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COMPLEMENTARY APOLLO APPLICATIONS AND MOL PROGRAM

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COMPLEMENTARY APOLLO APPLICATIONS AND MOL PROGRAM

INTRODUCTION

This paper is devoted primarily to manned systems and the interrelationship that currently exists between the Apollo Applications (AAP) and Manned Orbiting Laboratory (MOL) Program plans and future extensions. Included also is a brief summary of the unmanned and manned evolutionary program considerations of the Apollo Applications Program. NASA's efforts and objectives are R&D oriented only while DoD must ultimately meet an operational military objective.

Before discussing the complementary nature of the two programs, the current basic responsibilities and objectives of each Agency should be stated.

- NASA has been charged, through the Space Act, with the responsibility for developing space technology, obtaining basic scientific and technological information pertaining to the Aero Space Environment and for carrying out peaceful exploration of space.

. DoD has the responsibility for Military Missions in Space and for developing the necessary systems, weapons, and supporting technology.

Both NASA/AAP and DoD MOL have very specific objectives.

NASA's principal objective in the earth orbital part of the Apollo Applications Program is to determine the usefulness and effectiveness of man in space. Further objectives of the AAP are to develop manned spaceflight technology and to carry out selected scientific and engineering experiments which depend upon the space environment and require or benefit from man's participation. (very broad)

MOL's principal objective, as presently approved, is to secure very high resolution reconnaissance photographs of significant targets with systems designed for either manned or unmanned operation use. (very specific)

SYSTEM DESCRIPTION AND HARDWARE UTILIZATION

Before discussing the effective use both Agencies have made of the other's technology, a brief description of the AAP and the MOL system is outlined below:

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	AAP	MOL
Crew	3 men	2 men/unmanned*
Mission	Scientific experiments Long life system development	Selected high resolution photography
Booster	Saturn IB	Titan IIIM 7 seg
Re-entry Body	Apollo Spacecraft	Modified Gemini
Orbital Life	28 to 56 days (eventually 90 days to 1 year)	30 days with growth to 60 days
Orbital Module	10,000 cu. ft. Orbital Work Shop.	MO Lab - 1,000 cu. ft. press.; 3,500 cu. ft. unpress.
P/L	Scientific Equipment	Dorian Optical System
First Flight	1969-70	1971
No. Flights	6 Total	3 Manned/2 Unmanned

*Note: MOL has both Manned and Unmanned Modes of P/L Operation

Both NASA and DoD have made their respective technology available to the other. Cooperation between NASA and DoD has been of value to both agencies. In many cases, DoD technology has gone to NASA, has been further improved by NASA experience and developments, and has subsequently been readapted to DoD programs.

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Some specific examples of NASA contributions to MOL are listed below:

1. Verification of man's adaptability in space:

   Ability to remain in orbit 14 days.

   Ability to function effectively in zero-g environment.

2. Hardware for the MOL Program:

   Use of developed Gemini spacecraft and contractor capability.

   Refurbished Gemini GT-2 spacecraft for heat shield test.

   Aerospace ground equipment (AGE) for Gemini.

   Use of components, subsystems and contractor capabilities from Apollo program including such items as environmental control system, fuel cells and Apollo attitude control electronics.

   Use of Gemini flight simulator in training MOL pilots.

   Anticipated use for MOL of Apollo instrumented range ships and aircraft.

Continued cooperation between NASA and the DoD in future developments which make effective use of man and provide for adequate system redundancies will insure the development of truly economical R&D investigations and cost effective operational manned and unmanned automatic systems.

MANNED AND UNMANNED SYSTEMS CONSIDERATIONS

Considerable effort has been devoted within NASA (AAP) and DoD MOL Programs toward defining longer life systems in their respective mission areas. To be truly economical, operational space systems must operate on-orbit for extended staytimes. To be truly cost-effective, future space systems must be designed for long orbit life and/or maintainability through rendezvous and resupply.

Long life missions are very demanding and require special system design and test if the satellites are to operate reliably. Extensive automation design including extensive development and qualification testing must be performed to insure that future sophisticated manned and unmanned satellite systems will have the needed reliability for long stay-time operation.

Manned systems make maximum use of automation and redundancy and they, too, require extensive development and qualification testing. Apollo Applications and MOL space systems have the added requirement of being man-rated which dictates additional testing to insure high system reliability. With a manned space system, however, more mission flexibility may exist to extend the mission stay-time since periodic system maintenance functions can be carried out through intravehicular and extravehicular operations and emergency maintenance or alternate modes of manual operation could be conducted whenever the situation demands.

Future unmanned systems could also be designed for space maintenance by manned systems. This technique has not been utilized in the past since only recently have we developed and demonstrated rendezvous and potential resupply missions in the Gemini program. Both Apollo Applications and any MOL second generation system could make effective use of rendezvous, and resupply to maintain unmanned systems and onboard experiments and equipments.

To be effective, any operational manned space system must make maximum use of man's judgment. Man alone or system redundancy alone are not adequate. To have a truly effective system, maximum use must be made of both system redundancy and man. It has been shown through Mercury and Gemini that man and his judgment can be used effectively to maintain, adjust, and operate complicated space equipment for stay-times up to two weeks duration. Both the Apollo Applications Program and the MOL Program will demonstrate and investigate man's effectiveness to perform these functions over longer periods of space flight. In addition, AAP will measure man as a system or black box in the environment of space.

Much can be done on earth through simulation and systems development to minimize errors in judgment on orbit and to familiarize the crew with the proper maintenance and operational requirements of cooperatively designed unmanned or sophisticated manned satellite systems and onboard experiments. The MOL Program has made very effective use of partial task simulation to uniquely identify man's role in operating a very high resolution camera in a satellite. In a similar way, NASA has developed through partial task simulation and their mission simulation trainer, a very sophisticated capability to familiarize the astronauts with their equipment and mission and thereby minimize the possibility of catastrophic system failure and loss of the crew on orbit.

Considerations of AAP and MOL Alternate Mission Use

Considerable discussion and comment has been held in the press and Congress that suggest that the Apollo Applications and MOL Programs are duplicative. Although most of these discussions apparently are unknowing of the detailed objectives of MOL, the fundamental questions still are pertinent.

Could AAP Perform MOL Mission?

Could the AAP accomplish the MOL purpose? The answer is "yes", if properly qualified. Such utilization of Apollo was carefully considered during the contract definition phase of MOL, and it was concluded that the resulting system would be more costly since the Apollo spacecraft was designed for the more critical Lunar return capability than MOL. The AAP reconnaissance spacecrafts would, probably because of the nature of the mission, become a single purpose (DoD only) space vehicle. Assume that the three-man Apollo spacecraft were used as the launch and re-entry system. A new ground assembled pressurized camera control compartment would have to be designed and built. The Apollo spacecraft alone lacks necessary cubage to meet the payload need of MOL even if the crew were reduced to two men. The optical payload development costs would be the same. The total system would be heavier and would probably require a much improved IB booster or perhaps a Saturn V. The orbital workshop could probably be modified to house the MOL Dorian optical system, but extensive redesign would be required and the flexible scientific use of the workshop would be lost. This suggests that there is no unnecessary duplication when viewed from Apollo Applications. Penalizing the Apollo Applications Program to perform the specific MOL mission would defeat the purpose of the Apollo Applications Program. Also of great concern would be the reversal of NASA's peaceful image if it were to become accidentally known that the Agency was even peacefully involved in reconnaissance operations. In addition, DoD cannot effectively utilize or directly control NASA management to develop the needed technology for military systems or to conduct military mission operations without defining the detailed military requirements, schedule, and enemy state of development.

Could MOL Perform AAP Missions?

The present MOL system with or without the optical P/L aboard could perform many space and earth oriented experiments. Manned scientific or Natural Resources experiments closely aligned or related to the basic photographic mission could be performed. NASA recently let a contract to the principal MOL spacecraft contractor (Douglas) to study the use of the MOL laboratory for extended-lifetime and other on-orbit experiments; the results are now being analyzed by NASA. It is highly questionable whether this approach would be cheaper than the current plan to use Apollo hardware in earth orbit for many of the planned complex scientific experiments has not yet been determined -- and possibly may not be determined for some time depending on the availability of hardware from the basic Apollo Program.

AAP and MOL Programs Are Complementary

Careful review of these two programs suggests that they are additive and are not competitive in terms of mission or equipment. Proper planning and coordination will minimize specific use of new technologies in both program areas. Considerable discussion has been and should continue to be held between NASA and DoD to make effective use of each of their respective technology bases and mission peculiar capabilities. Figure 1 lists the objectives for both NASA and the Air Force MOL Program. They are summarized under five headings:

. Long duration space flight (with different) specific objectives)	NASA and USAF
. Scientific experiments in earth orbits)	NASA
. Military experiments in earth orbits)	USAF
. Extend lunar exploration)	NASA
. Planetary probes (Unmanned)*)	NASA

*Later manned planetary missions are undefined.

Figure 1

As pointed out earlier the objectives of the AAP are to further develop manned spaceflight technology and to carry out selected scientific and engineering experiments which require or benefit from man's participation. The objective of the MOL program is to secure high resolution reconnaissance photography of significant targets. The MOL astronaut will both operate and evaluate the high resolution optical system payload and determine the added benefits which result from man's participation in their operation in space. The nature of these payloads and their use is such that they require low earth polar orbit for maximum effectiveness.

If the United States is to have a future cost-effective manned earth orbital capability, then both NASA and the Air Force need long duration space flights in both their R&D and Operational Missions. The work being done by NASA in habitability and systems development will be effectively used by the MOL Program for their specific military application of man. NASA is attempting to extend the ability of man to survive in near earth-orbit from 14 days out to 90 days through a carefully planned and conducted evolutionary program. By overlapping resupply missions and crew interchange, it may be possible to extend man's stay-time in earth orbit to periods up to one year or more. It appears that a 90-day resupply cycle for a system that can fundamentally live and operate on orbit for a year or more, would be truly economical. This would be directly applicable to any follow-on to the present MOL Program.

Initially, the MOL Program is designed for 30 days. It, too, can effectively use the extension in life support and basic biomedical data for long duration stay-time on orbit that NASA will develop, experience and evaluate. It is assumed that man can improve the quality and quantity of photographs taken and can dynamically make choices that unmanned systems cannot do. In the minds of the MOL Program Managers, there is no question but that the presence of man is important to the assurance of achieving [redacted] resolution photography from space, to the early achievement of this objective, and to increase the quantity and value of photographs taken -- the only open question at this time is how hard can man be worked on the latter task in space; this can only be determined through flight test in space.

Many of the developments in life support, electrical power, and attitude stabilization that NASA develops through their long duration program can be effectively used by the

MOL Program. The MOL Program will use man to dynamically acquire [redacted] photographs of highly selected world targets. The primary purposes of man in MOL (in order of priority) are to "fine tune" the automatic systems, manually back up failed or malfunctioning systems and verify overall systems performance plus determine the suitability for unmanned system use. In addition to this, the program will evaluate the usefulness of man to enhance the intelligence content of the photographic mission.

NASA is going beyond the presently demonstrated capabilities of man in the Apollo Applications Program to determine man's usefulness in space for long duration science and earth applications missions with man as an evaluator, observer, and manipulator of scientific, technical and applications experiments. The AAP will obtain information on the functioning of man and systems for durations of a year and longer. This information, developed in the 1969-74 time period, will then be available to support potential earth orbit space station and planetary exploration activity in the mid and late 1970s. Long duration capability in AAP will be afforded through minimal modification to existing

Apollo hardware and the addition of selected subsystems, components and expendables. Concurrent with the long duration flights, basic scientific and technological data will be collected with emphasis in the astronomy, biomedical and engineering areas. In 1970 and 1971 the AAP plans to conduct specific biomedical experimentation for durations of 28 to 56 days.

The work conducted by NASA can be effectively used by the MOL Program and many of the partial tasks and very specific MOL uses of man will contribute effectively to the Apollo Application flights. Typical are the astronauts' sleep station, work restraints (i.e., straps), suit development, maintenance tools, partial task loading and work rest cycles.

Both the Apollo Applications Program and the MOL Program plan to make effective use of manned and unmanned operational satellite technology. Many of the future unmanned systems might well be developed and operated through the effective use of man performing a logistics, checkout, and maintenance role. After the development of this technique, the systems then can operate quite independently of the space-based manned development laboratory. Careful consideration must be given to designing systems for total replacement or manned maintenance, based on the complexity and cost of the entire system.

Future Areas of Development

Listed below are some technology areas that both NASA and the Air Force should continue to explore to determine where common developments might be effectively carried on or initiated to meet future mission needs:

- Communication and range control
- Boosters
- High energy upper stages -- nuclear/non-nuclear
- Uprated Titan and Saturn stages and engines
- Navigation and guidance and attitude stabilization
- Space power
- Space suits and life support equipment
- Survival and rescue approach and system development
- Rendezvous and resupply techniques

By careful planning and coordination, these technology items can be further developed for effective use both with the Apollo Applications and MOL programs.

The Apollo Applications and MOL programs have similar planning schedules. NASA is currently scheduled to launch some Apollo and AAP flights ahead of MOL. Much of the detailed work for long duration flights and life support will be available to any follow-on MOL program. NASA's current schedules are being formulated to reflect the changes made as a result of the fire and budget restrictions. A recent modified NASA schedule is shown on Figure 2. The MOL schedule is similar. (See Figure 3). Since both programs have similar requirements in many technology areas in essentially the same time periods, new technology developments permit maximum dual usage by both programs. There is one significant exception -- namely, the camera systems for MOL are entirely an advancement of DoD unmanned satellite technology with no parallel development or knowledge in the unclassified world of NASA.

SUMMARY

In summary, it can be seen that the Apollo Applications Program and MOL Program are different and complementary; they are not competitive in mission and are not redundant in terms of hardware development. MOL will perform an operational mission of national importance with a low technical risk because of the manned space flight technology developed within NASA.

MOL was established primarily to conduct photographic reconnaissance from space. It was and still is believed that such a satellite capability could be developed and coorindated sooner through the use of man on orbit. The analysis and simulation work to date has supported the thesis that man can effectively improve the quantity and quality of the photographs, exercise judgment on targets of momentary increased intelligence value, and can generally do many of those minor adjustments and alignments that would be very difficult to automate.

Many technologies developed within NASA have been and will continue to be effectively used by the MOL Program. Many of the results of unique mission peculiar simulations and operational designs that make effective use of man for military objectives will be made available to NASA in order that NASA may understand and make good use of the information in their own programs.

There is a definite need to recognize that differences exist between the objectives of our military and civilian space programs. There exists a close working relationship between NASA and DoD for effective use of their current common technology and to maximize usage of future new developments. The NASA-DoD relationship in space can provide the same value as did NACA-DoD relationship in past years for Aeronautics. NASA should continue to stress the pursuit of advanced technology and techniques in space flight for use by DoD in military applications, and for civilian users of space technology for non-military applications.

<u>Recommendations</u>

- o NASA should evaluate and extend man's ability to work and function on orbit through a very orderly evolutionary series of experiments for more than 30 days with the objective of staying for periods of a year or more.

- NASA should develop the necessary life support and space vehicle subsystems and equipments compatible with this long-term man-on-orbit evaluation program.

- DoD should continue to evaluate specific military missions for later operational payload deployment in both manned and unmanned systems with a full understanding of the cost and mission effectiveness of both modes of operation.

- NASA should continue to define a very orderly series of earth orbiting experiments working closely with the MOL Program to maximize the utilization of the information for both any MOL second generation program and NASA Natural Resources and Planetary Programs.

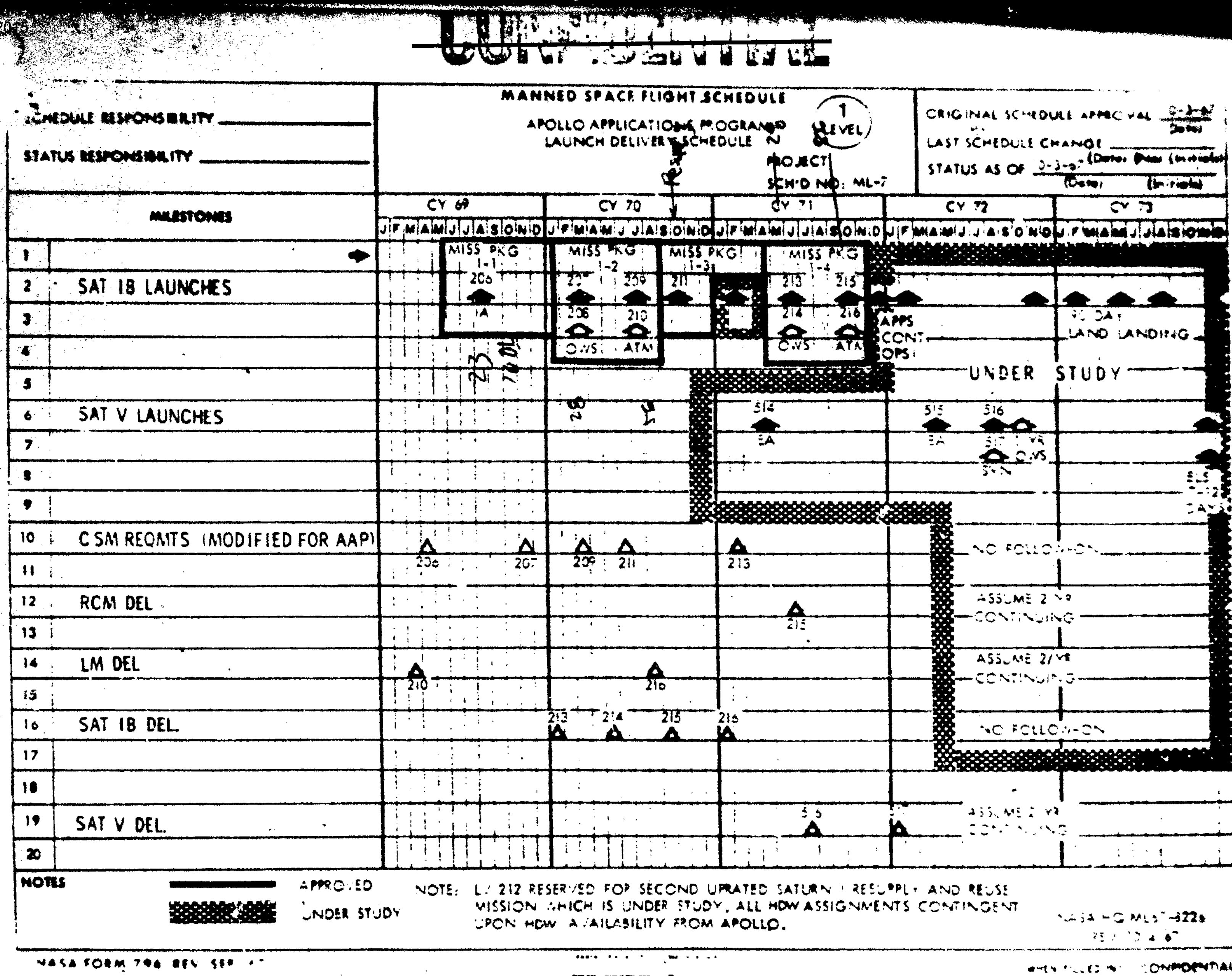
- Future optics needs of NASA and DoD must continue to be thoroughly coordinated to minimize development costs and prevent any unnecessary reinvention of systems and components.

- The existing AACB and MSFPC need to continue and perhaps intensify their efforts to insure that the MOL/AAP programs and supporting technology developments are closely coordinated and complementary insofar as possible.

- Quite a lot of review of the future plans of both programs for the next five to ten years has been completed through joint participation in the AACB and the MSFPC. Two major areas appear to need additional and perhaps special attention:

  - Future plans and growth of the T-IIIM booster and Saturn booster program.

- Maneuverable, reusable upper stage spacecraft for second generation application to either an AAP or MOL, operating in either a manned or unmanned mode.



MANNED SPACE FLIGHT SCHEDULE
APOLLO APPLICATIONS PROGRAM
LAUNCH DELIVERY SCHEDULE
LEVEL 1
PROJECT
SCH'D NO. ML-7
SCHEDULE RESPONSIBILITY
STATUS RESPONSIBILITY
ORIGINAL SCHEDULE APPROVAL
LAST SCHEDULE CHANGE
STATUS AS OF
MILESTONES
CY 69
CY 70
CY 71
CY 72
CY 73
SAT IB LAUNCHES
MISS PKG 1-1
MISS PKG 1-2
MISS PKG 1-3
MISS PKG 1-4
OWS
ATM
APPS CONT OPS
LAND LANDING
UNDER STUDY
SAT V LAUNCHES
CSM REQMTS (MODIFIED FOR AAP)
NO FOLLOW-ON
RCM DEL
ASSUME 2 YR CONTINUING
LM DEL
SAT IB DEL.
SAT V DEL.
NOTES
APPROVED
UNDER STUDY
NOTE: LV 212 RESERVED FOR SECOND UPRATED SATURN I RESUPPLY AND REUSE MISSION WHICH IS UNDER STUDY. ALL HDW ASSIGNMENTS CONTINGENT UPON HDW AVAILABILITY FROM APOLLO.
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CONFIDENTIAL

FIGURE 2

MOL PROGRAM SCHEDULE

MILESTONES	FY 68	FY 69	FY 70	FY 71	FY 72
PRE-FLIGHT EVENTS					
DYNAMIC TEST OPTICS ASSEMBLY	△	△			
STATIC FIRE 7-SEGMENT SRM		△			
TEST RUN CAMERA OPTICS ASSEMBLY		△			
[illegible] ACCEPT TEST 1ST PROD CAMERA			△		
ASSEMBLE/TEST FLIGHT VEHICLE #3		△		△	
FLIGHT SCHEDULE					
T-IIIM/GEM/STRUC QUAL			△ △		
MANNED ALL-UP				△ △	△
UNMANNED ALL-UP					△ △

FIGURE 3