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Paper Session I-A - Shuttle-C Heavy-Lift Vehicle of the 90's

Robert G. Eudy
Manager, Shuttle-C Task Team, Marshall Space Flight Center

SHUTTLE-C
HEAVY-LIFT VEHICLE OF THE 90'S

Mr. Robert G. Eudy, Manager
Shuttle-C Task Team
Marshall Space Flight Center

ABSTRACT

United States current and planned space activities identify the need for increased payload capacity and unmanned flight to complement the existing Shuttle.

To meet this challenge the National Aeronautics and Space Administration is defining an unmanned cargo version of the Shuttle that can give the nation early heavy-lift capability. Called Shuttle-C, this unmanned vehicle is a natural, low-cost evolution of the current Space Shuttle that can be flying 100,000 to 170,000 pound payloads by late 1994.

At the core of Shuttle-C design philosophy is the principle of evolvement from the United State's Space Transportation System. This will mimimize costs by taking every advantage of existing designs, hardware production capabilities, operations resources, and logistics support as well as major flight elements including the solid rocket boosters, external propellant tank and orbiter liquid rocket engines.

The only new element of the Shuttle-C, the payload carrier will be cylindrical with a payload bay 15 feet in diameter (same as the Shuttle) and 82 feet long (more than a third longer than the Shuttle).

The Shuttle-C, using state-of-the-art technologies and existing infrastructure, offers several distinct advantages to future space operations. It would complement the manned Shuttle and provide growth to support new space initiatives; serve as a test bed for new and modified systems; and deliver large outfitted space modules and planetary payloads far in excess of the United States current capability - size and weight. Shuttle-C would also provide design options for payloads planned for manifesting on smaller and more constraining vehicles. The robust performance provided by the Shuttle-C would enhance missions through extended observation times, flexibility, expansion of scientific targets, and additional margins in payload design.

Shuttle-C offers a flexible, reliable, and cost efficient heavy-lift cargo vehicle complementing the United States' existing fleet of Shuttles and expendable launch vehicles. Its flexibility, reliability and cost advantage will provide users with capabilities considered essential to effective space operations in the 1990's.

INTRODUCTION

Shuttle-C can promptly answer the call issued by the Congress, NASA Advisory Committees, and American people, for the United States to reassert its leadership in space. It will also meet the nation's need for increased payload capacity and unmanned operations to complement the Space Shuttle system, as identified by the United States current and planned space activities. It is an appropriate international competitor and restores to the United States a capability it has not had since the Saturn program ended almost 20 years ago. Because it uses existing systems and facilities, it can be ready for launch in 1994 with a new start in FY91. Without Shuttle-C, the nation will have no heavy lift capability for a least another decade.

Shuttle-C is not a "new" program and thus allows for minimum DDT&E costs. It is an unmanned derivative of the STS; one that will restore a capability which the United States has lacked since the Saturn program ended almost 20 years ago.

At the core of the Shuttle-C design philosophy is the principle of enhancing the Space Transportation System. This will hold down costs by taking maximum advantage of existing designs and facilities and will extend the life of the current Space Shuttle fleet.

In itself the Space Shuttle is a heavy-lift launch vehicle placing more than 230,000 pounds in low Earth orbit on each mission. Much of that mass, though, is wings, heat shield, crew compartment, and other components needed to return the crew and cargo. The current Space Shuttle can deliver about 39,500 pounds of payload to the Space Station orbit (220 nautical miles high). However, many Shuttle payloads do not require a crew, and national launch demands are expected to exceed the lift capability of the Shuttle and other launch vehicles through the end of the century.

Payload capability for the Shuttle-C to Space Station ranges from a minimum of about 100,000 pounds for the basic version with two Main Engines to 170,000 pounds with three Main Engines and the Advanced Solid Rocket Motor (ASRM) planned by NASA. The configuration used depends on the mission requirements.

The basic idea behind Shuttle-C is not new. NASA's original Space Shuttle studies in the early 1970s considered an unmanned second stage for large payloads as a complement to the manned orbiter. Various Shuttle enhancements were studied in the mid-1970s, and Shuttle Derived Vehicles (SDVs) were analyzed in the early and mid-1980s. Shuttle-C has emerged as the most promising of these concepts.

At first glance, Shuttle-C looks much like the current "baseline" Shuttle but for the wings. Closer examination shows that the vehicle also has has no crew cabin, and in some configurations has two rather than three main engines.

ADVANTAGES OF SHUTTLE-C

Shuttle-C meshes with the baseline Shuttle design to the greatest extend possible Ground facilities and the Solid Rocket Boosters (SRB) and the External Tank (ET) are used without change. the winged orbiter is replaced by the Shuttle-C Cargo Element (SCE) comprising a payload carrier and an aft fuselage. Unlike the Shuttle, though, the basic Shuttle-C Cargo Element is expendable.

Shuttle-C would enhance the national space launch capability by reducing the number of launches needed to perform a number of high-priority space missions. For example, Shuttle-C can simplify the assembly of the Space Station FREEDOM. A Mars Rover/Sample Return mission can be launched by a single Shuttle-C with a Centaur upper stage instead of two large expendable launchers, each with a Centaur. Shuttle-C/Centaur can also place about 20,000 pounds in geostationary orbit, almost four times the current capability. Other candidate missions are listed at the end of this document. In addition to enhancing planned missions, Shuttle-C can serve as an unmanned test bed for potential Shuttle upgrades like the Space Transportation Main Engine, and the ASRM.

NASA has been studying Shuttle-C with a contractor team made up of the Space Flight Systems Division of UTC Corp., Martin Marietta Aerospace, and Rockwell International. Because it uses existing systems, facilities and management infrastructure, it can be ready for launch in 1994 if a FY91 new start is authorized.

SHUTTLE-C DESIGN

The 70,000- to 80,000-pound Shuttle-c Cargo Elment comprises two major elements, a payload carrier and the aft fuselage (often called the "boattail"). The payload carrier is a cylindrical structure, much like a conventional aircraft fuselage, with a nose cone and payload bay doors. The carrier encloses a bay 15 feet in diameter and 82 feet long, effectively accommodating a payload as wide as and more than a third longer than the baseline Shuttle's payloads. Doors on the back of the SCE allow servicing with the current Rotating Service Structure (RSS) on Launch Complex 39 at Kennedy Space Center.

The spacecraft's liquid propulsion systems are in the aft fuselage which is almost identical to that of the baseline Shuttle. This takes advantage of existing designs for the STS propulsion system and thrust structure which distributes the thrust load from the Main Engines. Although this is an expensive, robust piece of equipment--built to withstand more than 40 launches--its use precludes major costs to design and qualify a new, "cheaper" system.

To guide Shuttle-C to its rendezvous with Space Station or other targets, the Orbital Maneuvering Vehicle (OMV) is attached to the front end of the payload and acts as the "brains" of the spacecraft after insertion into orbit. OMV is being developed as a short-range orbital tug, and is well-suited to this role.

A summary of Shuttle-C's "heritage" from other Shuttle systems include:

MAIN PROPULSION SYSTEM

Shuttle-C uses either two or three Main Engines, depending on payload mass.

REACTION CONTROL SYSTEM

The two large Orbital Maneuvering System (OMS) engines are deleted. Orbital circularization is accomplished by the 870-pound-thrust Reaction Control System (RCS) engines. Four thrusters are deleted from each pod. The duty of the forward RCS system is filled by the OMV. Costs may be reduced further by replacing the titanium tanks with aluminum tanks, the graphite-epoxy structure and composite skin of the OMV pods with aluminum and fiberglass, respectively, and the quad-redundant valves with single valves.

GENERAL PURPOSE COMPUTERS

The baseline Shuttle has five GPCs two pairs each running primary software, and a fifth unit running the backup software. Shuttle-C has a single pair running the primary software plus a third unit running the backup software. These are mounted in a pressurized avionics container in the nose cone.

POWER SYSTEM

The baseline Shuttle uses fuel cells that consume hydrogen and oxygen to produce electricity and water for the crew for more than a week. Shuttle-C is powered by batteries since mission timelines and power demands are less than those of the baseline Shuttle.

AUXILIARY POWER UNITS

The APUs provide hydraulic power to steer and throttle the main engines. Because they are not reused, features related to post-flight servicing are deleted. Shuttle-C flights using only two Main Engines require only two APU's.

OTHER SYSTEM - Life support systems, television and high-rate data systems, crew equipment, and other items are deleted or employed without backups, as appropriate.

A TYPICAL MISSION

In studies to date, Shuttle-C has been developed utilizing a standard mission which will accommodate the majority of potential customers.

If launched 2 to 3 times a year, Shuttle-C can be produced at a steady rate that helps assure low costs. Assembly, integration and launch of Shuttle-C is much like that of the Shuttle today. The payload is installed into the Shuttle-C in the Cargo Element Processing Facility, and the complete cargo element attached to the ET and SRB in the Vehicle Assembly Building.

Launch and ascent are almost identical to the baseline Shuttle. A two-engine Shuttle-C fires for 620 seconds, vs. 520 seconds for the three-engine Shuttle-C and the baseline Shuttle. For missions involving assembly or servicing of large payloads, such as Space Station, the Shuttle-C rendezvous maneuvers are accomplished by the OMV using aft thrusters in the OMS pods and its own thrusters. After deployment of the payload, the Shuttle-C is slowed to place it on a re-entry trajectory over open ocean.

CANDIDATE PAYLOADS

Many payloads have been studied that are possible Shuttle-C customers. A sampling (with possible launch dates) includes:

TRANSPORTATION DEVELOPMENT
Advanced Solid Rocket Motor initial launch (1994), Upgraded Space Shuttle Main Engine (1996), Space Transportation Main Engine (1997), Liquid Rocket Booster (1998); some with TBD payloads.

PLANETARY MISSIONS
Comet Rendezvous/Asteroid Flyby (1994), Cassini (Saturn orbiter/probes, 1996), Mars Roover/Samples Return (1998), Solar Probe (solar surface flyby, 1998), Coment Nucleus Sample Return (1999).

SPACE STATION
Assembly and resupply missions (1995-post 2000)

SPACE SCIENCE AND APPLICATIONS
Advanced X-ray Astrophysics Facility (1995), Earth Observing System polar platform (1996), Space Infrared Telescope Facility (1998), Geostationary Orbit Platform (2000), Mobile Satellite C (2001)

DEPARTMENT OF DEFENSE
Various DOD payloads (1995-post 2000).

SUMMARY

Shuttle-C can promptly answer the call issued by the Congress, NASA Advisory Committees, and American people, for the United States to reassert its leadership in space. It will also meet the nation's need for increased payload capacity and unmanned operations to complement the Space Shuttle system as identified by the United States current and planned space activities. It is an appropriate international competitor and restores to the United States a capability it has not had since the Saturn program ended almost 20 years ago.

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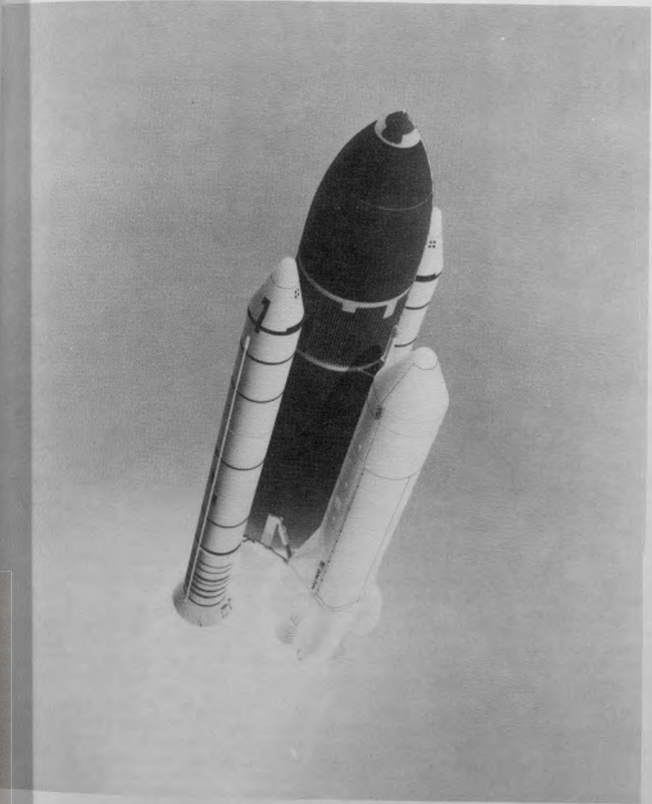

LAUNCH OF BASIC 3 ENGINE SHUTTLE-C