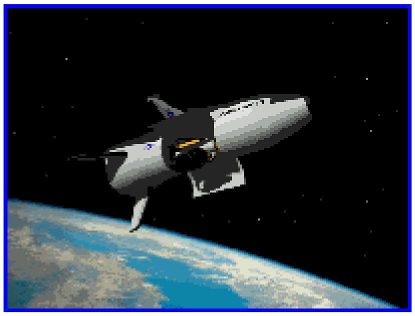
Military Spaceplane
X-40 Space Maneuver Vehicle
Integrated Tech Testbed



Air Force interest in military spaceplanes stretches back nearly 40 years. This has taken the form of science and technology development, design and mission studies, and engineering development programs. Examples of these activities include: the first Aerospaceplane program and Dyna-Soar/X-20 program (late 1950s-early 1960s); X-15 hypersonic and X-24 lifting body flight test programs (late 1950s through early 1970s); Advanced Military Space Flight Capability (AMSC), Transatmospheric Vehicle (TAV), and Military Aerospace Vehicle (MAV) concept and mission studies (early 1980s); the Copper Canyon airbreathing single-stage-to-orbit (SSTO) feasibility assessment and the National Aerospace Plane (NASP) program (1984-1992); SCIENCE DAWN, SCIENCE REALM, and HAVE REGION rocket-powered SSTO feasibility assessments and technology demonstration programs (late 1980s); and, most recently, the Ballistic Missile Defense Organization's Single-Stage Rocket Technology program that built the Delta Clipper-Experimental (DC-X) experimental reusable spaceplane.

Industry sources are being sought to develop critical technologies for future military spaceplanes using ground based advanced technology demonstrations. The first step is envisioned to include a streamlined acquisition that develops, integrates and tests these technologies in an Integrated Technology Testbed (ITT). Due to constrained budgets, the Air Force is seeking innovative, "out of the box", industry feedback and guidance to: 1) develop and demonstrate key military spaceplane technologies, 2) ensure competitive industry military spaceplane concepts are supported via critical technology demonstrations, and 3) ensure a viable, competitive military spaceplane industrial base is retained now and in the future.

The primary objective of the ITT is to develop the MSP Mark I concept design and hardware with direct scaleability: directly scaleable weights, margins, loads, design, fabrication methods and testing approaches; and traceability: technology and general design similarity, to a full-scale Mark II-IV system. The ITT is intended to demonstrate the technologies necessary to achieve systems integration within the mass fraction constraints of Single Stage to Orbit (SSTO) vehicles. In addition, the ITT will meet the military operational requirements outlined in the MSP SRD. The ITT is an unmanned ground demonstration. The Mark I demonstrator is also envisioned to be unmanned.

The Military Spaceplane (MSP) ITT ground demonstration consists of an effort to develop a computer testbed model. It may also include options for multiple technology, component and subsystem hardware demonstrations to support and enable the acquisition and deployment of MSP systems early in the next century. Although the ITT is not a flight demonstrator, it is anticipated that critical ground Advanced Technology Demonstrator (ATD) components and subsystems shall be designed, fabricated and tested with a total systems and flight focus to demonstrate the potential for military "aircraft like" operations and support functions. The latter point refers to eventual systems that 1) can be recovered and turned around for another mission in several hours or less on a routine basis, 2) require minimal ground and flight crew to conduct routine operations and maintenance , 3) are durable enough to sustain a mission design life of hundreds of missions, 4) are designed for ease of maintenance and repair based on military aircraft reliability, maintainability, supportability and availability (RMS&A) standards including the use of line replaceable units to the maximum extent possible, and 5) can be operated and maintained by military personnel receiving normal levels of technical training. The ITT effort is envisioned to culminate with a vigorous integrated test program that demonstrates how specific components and subsystems are directly traceable and scaleable to MSP system requirements and meet or exceed these operational standards.

The testbed itself shall be a computer sizing model of the Military Spaceplane. Input parameters include mission requirements and all of the critical component, subsystem and system technical criteria. Output are the critical design features, size, physical layout, and performance of the resulting vehicle. The computer model shall be capable of modeling the technology componenta, subsystems and systems demonstrated characteristics and the resulting effect(s) on the Military Spaceplane vehicle concept design. Although the ITT is required to show analytical component and subsystem scaleability to SSTO, the contractor may also show scaleability and traceability to alternative MSP configurations. Those alternatives may include two stage to orbit (TSTO) configurations. The ITT is using SSTO as a technology stretch goal in the initial ground demonstrations. However, a future Military Spaceplane can use either single or multiple stages.

The contract structure for ITT is anticipated to be Cost Reimbursement type contracts with possible multiple options and a total funding of approximately $125-150M. Due to initial funding limitations, the minimum effort for the contract is anticipated to consist of a broad conceptual military spaceplane design supported by a computer testbed model. However, should funding become available, additional effort may be initiated prior to the conclusion of the testbed model design. Offerors will be requested to submit a series of alternatives for delivery of major technology components and subsystems as well as an alternative for subsystem/system integration and test.

Upon direction of the Government through exercise of the option(s) the contractor shall design, fabricate, analyze, and test Ground Test Articles (GTAs), and provide a risk reduction program for all critical technology components, subsystems and subsystems assembly. The contractor will prepare options for an ITT GTA designs which satisfy the technical objectives of this SOO, including both scaleability and traceability to the Mark I and Mark II-IV vehicles. These design shall be presented to the Government at a System Requirements Review (SRR). The contractor shall use available technologies and innovative concepts in the designs, manufacturing processes, assembly and integration process, and ground test. Designs shall focus on operational simplicity and minimizing vehicle processing requirements. The contractor shall provide the detailed layout and systems engineering analysis required to demonstrate the feasibility and performance of the Mark I vehicle as well as scaleability and traceability to the Mark II-IV vehicles. The low cost reusable upper stage (i.e., mini-spaceplane) is envisioned to be an integral part of an overall operational MSP system.

The contractor shall use the ITT to implement the initial risk reduction program that mitigates risks critical to developing both the Mark I and Mark II-IV MSP configurations. The ITT shall mitigate risks critical to engineering, operability, technology, reliability, safety, or schedule and any subsequent risk reduction program deemed necessary. The program may include early component fabrication, detailed vehicle integration planning or prudent factory and ground/flight testing to reduce risks. The Technology levels will be frozen at three points in the Military Spaceplane Program (MSP): At the ITT contract award for the Ground Demonstrator, at contract award for any future Flight Demonstrator, and at contract award for an orbital system EMD.

Since the ITT is not a propulsion demonstration/integration effort there are two parallel propulsion efforts. One in NASA for the X-33 aerospike, and one in the AF for the Integrated Powerhead Demonstration (IPD). It is anticipated that the Mark I demonstrator would use an existing engine. Propulsion modifications and integration will be addressed in the offerors concept design but limited funding probably precludes any new engine development. The contractor should evaluate the use of the Integrated Powerhead Demonstration (IPD) XLR-13X engine as a risk reduction step being done in parallel and as a baseline engine for MSP. LOX/LH2 offers an excellent propellant combination for future Military Spaceplanes. Nearer term demonstrators, however, may be asked to use alternative propellants with superior operability characteristics.

MAXIMUM PERFORMANCE MISSION SETS

Maximum Performance Missions Sets are system defining and encompass the four missions and the Design Reference Missions. Instead of giving a threshold and objective for each mission requirement, missions sets are defined. Each mission set will define a point solution and provide visibility into the sensitivities of the requirements from the thresholds (Mark I) to the objective (Mark IV). If takeoff and landing bases are constrained to the U.S. (including Alaska and Hawaii), this will reduce stated pop-up payloads by at least half.

Mark I (Demonstrator or ACTD non-orbital vehicle that can only pop up)

- Pop-up profile: Approximately Mach 16 at 300 kft at payload separation

- Pop up and deliver 1 to 3 klbs of mission assets (does not include boost stage, aeroshell, guidance or propellant) to any terrestrial destination
- Pop up and deliver 3 to 5 klbs of orbital assets (does not include upperstage) due east to a 100 x 100 NM orbit
- Payload bay size 10' x 5' x 5', weight capacity 10 klbs

Mark II (Orbit capable vehicle)

- Pop up and deliver 7 to 9 klbs of mission assets (does not include boost stage, aeroshell, guidance or propellant) to any terrestrial destination
- Pop up and deliver 15 klbs of orbital assets (does not include upperstage) due east to a 100 x 100 NM orbit
- Launch due east, carrying 4-klb payload, orbit at 100 x 100 NM
- Payload bay size 25' x 12' x 12', weight capacity 20 klbs

Mark III

- Pop up and deliver 14 to 18 klbs of mission assets (does not include boost stage, aeroshell, guidance or propellant) to any terrestrial destination
- Pop up and deliver 25 klbs of orbital assets (does not include upperstage) due east to a 100 x 100 NM orbit
- Launch due east, carrying a 6-klb payload, orbit at 100 x 100 NM and return to base
- Launch polar, carrying 1-klb payload and return to base
- Payload bay size 25' x 12' x 12', weight capacity 40 klbs

Mark IV

- Pop up and deliver 20 to 30 klbs of mission assets (does not include boost stage, aeroshell, guidance or propellant) to any terrestrial destination
- Pop up and deliver 45 klbs of orbital assets (does not include upperstage) due east to a 100 x 100 NM orbit
- Launch due east, carrying a 20-klb payload, orbit at 100 x 100 NM and return to base
- Launch polar, carrying 5-klb payload and return to base
- Payload bay size 45' x 15' x 15', weight capacity 60 klbs

REFERENCE MISSIONS TO MISSION SETS MATRIX

Ref Mission	Mark I	Mark II	Mark III	Mark IV
Payload Bay Data	10' x 5' x 5' 10 klbs	25' x 12' x 12' 20 klbs	25' x 12' x 12' 40 klbs	45' x 15' x 15' 60 klbs
DRM 1 (Pop up and deliver mission assets)	1-3 klb	7 to 9 klb	14 to 18 klb	20 to 30 klb
DRM 2 (Pop up and deliver orbit assets due east 100 x 100 NM)	3-5 klb	15 klb	25 klb	45 klb
DRM 3 (Co-Orbit)	N/A	4 klb due east 100 x 100 NM	6 klb due east 100 x 100 NM	20 klb due east 100 x 100 NM
DRM 4 (Recover)	N/A	TBD	TBD	TBD
DRM 5 (Polar Once Around)	N/A	N/A	1 klb	5 klb

NOTES:

Mission asset weight is a core weight and does not include a boost stage, aeroshell, guidance or propellant.

Orbital asset weight does not include an upperstage.

Requirements Matrix for Mark II, III and IV
(Desired for Mark I)

Requirement	***Threshold***	***Objective***
Sortie Utilization Rates		
Peacetime sustained	0.10 sortie/day	0.20 sortie/day
War/exercise sustained (30 days)	0.33 sortie/day	0.50 sortie/day
War/exercise surge (7 days)	0.50 sortie/day	1.00 sortie/day
Turn Times		
Emergency war or peace	8 hours	2 hours
MOB peacetime sustained	2 days	1 day
MOB war/exercise sustained (30 days)	18 hours	12 hours
MOB war/exercise surge (7 days)	12 hours	8 hours
DOL peacetime sustained	3 days	1 day
DOL war/exercise sustained (30 days)	24 hours	12 hours
DOL war/exercise surge (7 days)	18 hours	8 hours
System Availability		
Mission capable rate	80 percent	95 percent
Flight and Ground Environments		
Visibility	0 ft	0 ft
Ceiling	0 ft	0 ft
Crosswind component	25 knots	35 knots
Total wind	40 knots	50 knots
Icing	light rime icing	moderate rime icing
Absolute humidity	30 gms/m3	45 gms/m3
Upper level winds	95th percentile shear	all shear conditions
Outside temperature	-20 to 100F	-45 to 120F
Precipitation	light	moderate
Space Environment		
Radiation level	TBD	TBD
Flight Safety		
Risk to friendly population	< 1 x 10-6	< 1 x 10-7
Flight Segment loss	< 1 loss /2000 sorties	< 1 loss/5000 sorties
Reliability	0.9995	0.9998
Cross Range		

Unrestricted pop-up cross range	600 NM	1200 NM
CONUS pop-up cross range	400 NM	600 NM
Orbital cross range	1200 NM	2400 NM
"Pop-up" Range		
CONUS pop-up range	1600 NM	1200 NM
Ferry range minimum	2000 NM	worldwide
On-orbit Maneuver		
Excess V (at expense of payload)	300 fps	600 fps
Pointing accuracy	15 milliradians	10 milliradians
Mission Duration		
On-orbit time	24 hours	72 hours
Emergency extension on-orbit	12 hours	24 hours
Orbital Impact		
Survival impact object size	0.1-cm diameter	1-cm diameter
Survival impact object mass	TBD	TBD
Survival impact velocity	TBD	TBD
Alert Hold		
Hold Mission Capable	15 days	30 days
Mission Capable to Alert 2-hour Status	4 hours	2 hours
Hold Alert 2-hour Status	3 days	7 days
Alert 2-hour to Alert 15-minute Status	1 hour 45 minutes	30 minutes
Hold Alert 15-minute Status	12 hours	24 hours
Alert 15 Minute to Launch	15 minutes	5 minutes
Design Life		
Primary Structure	250 sorties	500 sorties
Time between major overhauls	100 sorties	250 sorties
Engine life	100 sorties	250 sorties
Time between engine overhauls	50 sorties	100 sorties
Subsystem life	100 sorties	250 sorties
Take-off and Landing		
Runway size	10,000 ft x 150 ft	8000 ft x 150 ft
Runway load bearing	S65	S45
Vertical landing accuracy	50 ft	25 ft
Payload Container		
Container change-out	1 hour	30 minutes

Crew Station Environment (if rqd)		
Life support duration	24 hours	72 hours
Emergency extension on-orbit	12 hours	24 hours
Crew Escape (if rqd)		
Escape capability	subsonic	full envelope
Maintenance and Support		
Maintenance work hours/sortie	100 hours	50 hours
R&R engine	8 hours	4 hours

X-40 Space Maneuver Vehicle (SMV)

The Air Force Research Laboratory's Space Maneuver Vehicle (SMV) is a small, powered space vehicle technology demonstrator. An eventual operational version could function as the second stage-to-orbit vehicle as well as a reusable satellite with a variety of available payloads. SMV could perform missions such as:

- Tactical reconnaissance
- Filling gaps in satellite constellations
- Rapid deployment of Space Maneuver Vehicle constellations
- Identification and surveillance of space objects
- Space asset escorting

An SMV is envisioned to dwell on-orbit for up to one year. Its small size and ability to shift orbital inclination and altitude would allow repositioning for tactical advantage or geographic sensor coverage. Interchangeable SMV payloads would permit a wide variety of missions. SMV would use low-risk subsystem components and technology for aircraft-like operability and reliability.

An operational SMV might include:

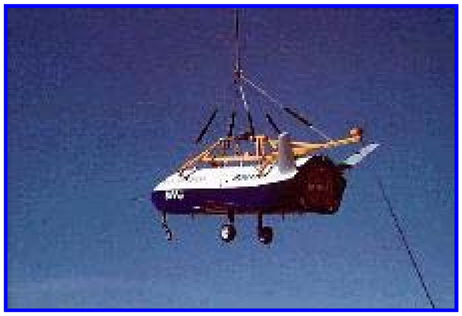
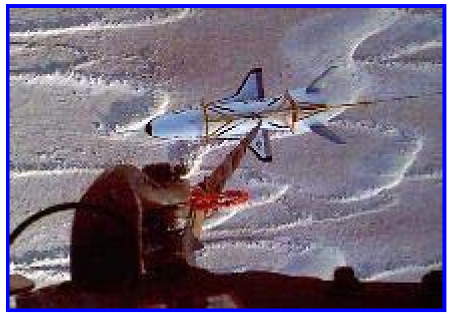
- Up to 1,200 pounds of sensors/payload
- 72-hours or less turnaround time between missions
- Up to 12 month on-orbit mission duration
- Rapid recall from orbit
- Up to 10,000 feet per second on-orbit velocity change for maneuvering

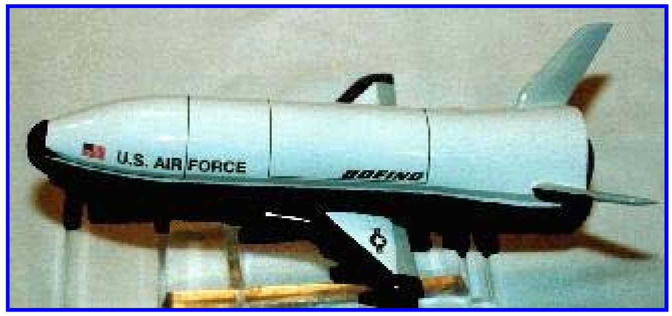
The Space Maneuver Vehicle Program is directed by the Air Force Research Laboratory's Military Spaceplane Technology Office at Kirtland Air Force Base, New Mexico. A three phase program is planned to provide affordable technology and operations demonstrations. The program is presently funded through Phase I. The schedule for Phases II and III depends on additional Air Force funding.

The program is currently conducting ground and flight tests of a 22-foot-long, 2,500-pound, graphite-epoxy and aluminum vehicle. The cost of this vehicle is approximately $1 million for fabrication and construction. In addition, the government has contributed approximately $5 million to the project. The partnership with the Air Force Research Laboratory's Air Vehicles Directorate and has already accomplished:

- A helicopter release of a 90-percent-scale of the SMV to demonstrate autonomous control and landing capability.
- The design and construction of a full-scale SMV center fuselage and wing carry-through box that successfully passed its structural tests.

The Space Maneuver Vehicle completed a successful autonomous approach and landing on its first flight teston 11 August 1998. The unmanned vehicle was dropped from an Army UH-60 Black Hawk helicopter at an altitude of 9,000 feet above the ground, performed a controlled approach and landed successfully on the runway. The total flight time was 1-1/2 minutes. During the initial portion of the its free fall, the maneuver vehicle was stabilized by a parachute. After it is released from the parachute, the vehicle accelerated and perform a controlled glide. This glide simulated the final approach and landing phases of such a vehicle returning from orbit. The vehicle, which landed under its own power, used an integrated Navstar Global Positioning Satellite and inertial guidance system to touch down on a hard surface runway. The 90 percent-scale vehicle was built by Boeing Phantom Works, Seal Beach CA, under a partnership between Air Force Research Laboratory Space Vehicles Directorate at Kirtland Air Force Base NM and the Air Vehicles Directorate at Wright-Patterson Air Force Base OH.

The structural test article program is proving out and failure-testing composite building materials needed for the spaceplane development. A full-scale vehicle center fuselage and wing carry-through box is being built and will be tested to evaluate the composite materials.

Future phases will depend on Air Force guidance and availability of funds. Subsequent phases are currently being planned, but are not funded. They involve initial capability technology demonstrations leading to expanded operations. If the technology program is successful, a full operational capability would eventually be fielded.

Resources

- Statement of Operational Objectives
- Systems Requirements Document
- MILITARY SPACEPLANE INTEGRATED TECHNOLOGY TESTBED (MSPITT) Commerce Business Daily: February 21, 1997
- Briefing For Industry (BFI)
- MSP ITT BFI QUESTIONS AND ANSWERS 11 MARCH 97
- Launch on Demand Impact [LODI] Study - June 1998

- The Need for a Dedicated Space Vehicle for Defensive Counterspace Operations David D. Thompson; Edward F. Greer (Faculty Advisor) *Air Command and Staff College* 1998 -- This vehicle should be ground-stationed, reusable, and prepared to launch into earth orbit in time of heightened tensions or war to carry out the defensive counterspace mission.
- Man's Place in Spaceplane Flight Operations: Cockpit, Cargo Bay, or Control Room? David M. Tobin; Mikael S. Beno (Faculty Advisor) *Air Command and Staff College* 1998 -- The proper place for humans in military Spaceplane flight operations is always in the control room, sometimes in the cargo bay, but possibly never in a traditional cockpit environment.
- Access to Space: Routine, Responsive and Flexible: Implications for an Expeditionary Force Dewey Parker; Edward F. Greer (Faculty Advisor) *Air Command and Staff College* 1999 -- The near-future advent of Reusable Launch Vehicles and their implications for an Expeditionary Air Force as an illustration of how future Joint Force Commanders may effectively bring aerospace power to bear in the battlespace as a combined, synergistic whole.

Other Sources

- Phillips Laboratory Contracting
- NASA's RLV Technology Program
- Aerospike Nozzle Engines

- **Spacecast 2020** - Spacelift: Suborbital, Earth to Orbit and On-Orbit
- **Air Force 2025** Spacelift 2025 The Supporting Pillar for Space Superiority
- **Air Force 2025** A Hypersonic Attack Platform: The S3 Concept
- **Air Force 2025** Space Operations: Through The Looking Glass (Global Area Strike System)

- X-Prize Society sponsors a competitive prize rewarding advancement in low-cost human spaceflight for the public. The X PRIZE will stimulate the development of commercial space tourism by awarding a US $10,000,000 cash purse to the first private team to build and fly a reusable spaceship capable of carrying three individuals on a sub-orbital flight.

- Advent Launch Services Space Flight Booster Society
- Black Horse is a proposed design for a single stage to orbit, reusable launch vehicle. The primary investigator for the Black Horse was Mitchell Burnside Clapp.
- Eclipse - Kelly Space & Technology
- Delta Clipper
- Kistler Reusable Rocketships
- Pioneer Rocketplane - a new company dedicated to revolutionizing aviation and space launch.
- ROTON - HMX, Inc.
- SKYLON - Reaction Engines Ltd. addresses the technical deficiencies encountered in the original HOTOL vehicle

Some other novel launchers

- Scorpius - Microcosm, Inc.
- Pac Astro's PA-X
- GreenSpace and other projects of William Mook Jr.

News

- Phillips Lab, Boeing roll out Space Maneuver Vehicle Released: Sep 3, 1997 - The Space Maneuver Vehicle Program ties into another larger program called the Military Spaceplane Program.
- Microcosm, Inc. *Scorpius* MINIMUM COST DESIGN EXPENDABLE LAUNCH VEHICLE TECHNOLOGY - January 26, 1998
- X-33 Space plane ventures closerBy 1st Lt. Chris Hemrick Air Force Flight Test Center Public Affairs Leading Edge February '98
- X-33 PROGRESS 03-Nov-97 THE REPLACEMENT FOR THE U-S SPACE SHUTTLE HAS CLEARED A MAJOR DESIGN HURDLE

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http://www.fas.org/spp/military/program/launch/msp.htm
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