported by the Air Force and the Army development programs.

Figure 3
RPV PERFORMANCE ON SELECTED MILITARY MISSIONS



RPVs eliminate pilot risk and cost less to operate

Because the experts firmly believed that there are missions RPVs can and should perform, we examined their responses on the advantages and disadvantages of RPVs when compared to manned aircraft. RPVs were seen as having the greatest advantage over manned systems where the mission entails much risk to the pilot. Nearly all the respondents listed this as the most important reason for the use of RPVs. The next most important reason was its smaller and less visible silhouette, which would allow the vehicle to have a greater survivability than a larger aircraft; therefore, the number of sorties it could fly would increase and replacement costs would be reduced. Better performance under boring, fatiguing, and hazardous conditions was also seen as a major advantage.

Other major advantages related to elements of cost. Even though there are no RPVs being produced at present from which to obtain cost estimates, they are still considered cheaper than manned aircraft. For example, a reconnaissance plane costs as much as \$30 million. And it costs about \$900,000 to train an Air Force pilot. Also, RPVs can save fuel.

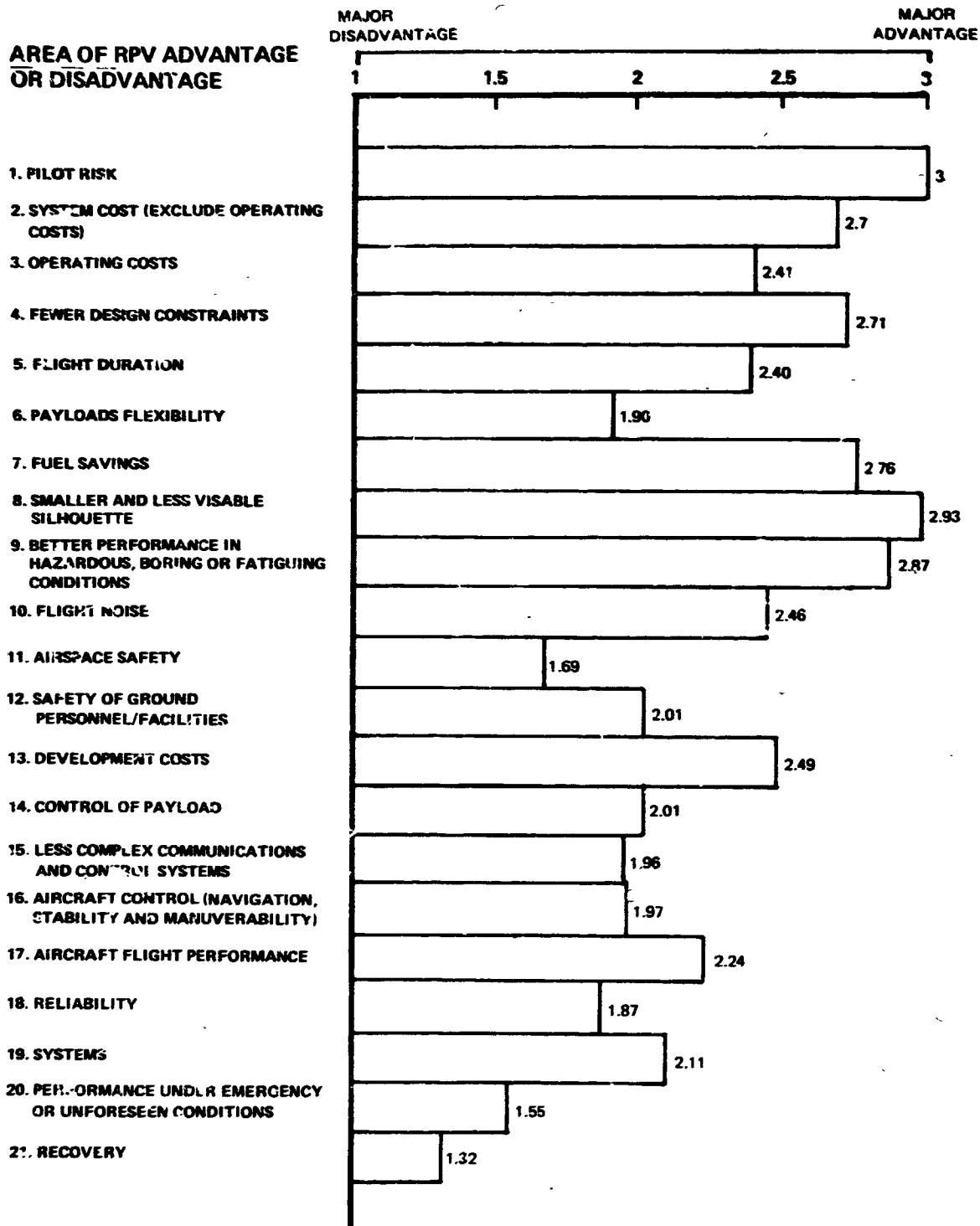
The most widely perceived disadvantages to military RPV systems were their performance under emergency or unforeseen conditions and recovery difficulties. Unmanned vehicles cannot duplicate all of the abilities a pilot brings to his aircraft. Better data links to bring the RPV operator's skill to the immediate situation may lessen this problem, but it may never be entirely eliminated. However, the gravity and frequency of these situations must be weighed against the lifesaving and cost advantages.

The experts were asked to compare RPVs with piloted systems in 21 performance areas applicable to military missions. They were to indicate whether RPVs offered a major advantage, no advantage, or a major disadvantage. The results are illustrated in figure 4.

Marketing not a factor in limited use of RPVs

Our questionnaire contained some questions concerning the marketing of RPVs. The purpose was to explore the possibility that RPVs have limited use because there has been little attempt to market them. Eighty percent of the 77 people responding to the questionnaire answered these questions.

Figure 4
RPV ADVANTAGES AND DISADVANTAGES IN MILITARY MISSIONS



Most felt that a reasonable attempt had been made to market RPVs. They had used a number of techniques, frequently submitting formal proposals and making sales contacts. At best, their marketing endeavors were only moderately successful. Their responses did not support marketing deficiencies as a cause for the limited development of RPVs. Of the potential market areas listed, defense was, by far, considered the most promising.

Military use limited by user resistance

The principal reasons for such limited exploitation of RPV technology within the defense establishment are user reluctance and insufficient Government support. According to representatives from DOD, without user support, it would be hard to generate DOD support. Operational constraints and potential users' lack of awareness of the technology were cited as problems having moderate influence on the amount of use. The state of the art has not been a hindrance and there was little feeling that RPVs could not compete with manned systems. (Fig. 5 illustrates the distribution of responses.)

The "pro-pilot bias" syndrome

In interviews and comments in the questionnaire, "pro-pilot bias" was frequently given as a major reason for not advancing the use of RPV technology in the military. It describes the reluctance to replace a known quantity with an unknown quantity. The risk is conceived as greater and therefore, any cost benefit/effectiveness must be overwhelmingly in support of the unknown system. This is difficult to demonstrate.

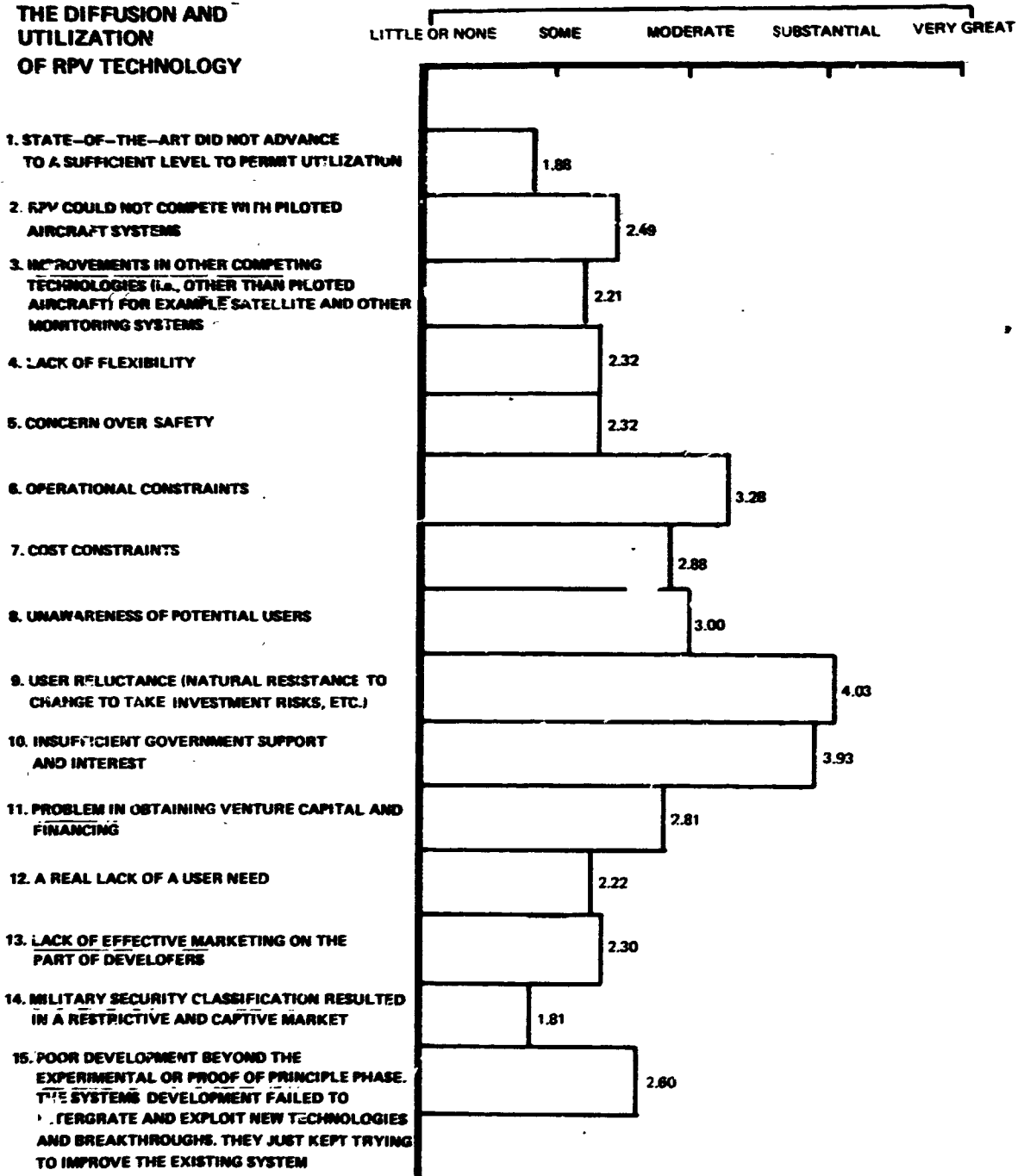
Our respondents believed that career advancement opportunities are limited for RPV operators. Another aspect of user reluctance is the perception of RPVs as too drab and unexciting to generate much enthusiasm. Therefore, while RPVs are accepted during wartime for very high risk missions or mundane jobs such as chaff dispensing and leaflet dropping, during peacetime they are not regarded with as much favor as the high technology manned aircraft.

The theme of user disinterest was consistent with user apathy being cited as the most important reason for DOD's not making more use of RPV systems. (See fig. 2.) Perceived as being of moderate importance were the related factors of user unawareness and unencouraging market forecasts.

Figure 5
REASONS FOR LACK OF DIFFUSION AND UTILIZATION OF RPV TECHNOLOGY

POSSIBLE CAUSES FOR HINDERING THE DIFFUSION AND UTILIZATION OF RPV TECHNOLOGY

EXTENT HINDERED



CONCLUSIONS

The majority of individuals who have been involved with military RPV systems for a number of years do not attribute the low level of RPV use to problems with the technology or the lack of perceived users' need. Rather, they trace the cause to the interrelated factors of reluctance on the part of users and the ensuing lack of funds for development.

They agree that eliminating danger to the pilot is a major advantage for RPVs. Its less visible silhouette and lower costs are also very important pluses. The main disadvantages are the problems with the recovery of the vehicles and their performance under emergency or unforeseen conditions.

According to the experts, RPVs can perform some missions, particularly harassment and decoy, much better than manned aircraft. To a lesser extent, they were considered better for surveillance/reconnaissance and electronic warfare. RPVs are considered less suitable for attack missions.

DOD COMMENTS AND OUR EVALUATION

In commenting on this report, DOD agreed with the general theme of the report that technologies are now sufficiently mature to support a variety of RPV applications and pointed out that there had been some technical problems in using this technology resulting in costs that are higher than initially projected, a factor relevant to comparing cost effectiveness of RPVs and alternative systems.

We have noted that technical problems and cost increases occur in both unmanned and manned aircraft programs. Thus, these should not be reasons for not considering RPVs as viable alternatives when mission requirements permit their use.

DOD did not agree that career advancement limitations and occupational drabness were hindering military acceptance of RPV systems and stated that this finding came principally from a survey of experts, a source which does not necessarily constitute an unbiased forum of views.

While the experts surveyed are not necessarily unbiased, their general views about user reluctance are compatible with other evidence we developed. For example, a lack of operational RPVs, only two development programs, limited plans for future applications and reduced funding and support by DOD also suggest that RPV technology has not been vigorously pursued by the military.

In DOD's opinion, users have been willing to objectively assess the merits of RPVs in comparison with other ways of providing required operational capabilities. DOD noted that RPV technologies are currently being applied to several systems now in development (LOCUST, the Army's RPV, and the family of cruise missiles). DOD said that it will continue to consider application of RPV technology and support RPV acquisition programs when they merit it.

RECOMMENDATION TO THE CONGRESS

Experts have cited various advantages of RPVs over manned aircraft for certain military missions and have identified user reluctance and lack of support as hindering a greater use of RPV technology by DOD. The Congress has taken notice of DOD's inability to field new RPVs.

In view of the information we developed and DOD's position, the Congress should scrutinize proposed manned aircraft developments to assure that DOD gives adequate consideration to the use of the RPV technology for some of the missions to be performed. While DOD is making some use of RPV technology, there is a need to assure that its use is maximized where suited to save lives and money.

CHAPTER 4

CIVIL USE OF RPVS NOT LIKELY

WITHOUT MILITARY DEVELOPMENT

Our third objective in undertaking this study was to determine the potential for applying RPV technology to non-military uses. We found no civil programs for using RPVs to fulfill agency missions, although we noted that the National Aeronautics and Space Administration does use a research RPV in one of its aircraft technology programs and is also studying the possible use of lighter-than-air RPVs.

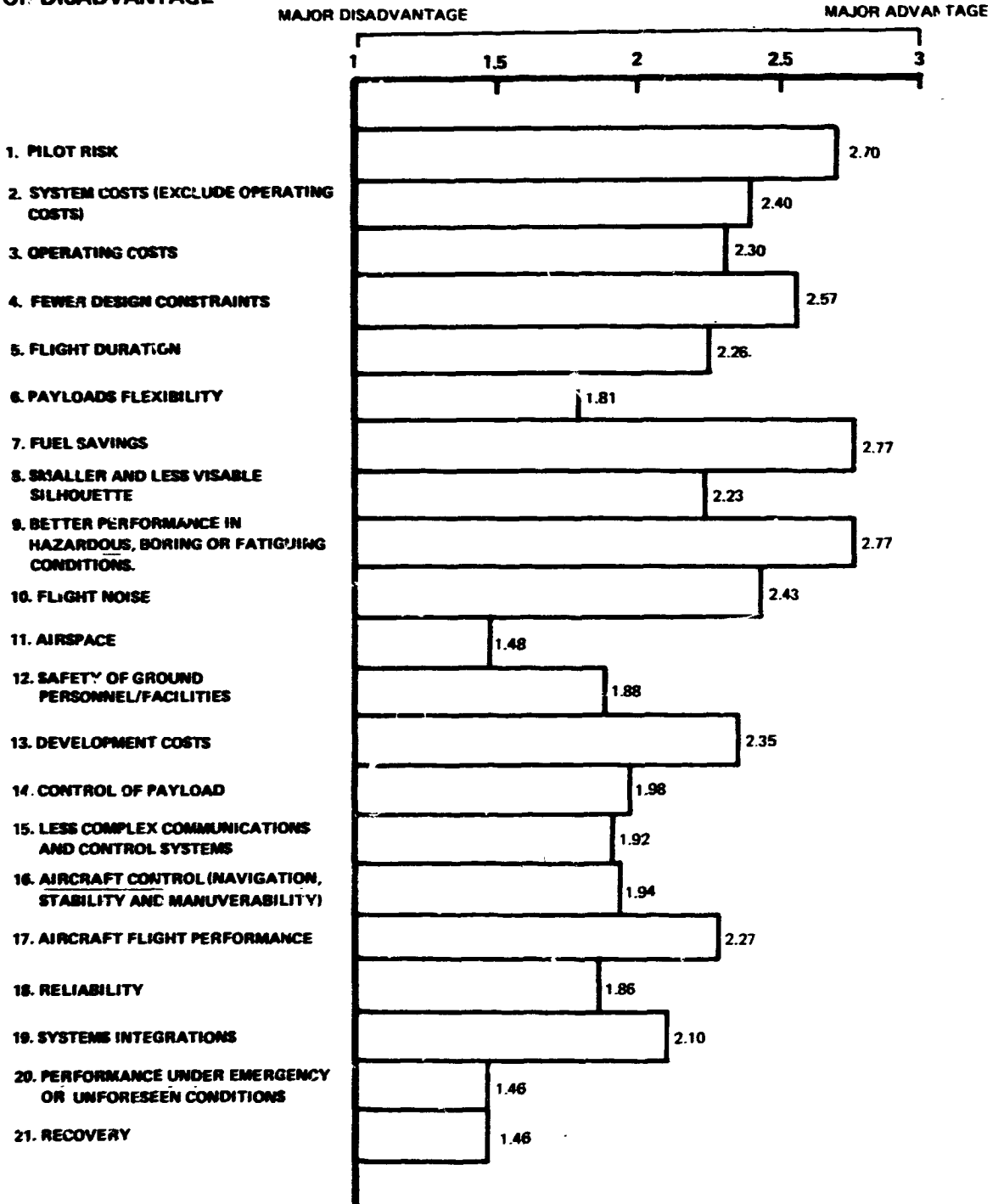
A number of promising civil applications for RPVs exists and there is a continuing need and interest in the user community for inexpensive airborne platforms. In areas such as atmospheric sampling or ground or sea surveillance, they show potential for providing the altitude advantage and flexibility of a helicopter at a fraction of the cost. For any mission where pilot risk is a factor, such as forest fire surveillance or the monitoring of volcanic activity, RPVs are a safe alternative. They are also a promising alternative where boring or fatiguing missions increase the likelihood of an accident.

The research and development budget for most civil agencies is small compared to the military. As military interest in RPVs has waned, the possibility of their being used in the civil sector has become more remote. Perhaps because of this factor, developers have made little attempt to market RPVs in the civil sector. They estimate a low use for most civil missions, not enough to profitably undertake a development program. Widespread use of RPVs in civil aviation is, therefore, not likely. RPVs could be useful in civil aviation, but unless military development brings their cost down, they will not be affordable for most civil applications.

Responses to our questionnaire by the RPV experts on the advantages and disadvantages of RPVs in nonmilitary missions were as follows:

Figure 6
RPV ADVANTAGES AND DISADVANTAGES IN NON-MILITARY MISSIONS

**AREA OF RPV ADVANTAGE
OF DISADVANTAGE**





RESEARCH AND
ENGINEERING

THE UNDER SECRETARY OF DEFENSE

WASHINGTON D.C. 20301

22 JUL 1980

Mr. W. H. Sheley, Jr.
Acting Director
Procurement & Systems Acquisition Division
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Sheley:

This is in reply to your letter of 3 December 1980 to the Secretary of Defense regarding your report dated November 1980 on "Remotely Piloted Vehicles--A Neglected Technology That Could Save Lives and Money," (OSD Case #5573) (GAO Code 952244).

We agree with the general theme of the report that technologies are now sufficiently mature to support a variety of RPV applications. Indeed we are applying those technologies to several systems now in development: Locust, the Army's RPV which is a follow-on to AQUILA, and our family of cruise missiles. However, the implementation of this technology has not been free of technical problems. We have had to overcome technical challenges not fully appreciated before. One result is that costs are higher than initial projections, a factor which is relevant to any comparison of the cost effectiveness of RPVs and alternative systems.

The report indicates that a user reluctance, caused by "perceived career advancement limitations and occupational drabness," is hindering Service acceptance of RPV systems. We have not encountered this reluctance. Rather, we have found a willingness to assess, objectively, the merits of RPVs in comparison with other ways of providing required operational capabilities. You may wish to re-examine this aspect of your report, especially since the data leading to the finding apparently came principally from a survey of experts on RPVs--a source which, as you say, does not necessarily constitute an unbiased forum of views.

I assure you that we shall continue to consider application of RPV technology, and we shall support RPV acquisition programs when they are judged to merit that support.

Sincerely,

William J. Perry
Acting



National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Airm of L

DEC 10 1980

Mr. W. H. Sheley, Jr.
Acting Director
Procurement and Systems
Acquisition Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Sheley:

Thank you for the opportunity to review GAO's draft report entitled, "Remotely Piloted Vehicles--A Neglected Technology That Could Save Lives and Money," (Code 952244) which was forwarded with your letter dated December 3, 1980.

The report has been reviewed by all appropriate NASA staff. The material submitted to GAO earlier by NASA, in response to GAO questions, has been accurately reflected in the draft report. Therefore, we do not wish to submit additional comments. 1/

If we can be of further assistance, please let me know.

Sincerely,


Gerald D. Griffin
Acting Associate Administrator
for External Relations

cc: GAO/Mr. Lindemuth

1/Material referred to was narrative description of NASA sponsored RPV research programs. This material was not used in the final report.

U. S. GENERAL ACCOUNTING OFFICE

REMOTELY PILOTED VEHICLES: A UTILIZATION FORECAST SURVEY

The purpose of this questionnaire is to assess the utilization and potential for remotely piloted vehicles (RPV's). This survey is being conducted by the U.S. General Accounting Office, which is responsible for providing congressional oversight for all Federal programs and expenditures. This questionnaire is being directed to people like yourself, who, by virtue of experience, affiliation or interest have a certain knowledge about RPV's. Specifically, we would like to know about your experiences, observations and assessments with respect to the following issues: 1) the status of RPV technology, 2) reasons for the application or lack-there-of, 3) the potentials and limitations for application of RPV's as an alternative to piloted aircraft for military and non-military uses (e.g., space, forestry, customs, immigration, etc.)

The questionnaire can be completed in fifteen or twenty minutes. Most of the questions can be answered quickly by checking a box or filling in a blank. However, if we are to make a meaningful assessment it is very important that you give us your most frank and honest answers. However, be careful to keep certain answers general and do not violate restricted, classified or proprietary information.

To maintain a common ground of understanding we would like to use the following definition of an RPV. For the purpose of this study an RPV is a piloted aircraft which can be controlled from a remote distance by means of a data link involving up and down command controls. We do not wish to consider land or water vehicles, target drones or missiles.

Please complete and return the questionnaire in the enclosed, franked envelope within ten days after receiving this letter. If you have any questions please do not hesitate to call either myself, Bob Lindamuth, or Beverly Brown at (202) 275-3195.

Thank you for your cooperation.

Jack S. Weinbough
Team Director

Your Interest and Area of Expertise

- For about how many years have you been concerned with remotely piloted vehicles (RPV's)?

_____ No. of years concerned with RPV's

- Are you concerned principally with military or non-military systems or both? (Check one.)
 - Military systems
 - Non-military systems
 - Both military and non-military systems
- Which, if any, of the following phases of development are of primary interest to you? (Check one or more.)
 - Research
 - Development
 - Application
 - Other (identify)
 - None of the above
- To what extent, if at all, do you consider yourself to be knowledgeable about each of the following areas of RPV systems technology and operations? (Check one column for each area.)

Extent of knowledge

	Extent of knowledge				
	1	2	3	4	5
	To little or no extent	To some extent	To a moderate extent	To a substantial extent	To a very great extent
1. Airframe design					
2. Engine design					
3. Remote sensing and target acquisition					
4. Data links					
5. Collision avoidance					
6. Launch and recovery					
7. Auto pilot					
8. Command and control					
9. Navigation					
10. Logistics support and maintainability					
11. Flight operations					

Your Opinions About the Utilization of RPV's

3. Several years ago the military interest in RPV's was high and forecasts for both military and civilian utilization was optimistic. But as we see today these early expectations were not fully realized. To what extent, if at all do you feel that each of the following possible causes played a role in hindering the diffusion and utilization of RPV technology.

Possible causes for hindering the diffusion and utilization of RPV technology	Extent Hindered				
	1 To little or no extent	2 To some extent	3 To a moderate extent	4 To a substantial extent	5 To a very great extent
1. State-of-the-art did not advance to a sufficient level to permit utilization					
2. RPV could not compete with piloted aircraft systems					
3. Improvements in other competing technologies (i.e., other than piloted aircraft) for example satellites and other monitoring systems					
4. Lack of flexibility					
5. Concern over safety					
6. Operational constraints					
7. Cost constraints					
8. Uncertainty of potential users					
9. User reluctance (natural resistance to change to take investment risks, etc.)					
10. Insufficient government support and interest					
11. Problem in obtaining venture capital and financing					
12. A real lack of a user need					
13. Lack of effective marketing on the part of the developers					
14. Military security classification resulted in a restrictive and captive market					
15. Fear development beyond the experimental or proof of principle phase. The systems development failed to integrate and exploit new technologies and breakthroughs. They just kept trying to improve the existing system					

6. Compare NPV's with piloted systems for both military and non-military applications with respect to each of the performance areas listed below. Check to indicate whether NPV's have major disadvantages, no major disadvantages or advantages or major advantages. (check one column for military and one column for non-military uses)

Area of NPV advantage or disadvantage	1. Military uses			2. Non-military uses		
	Major disadvantages or advantages			Major disadvantages or advantages		
	1	2	3	1	2	3
1. Pilot risk						
2. System costs (include operating costs)						
3. Spacing costs						
4. Lower design constraints						
5. Flight duration						
6. Payload flexibility						
7. Fuel savings						
8. Smaller and less visible aircraft						
9. Better performance in hazardous, boring or fatiguing conditions						
10. Flight noise						
11. Airspace safety						
12. Safety of ground personnel/facilities						
13. Development costs						
14. Control of payload						
15. Less complex communications and control systems						
16. Aircraft control (navigation, stability and maneuverability)						
17. Aircraft flight performance						
18. Reliability						
19. System integrations						
20. Performance under emergency or unforeseen conditions						
21. Recovery						
22. Other (specify)						

7. Again compare RPV with piloted aircraft for cost effective performance on each of the military and non-military missions listed below. Consider the use of current, 1980 technology. Check to indicate whether the RPV performance would be much better, much worse or not substantially different.

8. To what extent, if at all, are each of the following possible technical, cost and operational constraints a barrier to the utilization of RPV's. (Check one column for each row.)

MILITARY MISSIONS	RPV Performance		
	1 Much better	2 Not substantially different	3 Much worse
1. Surveillance/reconnaissance			
2. Electronic warfare support			
3. Harassment			
4. Escort			
5. Target acquisition			
6. Attack			
7. Other (specify)			
NON-MILITARY MISSIONS			
8. Law enforcement (traffic and security surveillance)			
9. Search and rescue			
10. Linear surveillance (e.g., coastline, pipeline and border patrol)			
11. Crop dusting			
12. Meteorological data gathering			
13. Atmospheric sampling			
14. Aircraft research			
15. Communications platform			
16. Other (specify)			

	Extent to which possible constraint is a barrier				
	1 To little or no extent	2 To some extent	3 To a moderate extent	4 To a substantial extent	5 To a very great extent
1. Remote sensing technology, particularly the size, cost, weight controls or flexibility constraints					
2. Navigation technology					
3. Recovery technology					
4. Data link technology					
5. Investment costs					
6. Operating costs					
7. Airspace safety					
8. Safety of ground personnel/facilities					
9. Federal, state and local regulations on operations					
10. Other (specify)					

9. Have you or any of the firms you have been associated with made an appropriate and reasonable effort to market an RPV system? (Check one.)

- 1. Yes (Continue)
- 2. Probably yes
- 3. Undecided
- 4. Probably no (Go to question 14)
- 5. No

10. If yes or probably yes, what types of marketing efforts were conducted? (Check all that apply.)

- 1. Conducted market surveys
- 2. Submitted formal proposals
- 3. Made sales contacts with potential customers
- 4. Prepared and distributed advertising media materials
- 5. Conducted customer demonstrations
- 6. Presented trade show exhibits
- 7. Made lobbying contacts
- 8. Other (specify)

11. How successful or not was this marketing activity? (Check one.)

- 1. Of little or no success
- 2. Somewhat successful
- 3. Moderately successful
- 4. Very successful
- 5. Of very great success
- 6. No basis to judge

12. Would you briefly comment on your success or lack there-of. Write in the space below.

13. Consider each of the following potential market areas listed below. How many, if any, RFP's do you think could be cost-effectively utilized in each market area? (Indicate your answer by checking one column in each row.)

	None A few	Several	Up to 25	25 to 50	50 to 100	100 to 250	250 to 500	Over 500
1. Defense								
2. Environmental research and monitoring (exclude weather)								
3. Weather research and monitoring								
4. Environmental protection								
5. Forestry								
6. Customs								
7. Coast guard								
8. Immigration								
9. Agriculture								
10. Auto traffic surveillance control and/or enforcement								
11. Law enforcement								
12. Other (specify)								

14. How important or not are each of the possible reasons listed below in explaining why there has not been a greater effort to utilize MPV technology? (Check one for each row.)

Possible reason for explaining lack of utilization	Importance of reason				
	1 of little or no importance	2	3 importance of moderate	4 importance of great	5 too hard to judge
1. Lack of interest by industrial developers					
2. Discouraging market forecasts					
3. The unavailability of a cost-effective system					
4. Technological problems					
5. Poor quality					
6. Poor awareness					
7. Other (specify)					

Additional Comment

15. If you have additional information which you feel is relevant to any of the preceding questions, or if you have comments about questions we should have asked but did not, please feel free to express your views below.