Reinventing

In creating the launch vehicles for its Constellation program, NASA planners have envisioned the Ares V as a launcher that will outstrip even the Saturn V in capability and lifting power. But unlike its Saturn predecessor, Ares V will not transport humans, acting instead as a cargo vehicle and a booster for injecting a lunar lander into orbit. The Earth Departure Stage, the Altair lunar lander, and vital supplies for astronauts are among the elements it will carry when NASA returns to the Moon.

What Phil Sumrall remembers about that hot summer nearly a half-century ago is the character of the man he worked for. The young aerospace engineer had just started his career at NASA Marshall in Huntsville, Ala. He was part of the team designing space launch vehicles that were unique for their time, developed from the start for space exploration.

In an era when the operational manned launcher was derived from an Atlas missile, the Saturn I and V were an enormous leap, in both size and capability. The young engineer's boss was a genius at designing rockets, and had a global reputation—in peace and in war. He was Wernher von Braun, and in the late 1950s and early 1960s his very name conjured up visions of space exploration.

One distinguishing feature of von Braun's powerful personality, Sumrall recalls, was his willingness to listen. "He had a remarkable ability to listen to every opinion, even from the more junior engineers," says Sumrall. "He would listen to you if you brought him data; he would hear you out as long as you didn't stray into opinion," he adds.

"He was so bright, so quick, he was fun to present to, and it wouldn't be long before he was way out ahead of you—he'd quickly know more about your subject than you did." Sumrall and his team in the aeroballistics division at Marshall were working on the designs and flight characteristics of the early Saturn vehicles. Von Braun was "the most exciting and dynamic leader that I've ever been around," he recalls.

Ares V and the

heavy lift

Saturn legacy

by Frank Sietzen Jr.
Contributing writer

"He could walk into a room [full] of people that didn't know who he was, and in a few minutes they'd all be gathered around him [as he] held court." Such charismatic figures as von Braun are missing from today's developmental programs, Sumrall says.

Today, Sumrall is manager of Ares Advanced Planning at NASA Marshall, focused on the heavy lift Ares V launcher. There he is part of a design team addressing the large rocket's aerodynamic performance, vehicle designs, and specific requirements during flights supporting Constellation missions. The Ares V is envisioned as a true heavy lift space launch vehicle, meant to surpass even the legendary Saturn V in capability and lifting power.

Early concepts for the new launcher

Despite the effort to carry forward the von Braun team's legacy, NASA has chosen a different path to lunar heavy lift. The Ares V will not transport a human crew but will instead act as both a cargo vehicle and a booster for the eventual injection into a lunar trajectory. In the von Braun era, the Saturn V performed both functions now to be done separately by Ares I and V, having carried both the crewed Apollo command and service module capsule and the lunar module. The third stage of the rocket, powered by a single J-2 rocket engine and carrying the lander stowed beneath the capsule, inserted the stack of stages and modules into a parking Earth orbit. It also provided the restart boost toward the Moon, usually after a single Earth orbit checkout.

For Constellation's missions, the launch architecture was studied by the team in charge of the 2005 Exploration Systems Architecture Study (ESAS). One of the options examined was a large launch vehicle capable of lifting all elements of a lunar landing mission, but it was discarded as too expensive and complex. The team also studied larger versions of today's evolved expendable launch vehicle (EELV) fleet, adding engines, strap-ons, and upper stages to various versions of the Atlas V and Delta IV. But EELV variants were also rejected. In the end, ESAS planners elected to recommend a smaller vehicle for the crew capsule and a bigger launcher for the lander and injection stage. This became known as the "one-and-a-half launch solution."

ESAS drove the requirements for the two launcher designs and commonality of shuttle-derived components. The initial ESAS recom-

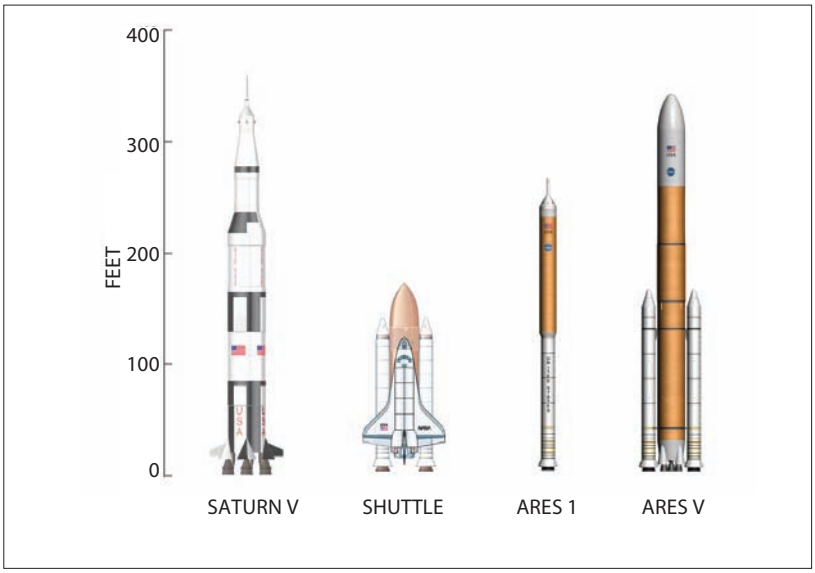
mendation was for development of a heavy lift cargo vehicle (CaLV) using a pair of five-segment strap-on solid rocket booster motors adapted from the four-segment motors used in the shuttle program. The rocket's core would be a stretched and strengthened version of the space shuttle's external fuel tank—but with a major change. ESAS called for a cluster of five space shuttle main engines (SSMEs), also called the RS-25 liquid oxygen/liquid hydrogen engines, to be mounted at the tank's base.

Atop this core stage would be a new cryogenic upper stage called the Earth departure stage (EDS). Weighing 501,000 lbm at launch, the 27.5-ft-diameter, 74.6-ft-long stage would contain two Saturn-derived J-2 engines. The craft would insert itself and the lunar lander into an Earth parking orbit, where original ESAS plans called for it to loiter for up to two weeks awaiting the launch of the smaller Ares I with the crew. Target for the launcher, called by ESAS LV 27.3, was to lift 54.6 metric tons to a translunar injection (TLI), or 124.6 metric tons to an initial parking orbit of 30x160 n.mi. at the 28.5° NASA Kennedy ascent inclination. ESAS also called for use of the remaining EELV fleet for "scientific and ISS cargo missions in the 5-20 metric ton cargo range."

But that is not the launcher Sumrall and the Ares team at Marshall wound up designing.

Modified Ares V design emerges

Follow-up trade studies modified both the launch vehicles selected by ESAS. The size of the core, set by ESAS at the same 27.5-ft diameter as the shuttle fuel tank, was expanded to a 33-ft diameter—ironically the same size as the Saturn V's S-IC first and S-II second stages.



More significantly, the SSMEs were eliminated from both the crew launch vehicle and the cargo launch vehicle, replaced by a single J-2-derived engine in the CLV upper stage and by five RS-68 engines adapted from the Delta IV program clustered in the CaLV's core stage.

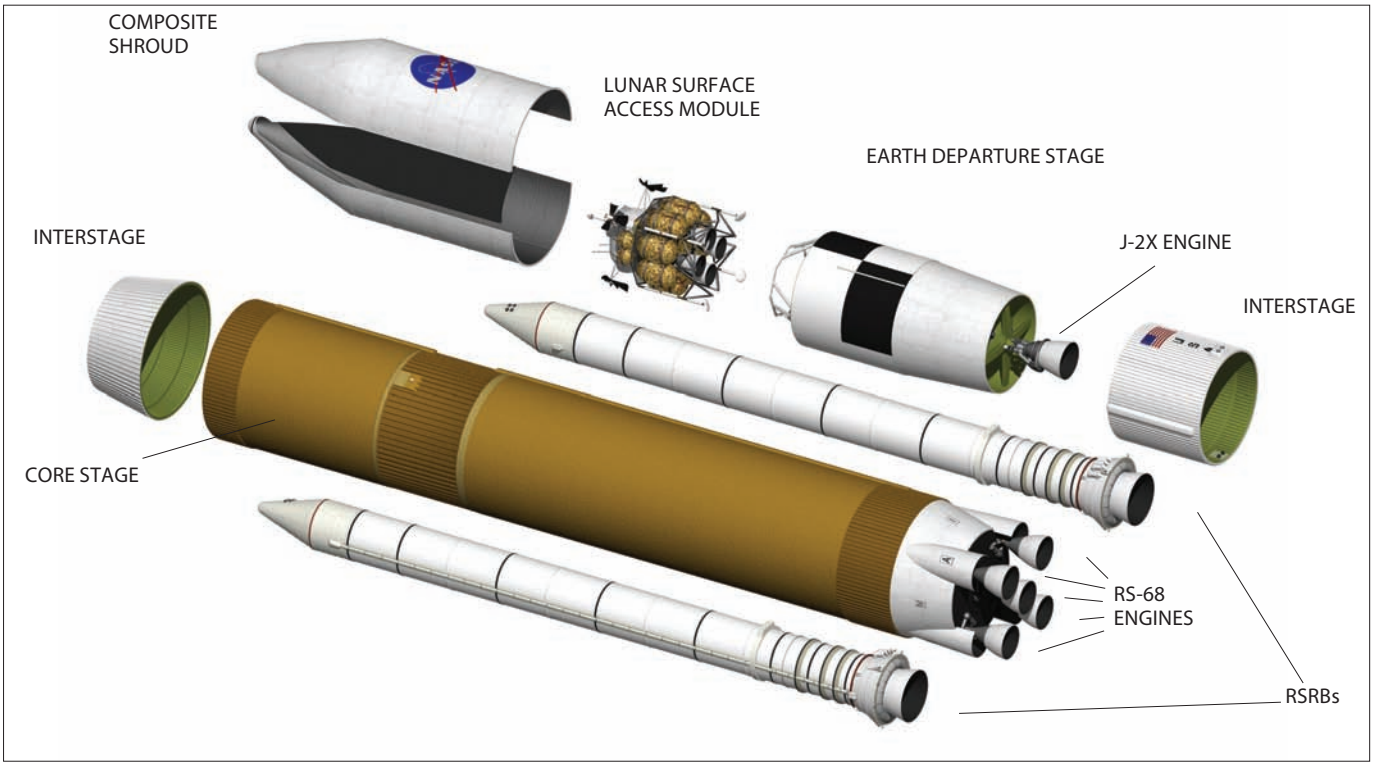
"The EDS was tailored to have more commonality with the CLV second stage," says Steve Cook, manager of the Ares program at Marshall. This resulted in a longer and wider stage that would use only one J-2-derived engine, the J-2X. Ares designers at Marshall also believed that the larger and more powerful cargo rocket, now capable of lifting 200 metric tons to low orbit, would better facilitate the design of even larger versions for future manned interplanetary missions into deep space.

"There are differences [between the Ares I upper stage and the EDS], but we are building as much commonality between the two as possible," says Cook. He points out that unlike the smaller upper stage aboard the Ares I, the EDS must be able to restart its J-2X and send the combined vehicles toward the Moon. "So the J-2X that we'll use will differ because of the restart requirement," Cook explains.

Production and manufacturing of the Ares I upper stage will take place at the NASA Michoud Assembly Facility in New Orleans. While the choice of the manufacturing site for the EDS has not been finalized, building both units at Michoud makes great sense to Ares planners. The Ares V core stage, with its set of RS-68 engines, is also to be manufactured at Michoud. The engine sets, both the J-2X and the RS-68 for the lunar missions, will be tested at nearby Stennis. Cook says the engines will be returned to Michoud after validation test firings and installed on flight hardware. The completed core stages will then be shipped by barge—the same used for the Saturn series rockets in the 1960s and the large shuttle fuel tank ever since—to Kennedy Space Center for assembly into a final launch vehicle.

Atop the Ares V stack will be the largest fairing ever produced for a launcher—and its size has also grown. The fairing will now be the same width as the entire EDS, which is also the same width as the core stage, some 33 ft.

The larger, 10-m-plus fairing accommodates a wider Altair lander, says Sumrall. A bigger lander in turn allows for greater surface mobility and flexibility in carrying the landing craft, plus other heavy payloads that might be attached, such as pressurized rovers or power equipment. The bigger Ares girth accommodates the large lander descent stage as well, since that stage's engine also performs the brak-



ing maneuver into lunar orbit. This is another change from Apollo-Saturn heritage, where the Apollo service module engine did the lunar insertion burn while the lunar module was inert.

Vehicle basics

Sumrall cautions that the full requirements for the Ares V are still being developed. "The baseline [for the vehicle] is incomplete; we're still working on it," he says. Currently, planners envision a 7.4-million-lb gross liftoff weight for the vehicle, about 360 ft tall when assembled. Other basics now assumed include a maximum four-day loiter in Earth parking orbit, 130 n-mi. altitude at insertion, and a 100 n.mi. circular orbit at translunar injection burn, angled 28.5° at the equator.

Although each vehicle will vary for its particular assigned mission, Sumrall says that commonalities between vehicles would include composite dry structures, metallic cryo tankage, the 10-m shroud, and the RS-68 engine cluster burning at 108% of rated thrust at sea level. "We are looking at different configurations as well," Sumrall says, including adding a sixth engine to the cluster at the base of the core stage, or a pair of five-and-a-half-segment booster motors. Another trade study is considering adding an expendable cryogenic stage between the core and the EDS.

In addition, Marshall planners have shifted the launch campaign for lunar missions. Current plans, which may also change, now have the astronaut crew launched first aboard the Orion/Ares I and waiting on average 90 min for the launch of the Ares V with the EDS stage and Altair on board. Sumrall says that if the sequence were reversed for a given mission, the EDS-Altair combination could wait in orbit for an astronaut crew for as long as four days, and longer if possible. Engineers found that a much longer loiter time as originally envisioned in the ESAS review, say two weeks, would have posed problems involving the insulation that keeps the cryogenic liquid oxygen and liquid hydrogen at their supercold state. Total weight of the EDS, lander, and docked Orion at TLI injection is targeted at 74.2-75.1 metric tons.

The number and mission assignments of the early Ares V test launches are still being configured, says Sumrall, but the Ares V systems requirement review is scheduled for 2011, the system design review for 2012, and the preliminary design review for 2013. Ground vibration testing at Marshall using a prototype Ares V core stage would be conducted in 2014 and end in 2015. Detailed trade studies of the integrated vehicle and core stage were conducted between February and July of 2007, with detailed trade studies of the EDS now ongoing and ending this October. First launch of an Ares V test vehicle is planned for the 2018 time frame.

On March 11, 1969, a Saturn V was rolled out from the Vehicle Assembly Building carrying Apollo 10.

Whither heavy lift?

The legacy of the Saturn V casts a long shadow on its Ares successors, not always in a positive light. Sumrall's hopes that the huge vehicle will find uses beyond NASA's Constellation program mirror the optimistic predictions made about the Saturn series a generation ago. Von Braun's team anticipated that NASA and other U.S. government customers would exploit the heavy lifting capabilities of their vehicles for years beyond the Apollo lunar missions.

"These ships will be the workhorses of the space program for decades to come," said one glossy brochure in the early 1970s, published even after the Saturn V assembly line had been shut down in 1969. Not only did the nation fail to use the Saturn's heavy lift and growth capacity fully, it ended the rocket project long before Apollo's final missions—with two built launch vehicles abandoned instead of used. Only one Saturn V was ever used as a heavy lift cargo vehicle, to boost the Skylab space station in 1973—and that launcher was diverted from canceled Apollo plans. NASA had constructed launching pads and assembly buildings in Florida to accommodate dozens, if not hundreds, of Saturn launches.

But space supporters found that the U.S. presidents who followed John F. Kennedy and Lyndon Johnson had little use for big expendable boosters. Like the launchers themselves, the billions invested in their capabilities came to a dead end. If the present-day Ares V is to survive the budget squeeze long enough to establish its capabilities in civil and national security space launch, Sumrall's team must hope for political stability, with budgets to match. That may prove to be a more complex undertaking than building and launching the big rockets themselves.