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Paper Session II-C - Pegasus and Taurus Launch Vehicles

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Pegasus

The Pegasus Air-Launched Space Booster is an innovative new space launch vehicle now in full scale development and initial production. Pegasus, developed by a privately-funded joint venture of Orbital Sciences Corporation (OSC) and Hercules Aerospace Company, is a three-stage, solid-propellant, inertially-guided, winged vehicle that is launched from a carrier aircraft at 40,000 ft and Mach .8. This 50 ft long, 41,000 lb vehicle can deliver a payload of 900 lb into a low inclination, 150 nmi Earth orbit. The first two Pegasus flights are sponsored by the Defense Advanced Research Projects Agency (DARPA), with additional missions currently reserved by the U.S. Air Force and commercial customers.

Pegasus was conceived to provide a more flexible and more efficient launch system for small space payloads by taking advantage of the many benefits inherent in the airborne launch approach. The Pegasus system achieves a substantial improvement in payload performance relative to comparable ground-based launch vehicle designs, while also providing numerous advantages in operational flexibility and cost effectiveness.

The flight vehicle, shown in **Figure 1**, consists of three solid-propellant rocket motors, a fixed high-mounted composite delta wing, an aft skirt assembly including three composite fins, an avionics section atop the third stage, and a two-piece composite payload fairing.

Payload performance capability for Pegasus is summarized in **Figure 2**. The polar performance (solid lines) assumes a baseline launch latitude of 36°, and the equatorial performance (dashed lines) assumes an equatorial launch latitude (0°). Pegasus can achieve a complete range of circular and elliptical orbits, both prograde and retrograde through a suitable choice of launch point and launch azimuth. Orbital inclinations from 55° through 110° or better can be obtained from launch points within control of the Western Space and Missile Center (WSMC), inclinations from 20° to 60° or better can be achieved from over water launch points within control of Eastern Space and Missile Center (ESMC). Special arrangements can be made to launch into very low inclinations (O° to 20°) from over water launch points at low latitudes. For a 400 nmi circular, polar orbit injection accuracies are expected to be ±20 nmi deviation in altitude and ±.2 degrees in inclination. Pegasus can also place non-satellite payloads (attached or deployed) into a wide range of ballistic and depressed suborbital trajectories. For such missions, payloads can be as much as 1500 lb or more.

Payload accomodations/services such as fairing volume, mass/cg requirements, environments, mechanical and electrical interfaces, command discretes (including pyrotechnics) and telemetry support and attitude control at separation were extremely important considerations in the design of Pegasus. **Figure 3** shows typical fairing envelope dimensions.

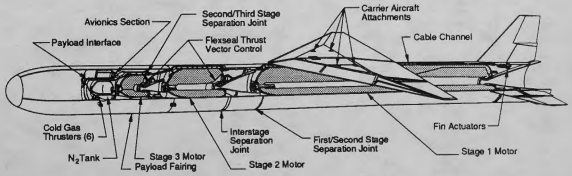


Figure 1. Pegasus Cutaway Drawing

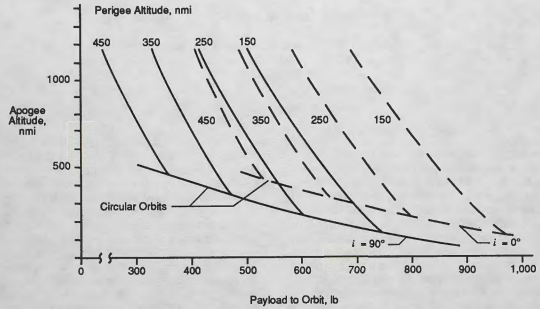


Figure 2. Pegasus Payload Performance

In each of these and related areas, every effort was made to make the Pegasus "user friendly" to a wide variety of spacecraft designs and requirements. Details of these accomodations are presented in the Pegasus Payload Users Guide.

Since the conception of the Pegasus Air-Launched Space Booster in April 1987, OSC, together with Hercules and the Pegasus subcontractor team, has embarked on an aggressive development program focused on fielding an initial launch capability in the shortest time possible without sacrificing any critical safety or reliability objectives. **Table 1** summarizes some of the recent achievements of the Pegasus development program as of January 1990.

The integration and test flights of the flight-equivalent Pegasus vehicle assembled with inert motors verified ground and airborne procedures; qualified the B-52 to Pegasus mechanical and electrical interfaces, and verified range connectivity for telemetry and flight termination systems. Successful completion of these missions occured in January 1990. Plans are to launch DARPA and NASA Goddard payloads on the first Pegasus launch in early March 1990.

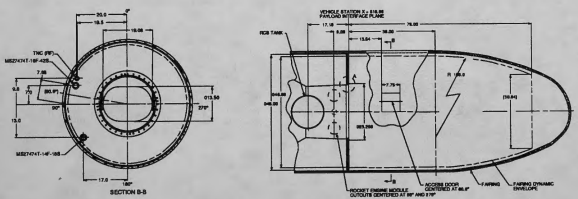


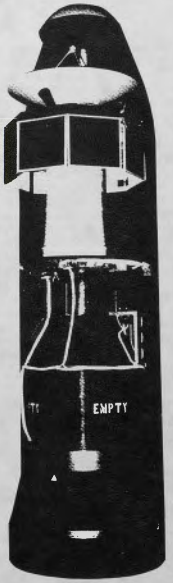
Figure 3. Pegasus Payload Fairing Dimensions (Inches)

Table 1. Recent Pegasus Achievements

Achievement	Date
Preliminary Design Complet	Dec 1987
Motor Cases Hydroproof Complete	Jan 1989
Third Stage Motor Static Firing	Mar 1989
Second Stage Motor Static Firing	May 1989
First Stage Motor Static Firing	Jul 1989
Vehicle Assembly Building Complete	Jul 1989
Inert Vehicle/B-52 Flight #1	Nov 1989
Inert Vehicle/B-52 Flight #2	Dec 1989
Inert Vehicle/B-52 Flight #3	Jan 1990
First Operational Launch Scheduled	Mar 1990

In areas where OSC is developing and introducing innovative new space products such as Pegasus, we have entered into teaming arrangements, joint ventures, and business alliances with major space system suppliers.

OSC, Hercules and Arianespace entered into such an agreement in the summer of 1980 under which Arianespace will exclusively market and sell Pegasus launch services to European customers. We will also be evaluating possible cooperative activities including performance upgrades to Pegasus and establishment of a European base of operations. These agreements have already resulted in the signing of Launch Reservation Agreements with several customers in 1989. For example: OSC and Hercules, Inc. and Arianespace signed an agreement with the Swedish Space Corporation (SSC) for a late 1992 launch of SSC's FREJA scientific satellite. In addition, an agreement was signed whereby Ball Corporation's Aerospace Systems Group will launch two Ball BGS-100 satellites in late 1990 to early 1991. The BGS-100 series of satellite will be launched by the standard Pegasus, whereas are enhanced Pegasus could launch the BGS-400 series. The photo shown at the right is a 16-ft-long, full-scale Pegasus nose fairing - cut in half to exhibit the Ball BGS-100 spacecraft's placment in the Pegasus payload envelope.



Pegasus Nose Shroud Cutaway Shows the New Ball BGS-100 Spacecraft

Taurus

Taurus, being developed by OSC for the DARPA Standard Small Launch Vehicle program, other civil government and commercial applications, is a four-stage, solid-propellant, inertially guided, ground-mobile and ground-launched vehicle. This 90 ft long, 150,000 lb vehicle is capable of delivering 3,600 lb of payload to a low inclination, 150 nmi Earth orbit.

The Taurus system design evolved in early 1989 in response to the DARPA requirements for a Standard Small Launch Vehicle (SSLV). Some specific SSLV requirements included: full launch system ground transportability; launch from a dry concrete pad; launch system set up time of 5 days or less after arrival at the launch site; launch within 72 hours of a command to launch after set up; and launch of a 1000 lb payload into a 400 nmi circular polar orbit from Vandenburg AFB, CA with orbit insertion accuracies of ±20 nmi in attitude and ±.2 degrees in inclination. The Taurus system design will also support reliable and cost effective launch of other DoD, NASA and commercial payloads using less demanding launch site and time requirements. The following paragraphs will describe the Taurus system design and provide a current program status.

The Taurus vehicle configuration is shown in **Figure 4**. Propulsion is based on proven motors currently in production for Peacekeeper (MX) and Pegasus. First stage propulsion will be provided by a Peacekeeper Stage 1 solid rocket motor. This motor is currently in production by Morton Thiokol, Inc. for the Air Force Peacekeeper ballistic missile program, and the Air Force has authorized production and procurement of the motor for SSLV use.

Payload performance for the Taurus vehicle is shown in **Figure 5**. The performance shown is for a vehicle that has no ballast added to limit payload performance to meet DARPA requirements for the SSLV demonstration launch (1,000 lb into a 400 nmi circular-polar orbit and less than 8g's axial acceleration). This vehicle would be able to place approximately 830lb into into a geosynchronous transfer orbit out of the Eastern Test Range (ETR) and 515 lb into a full Molnyia orbit out of the Western Test Range (WTR). Injection accuracies to the 400 nmi circular polar orbit are expected to be better than ±20 nmi in altitude and ±.2 degrees in inclination.

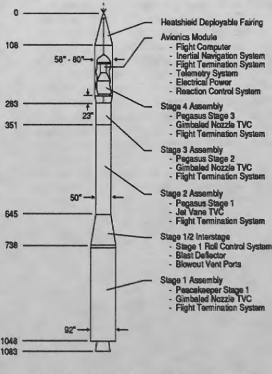


Figure 4. Taurus Vehicle Configuration

Payload accommodations and services provided by the Taurus vehicle will be almost identical to those provided by Pegasus, since the avionics and structures of Stage 4 are the same as Pegasus's Stage 3. One significant difference, is the much larger payload fairing size for Taurus. The fairing for the SSLV demonstration launch is shown in **Figure 6**. OSC is also looking at bulbous fairing designs with internal dynamic envelopes of possibly 65 in.

The DARPA SSLV contract was awarded in July 1989 and the actual demonstration launch date will be established by DARPA in the near future. OSC plans to offer Taurus launches to other customers on a fixed-price launch service basis. A launch would be available 18 months after receipt of an order.

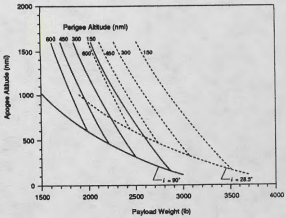


Figure 5. Taurus Payload Performance

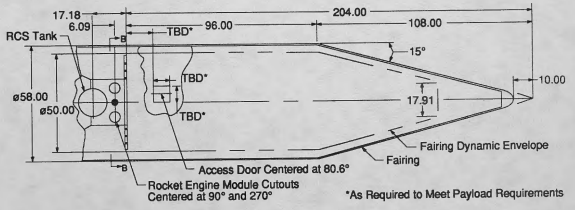


Figure 6. Taurus Payload Fairing Dimensions (Inches)