version. "The changes made to the final flight version will be introduced primarily to improve productivity, for cost reduction, to improve reliability and possibly for weight reduction," he said. "We are not working to improve its performance since the engine is designed for the performance needed by Ariane 5 in its current configuration."

One modification that already has been adopted for the Vulcain is a reinforcement of the lower half of the engine's nozzle. This step was taken after a nozzle collapsed during a component firing test on the P32 test stand at Lampoldhausen.

INCREASE IN ENGINE WEIGHT

The collapse was caused by a flow separation of the exhaust jet from the nozzle's inner wall during the startup/thrust buildup phase. This created high loads on the nozzle. As a result of the problem, a series of ring reinforcements have been added to the lower part of the nozzle.

Addition of the reinforcements adds approximately 20 kg. (44 lb.) to the total engine weight, according to Eury. The weight goal established for Vulcain is 1,475 kg. (3,245 lb.), according to CNES program managers.

Vulcain's nozzle uses the dump cooling method in which hydrogen is circulated through small, downward spiraling tubes. Program officials said the addition of the ring reinforcements will not affect the dump cooling system in the nozzle.

The M1 engine now installed on SEP's PF50 test stand has a short nozzle, which will be replaced by the full-sized nozzle later this year when the full-thrust tests are started.

"We put the small nozzle on M1 since the tests we are performing are of short duration and we do not need to cool the nozzle," Eury said. "In addition, since we are in the early phase of testing the engine startup, we don't want to have problems with the full nozzle."

Engineers said the overall Vulcain program goal is to perform approximately 500 engine runs by the end of 1995. This will involve 18 engines and includes the two qualification flights that are planned for Ariane 5.

Program activity from 1992 onward will focus on optimizing the Vulcain for its final, mature flight version

Ariane 5 is being developed in a multinational effort within the framework of the European Space Agency. The role of overall prime contractor for the vehicle was delegated by ESA to the French CNES national space agency.

More than 30 companies are involved in the Ariane 5 program, including SEP as prime contractor for the Vulcain.

Program engineers described the Vulcain as an engine that uses relatively simple, classic architecture. "The main objective of CNES was to produce a motor at the lowest cost," one engineer explained. "This was the overriding factor throughout the program."

Andre Van Gaver, Ariane 5 program manager at CNES, said the industry's cost target is to produce the fully equipped Vulcain with its nozzle at a cost of about 40 million French francs (about $7.5 million). The launcher's primary application will be to place unmanned spacecraft into geostationary transfer, Sun-synchronous and low Earth orbits. It also is designed to launch Europe's Hermes manned spaceplane.

Guaranteed payload performance into geostationary transfer orbit of 280 × 36,000 km. (174 × 22,370 mi.) inclined 10 deg. has been set at 5,950 kg. (13,090 lb.) for a dual-satellite launch configuration. The payload total for this mission includes the hardware needed for stacking and orbital injection of two satellites. Ariane 5s also will be able to launch triple satellite payloads.

The guaranteed payload performance for Ariane 5 into low Earth orbit of 550 km. (342 mi.) inclined 28.5 deg. is 18,000 kg. (39,600 lb.), while a 10,000-kg. (22,000-lb.) payload is guaranteed for the Sun-synchronous orbit of 800 km. (497 mi.) inclined 98.5 deg.

Ariane 5 has a guaranteed performance of 22,000 kg. (48,400 lb.) for its mission to place the Hermes spaceplane in a 100 × 463-km. (62 × 288-mi.) orbit inclined 28.5 deg.

According to CNES' Van Gaver, the currently calculated performances for Ariane 5 exceeds the guaranteed performance for all four missions.

Alain Souchier, deputy manager for SEP's liquid propulsion technical group, said the Vulcain engine's thrust eventually could be increased by 10-20% without modifying the basic design or hardware significantly. The increase would be accomplished by increasing the operating pressure, and could provide an engine for improved performance Ariane 5s if such an upgraded launcher is needed to meet future market demand. □

Pioneer 10 Passes Beyond 50-AU Distance, Continues Search for End of Heliosphere

SAN FRANCISCO

The Pioneer 10 spacecraft, continuing to record unprecedented achievements during its 18-year journey through space, passed another milestone Sept. 22 when it reached a distance of 50 AU (astronomical units) from the Sun.

At 1:19 p. m. on that day, the spacecraft was 50 times farther from the Sun than the Sun is from the Earth. This, according to noted space scientist and Pioneer experimenter James Van Allen, "has been a goal of physicists for many decades." The AU is the average distance—93 million mi.—between the Sun and the Earth and is the primary measurement unit for the solar system.

Pioneer 10, which originally was expected to have a lifetime of 21 months, already has traveled farther than any man-made object, and on Sept. 22 it was more than 4.6 billion miles from Earth. It was launched Mar. 2, 1972, and escaped the solar system 11 years later on June 13, 1983 (AW&ST June 20, 1983, p. 21).

The spacecraft's major contribution has been to determine that the Sun's heliosphere extends far beyond the orbit of Jupiter rather than ending there as first believed, according to scientists at NASA-Ames Research Center, which manages the program. Pioneer is now almost 10 times beyond Jupiter's orbit and still within the solar heliosphere. The spacecraft continues to be tracked 24 hr. per day at Ames by a team of about 30 NASA and contractor personnel.

In the earlier years of its journey, Pioneer was the first to cross the asteroid belt and fly by Jupiter, returning pictures and data at the cost of a severe radiation dosage from the planet. But the rugged spacecraft, built by TRW's Space and Communications Group, escaped largely unscathed.

It is continuing to seek the boundaries of the heliosphere, as well as search for gravity waves and for evidence of the existence of a 10th planet, or "dark star," whose presence is suggested by irregularities in the orbits of Uranus and Neptune.

Pioneer 10's 8-w. signal has weakened to the point that NASA describes it as "four billionths of a trillionth" of a watt when it reaches NASA's huge Deep Space Network antennas. Round-trip time for radio signals to the spacecraft and back to Earth is 13 hr. 47 min. The spacecraft is traveling at 28,900 mph., and communication with it is expected to continue until the year 2000, when it will be 6.9 billion miles from the Sun. □