N93-22086

3.3 Single Stage to Orbit/SDIO – James R. French, Strategic Defense Initiative Organization

This paper included a discussion of the United States' need for a launch system that demonstrates both high capacity and low cost. Current systems, which typically require two years' lead time to provide on-orbit service to space platforms, are too inflexible for many missions. A system is needed that is able to operate in much the same way as existing commercial aircraft. The SSTO program is focused on satisfying aircraft-like operations and logistics support requirements such as engine-out intact abort capability and seven-day, 350-man-day vehicle turnaround times.

The SSTO program underway by the Strategic Defense Initiative Organization has the following objectives:

- To unite today's advanced aeronautics and space technologies developed by the government and industry for NASP and other relevant applications

- To demonstrate an alternative U.S. launch system with the potential for weekly or daily scheduling and low operational costs

- To ensure the capability to meet civil and military space mission needs involving both satellite deployment and personnel transfer

- To design, develop and validate an SSTO launch system for manned and unmanned missions

SDIO's SSTO program is benefiting from previous investments in advanced technologies to aggressively challenge existing limits on vehicle operability, maintainability, reliability and cost. The present program has completed Phase I, which featured competition between Boeing, General Dynamics, McDonnell Douglas and Rockwell International. The initial solicitation allowed industry to consider a wide variety of potential designs such as vertical and horizontal take-off and landing schemes, winged vehicles and ballistic vehicles. Phase I demonstrated that multiple SSTO concepts using all-rocket propulsion appear feasible.

The SSTO program is now proceeding into Phase II with the fabrication and flight test of a subscale "X" rocket demonstration vehicle using the ballistic vertical take-off, vertical landing design developed by McDonnell Douglas Space Systems Corporation (MDSSC). In parallel, SDIO and MDSSC will define a full-scale "Y" rocket. Based upon the results of Phase II, which is scheduled to extend through FY 1993, the SDIO will decide upon proceeding with Phase III and the fabrication and flight testing of the "Y" experimental prototype.

The SSTO program, which is predicated on full reusability, is using a streamlined set of mission-oriented contract specifications. Key performance parameters, such as the ability to take 10 klb. to polar orbit, or 20 klb. to a lower inclination orbit, would allow SSTO to handle 60-80% of U.S. payloads. The SSTO vehicle is also intended to ultimately satisfy requirements for improved operability and man-rateable levels of safety. The "Y" vehicle will include a cockpit and crew compartment for use on manned missions, but a crew is not necessary and the SSTO vehicle will be able to operate unmanned. In fact, the cockpit and crew compartment could be removed for unmanned missions although the advantage of greater payload capacity would be offset by the added complexity of recertifying the vehicle for manned flight following the reinstallation of the cockpit and crew compartment.

The SSTO vehicle will carry its payload amidships. This offers the important advantage of minimizing the impact of payload mass and mass distribution on the vehicle's center of gravity, and it also provides operational advantages in preparing for launch on short notice as well as minimizing the change in vehicle flight performance after the payload is delivered to orbit.

The McDonnell Douglas operations concept includes vertical take-off, up to four days of on-orbit operations, a nose-forward reentry with a crossrange capability of 1640 km, and a nose-up vertical landing following a pitch-up maneuver at an altitude of 10,000 feet. The SSTO office is aware of the many technical challenges that they must overcome to make this concept a reality. For example:

- Special care is necessary to control propellant positioning in the tanks and lines during the pitch-up maneuver prior to landing.
- Weight growth is critical because the viability of all SSTO designs is closely tied to propellant mass fraction and, hence, vehicle weight. Langley Research Center reviewed the current baseline design for the SSTO and provided important feedback to SDIO. In particular, LaRC suggested that vehicle inert weight, which was at that point estimated to be 80 klb. and has since increased to about 100 klb., might grow to as much as 150 klb.
- Engine performance is also extremely important. The existing program includes two LO_2 / LH_2 engine design options for eventual use in the "Y" vehicle: a modular aerospike engine, and a cluster of new high-performance bell engines. The much smaller "X" vehicle will use four RL-10's modified for sea-level start and throttling.

Three materials and structures issues are evident:

- Thermal Protection System. A thermal protection system is needed which demonstrates elevated temperature limits, minimum weight, resistance to impact by bird strikes, minimal or no coating requirements, and no moisture absorbancy. Absorption of moisture is impermissible because of its effect on performance and vehicle weight. If a coating is required, it should last for at least five-to-10+ flights to lessen its impact on operations and turnaround time.
- Cryogenic Tankage. Cryogenic tanks must be easy to fabricate and operate leak-free for many thermal cycles. The ability to conduct reliable and meaningful inspections of tanks between flights becomes a very important and difficult challenge, especially for wrapped tanks.
- Structure. Vehicle structures must provide adequate rigidity, strength, and vibration damping with minimum weight. They must also be compatible with effective joining techniques and resist all types of mechanical failure, including fatigue, for the number of cycles the structure will undergo during the total vehicle lifetime.

SSTO

SINGLE STAGE TO ORBIT (SSTO) PROGRAM

PRESENTED BY:
MR. J.R. FRENCH

BACKGROUND

- LAUNCH CAPACITY VS CAPABILITY
  - NUMEROUS BOTTLENECKS IN INTEGRATION AND OPERATIONS
  - SCHEDULES OFTEN PERTURBED BY LAUNCH DELAYS
  - COMMERCIAL USERS DISCOURAGED BY LACK OF SCHEDULE ASSURANCE
  - LAUNCH RATE LESS THAN ONE-THIRD OF THE USSR
- U.S. SPACE LAUNCH IS HIGH COST
  - LARGE STANDING-ARMIES REQUIRED FOR LAUNCH SUPPORT
  - CUSTOM BUILT SINGLE EVENT SYSTEMS (DISPOSABLE/PARTLY REUSABLE)
- U.S. SPACE SYSTEMS LACK MARGIN
  - LAUNCHES HELD UP BY WEATHER (RAIN, COLD, WINDS ALOFT, CLOUDS)
  - PAYLOADS HAMPERED BY LACK OF GROWTH POTENTIAL
  - NO SLACK IN TURNAROUND TIME
  - TRAFFIC LIMITATIONS - #LAUNCHES/YEAR

SDIO SSTO OBJECTIVES

- BRING TOGETHER TODAY'S TECHNOLOGIES
  - NASP AND SDIO MATERIALS AND STRUCTURES
  - BITE AND OTHER AIRCRAFT TECHNOLOGIES
  - COMMERCIAL PRODUCTION AND DESIGN ADVANCEMENTS
- DEMONSTRATE A U.S. LAUNCH SYSTEM ALTERNATIVE
  - HIGH CAPACITY (WEEKLY/DAILY SCHEDULE)
  - LOW COST ASSURED ACCESS TO SPACE
- ENSURE A WIDE VARIETY OF POTENTIAL APPLICATIONS
  - SDS DEPLOYMENT (GPALS)
  - SPACE EXPLORATION INITIATIVE (SEI)
  - PERSONNEL TRANSPORT
  - ON-ORBIT SERVICING AND REPAIR
- DESIGN, DEVELOP, AND VALIDATE MANNABLE SSTO LAUNCH SYSTEM

DESIGN GOALS

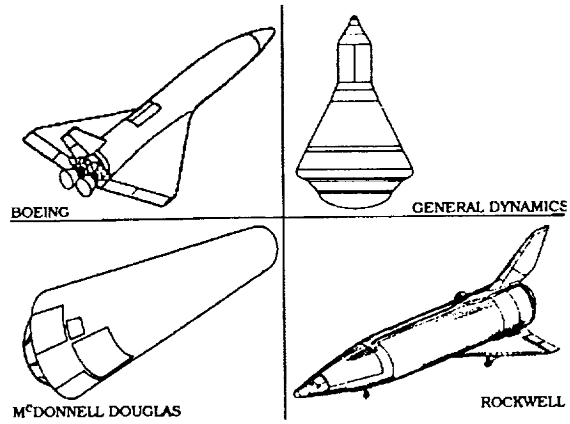
- AIRCRAFT LIKE OPERATIONS AND LOGISTICS SUPPORT
  - ENGINE OUT INTACT ABORT CAPABILITY
  - 7-DAY, 350 MAN-DAY TURNAROUND
- 10,000 POUNDS TO POLAR ORBIT
- 600 FT/SEC ON-ORBIT ΔV FOR MANEUVER
- MANNED OR UNMANNED

SDIO SSTO PROGRAM MANAGEMENT STRATEGY

- USE RAPID PROGRAM PHILOSOPHY (DELTA 180, 181, & DELTA STAR)
  - SMALL TECHNOLOGY COMPETENT GOVERNMENT TEAM
    - SDIO, NASA, AF SPACECOM, SSD, NASP ASTRONAUTICS LAB
    - TASK/ON-CALL MODELING/SIMULATION FOR THE GOVT TEAM
  - SHORT SINGLE LINE OF AUTHORITY
  - MINIMIZE MICROMANAGEMENT -- GIVE THE CONTRACTORS ROOM TO BE INNOVATIVE
  - USE APPLIED TECHNOLOGY WISELY; AVOID TECHNOLOGY DEVELOPMENT PROGRAMS
  - DO NOT OVER ENGINEER THE CONCEPT; DO NOT OPTIMIZE TO DEATH
- DEMONSTRATOR/PROTOTYPE APPROACH
  - SHOW THAT SSTO IS AN ENGINEERING PROBLEM NOT A TECHNOLOGY QUESTION
  - BUILD AND FLY VEHICLE NOT EXCESS PAPER
  - USE TEST BUILDING BLOCK APPROACH
    - SUBORBITAL DEMO SHOWS AIRCRAFT OPERABILITY IN THE FLEET MODE
    - GET HARD DATA NOT ESTIMATES OR ENGINEERING JUDGEMENTS

PHASE ONE COMPLETED

- FOUR CONTRACTORS
  - — BOEING
  - — GENERAL DYNAMICS
  - — M[c]DONNELL DOUGLAS
  - — ROCKWELL
- CONCEPT DEFINITION
  - — CONCEPT EVALUATION/ SELECTION
  - — CONCEPT REFINEMENT AND RISK REDUCTION



PHASE ONE RESULTS

- VEHICLE CONCEPT DEFINITION & EVALUATION
  - BASIC CONCEPTUAL DESIGN
  - TURNAROUND APPROACH DEFINED AND ANALYZED
  - EARLY RISK REDUCTION DEMONSTRATIONS
  - DEFINE APPLICABLE TECHNOLOGIES
- PROGRAM EVALUATION
  - PROGRAM PLAN & SCHEDULE DEFINED
  - EMPHASIZE LOW COST
  - IDENTIFY INFRASTRUCTURE REQUIREMENTS

PHASE TWO

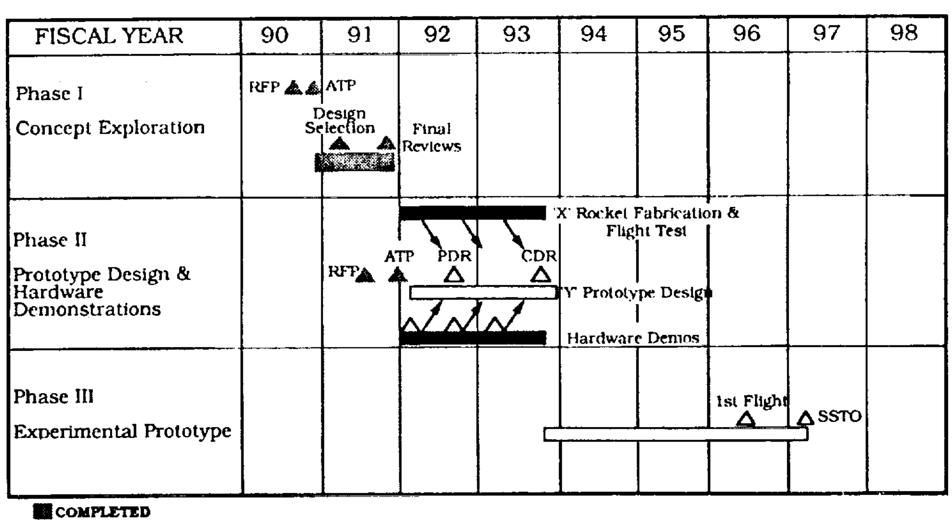
- TWO TRACK APPROACH
  - PROTOTYPE VEHICLE DESIGN TO "CDR", LATE FY 93
  - PARALLEL TECHNOLOGY/HARDWARE DEMOS LEADING TO SUBORBITAL FLIGHT IN '95
- COMPETITION FOR PHASE TWO CARRIED OUT MAY THRU AUGUST '91
  - THREE BIDDER TEAMS
  - MDSSC - LED TEAM SELECTED

THE MDSSC DELTA CLIPPER CONCEPT

MAJOR MATERIALS AND STRUCTURES TECHNICAL ISSUES

- THERMAL PROTECTION SYSTEM
  - TEMPERATURE LIMIT
  - MINIMUM WEIGHT
  - NO MOISTURE ABSORBENCY
  - IMPACT RESISTANT
  - NO (OR MINIMAL) COATING
- CRYOGENIC TANKAGE
  - CYCLE LIFE
  - LEAK FREE (COMPOSITE)
  - FABRICABILITY
- STRUCTURE
  - MINIMUM WEIGHT
  - RIGIDITY
  - VIBRATION DAMPING
  - FABRICATION / JOINING TECHNIQUES
  - FATIGUE / CYCLE LIFE

SCHEDULE



3.4 National Aero-Space Plane (NASP) Airframe Structures and Materials Overview – Terence Ronald, NASP Joint Project Office (JPO)[1]

Terence Ronald presented an overview of the NASP airframe structures and materials. Due to International Traffic in Arms Regulation (ITAR) restrictions, this presentation has not been reproduced for this publication.

[1]Speaking on behalf of J. Arrington, who was unable to attend.