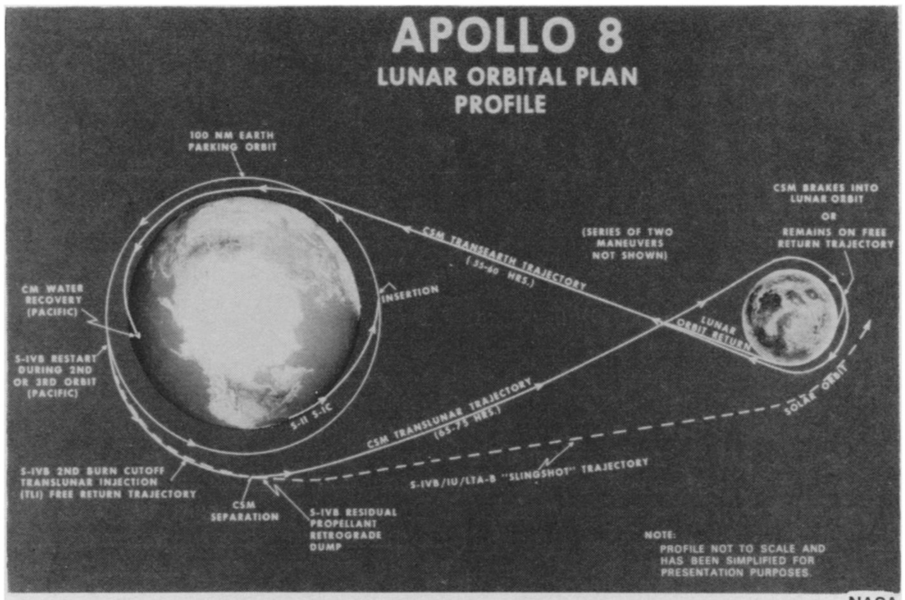
Apollo 8: Options on the way

The pioneering flight to the moon is studded with escape points



NASA

The moon for Christmas could be the story of Apollo 8's figure-eight mission.

Beginning with Alan B. Shepard Jr.'s sub-orbital ride on May 5, 1961, the six manned Mercury missions came, on the average, every four months. The Gemini program cut that interval in half, with 10 of the two-man flights in a 20-month span.

The Apollo program's managers have paced it to proceed at about the same rate. The result is that just two months after the end of the successful first manned Apollo flight, and with a year still available to reach President John F. Kennedy's goal of putting men on the moon in this decade, three astronauts are ready to fly this Saturday to within 70 miles of the lunar surface, and start for home Christmas morning.

Apollo 8 Astronauts Frank Borman, James A. Lovell Jr. and William A. Anders will be the first men to ride the powerful Saturn 5 rocket, which will also provide the push for the moon landing mission. Until last April, space officials were not sure that they wanted a crew to go along on Apollo 8. On April 4, however, the second unmanned flight of the Saturn 5 proved to be such a success that it was decided to entrust astronauts to the mighty booster. This also moved the scheduled lunar landing up from Apollo 12 to Apollo 11, which could put men on the moon as early as next summer.

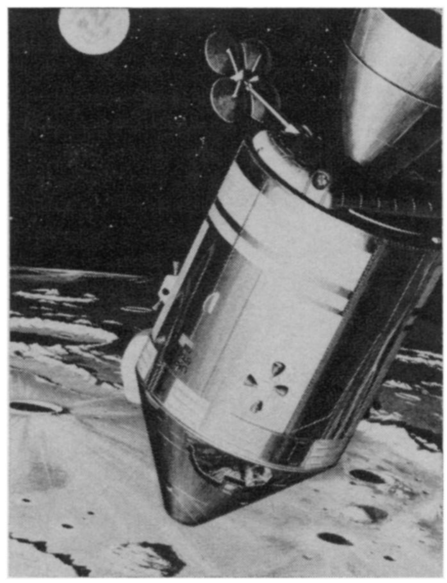
The Apollo 8 plan is for the astronauts to fly as many as 10 orbits around the moon before heading home, rather than just swinging around the moon's far side in a great arc, as did two unmanned Soviet spacecraft.

The major difference between the two missions is that, in a swing-around, the spacecraft would pass behind the moon and return to earth almost automatically. The more complicated flight requires the astronauts to commit themselves to a lunar orbit by firing their spacecraft's engine to slow down and be captured by the moon's gravity. Getting back to earth then depends on firing the engine again to break free of the moon.

If that single rocket firing fails to take place, there is no escape. The astronauts will be stranded, circling the moon, to die within 14-plus days from lack of oxygen. Though most of Apollo's critical components have one, two or even three backup systems in case the main one fails, the combustion chamber and propellant injector of Apollo's vital Service Propulsion System engine are each one of a kind.

These factors, plus memories of the overconfidence and carelessness that led to the Apollo fire almost two years ago, have caused some concern that the space agency may be pushing too fast in its enthusiasm to reach the moon first. But NASA officials insist that they have thought long and hard about the risks involved, and are not moving out of cockiness or ignorance.

The SPS engine, for instance, has been designed as simply as possible, to minimize chances for malfunction. Its propellants are hypergolic—they react together on contact, without the need for an ignition system. The valves controlling the propellant flow are operated by separate, self-contained tanks of compressed gas, so that they are independent of changes in the propellant supply pressure. In addition, each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Astronauts look down, SPS engine up.

valve has three backups, arranged to control the flow even if the main valve should become permanently stuck, either open or closed. It has fired successfully on Apollo 4 (to build up reentry speed for a heat shield test), Apollo 6 (to change the spacecraft's orbit) and the manned Apollo 7, as well as almost 3,200 times on the ground.

In addition, Apollo 8's flight plan is the most flexible the space agency has ever designed. To cover virtually every conceivable contingency, there are nine so-called abort modes, points at which to cut the mission short if something goes wrong; 16 go/no-go decision points when ground controllers or the astronauts themselves can elect not to take the next step, such as locking into the lunar orbit, and six complete alternate missions, ranging from the lunar swing-around down to a low orbit around the earth. These are already completely computed and planned for, as thoroughly as if each were the primary goal of the flight.

The earliest that Apollo 8 could be launched, due to variables ranging from lighting on the moon to the inadvisability of hitting Cuba with falling rocket stages (SN: 12/7, p. 569), is 7:51 Saturday morning, Dec. 21. There are two opportunities a day to launch the spacecraft, through Dec. 27. If difficulties hold things up past that date, the flight will have to wait until the next launch window opens, from Jan. 18 to Jan. 24.

Slightly more than eight seconds after ignition, the first stage of the Saturn 5 booster will reach its full thrust of 7.5 million pounds, and lift the 363-foot-high stack of rockets and spacecraft on its way. About two and a half minutes later, the first stage will fall away and the second stage will take over, only to drop away itself after another six minutes. Then the S-4B third stage will ignite for the first time to push the spacecraft into a circular parking orbit, 119 miles above the earth.

For the next two and a half hours, the astronauts and controllers on the ground at the Manned Spacecraft Center in Houston will check over the spacecraft and its numerous subsystems to make sure it is ready for the big step. During the second or third earth orbit, if all is well, the third stage will fire again, to accelerate the spacecraft to more than 24,000 miles per hour, pushing it out of earth orbit toward the moon.

If the burn is successful, the spent third stage will be separated from the spacecraft shortly after injection onto the path to the moon. As the astronauts move to about 50 feet from the rocket, protective panels on the booster's forward end will be kicked away by springs and explosive charges, revealing the dummy lunar module that was decided on for Apollo 8 last August to replace the trouble-ridden real LM. The LM's first manned flight will be Apollo 9, possibly in late February.

The Apollo 8 astronauts will practice, with the dummy, the docking maneuver they will need for the lunar landing mission, when the LM, returning from the lunar surface, will have to meet and couple with the command and service modules waiting in orbit around the moon.

After that, the remaining propellant in the free-floating rocket stage will be jettisoned to give the booster a kick into an orbit around the sun, while the spacecraft continues on toward the moon. During the outbound voyage, four small bursts of the spacecraft's engines are scheduled to make small changes in speed and direction. If by the last one a change of more than about seven miles per hour is still necessary, the correction will not be made; instead, the astronauts will simply let their spacecraft swing around the moon and head back to earth, without trying for a lunar orbit.

If speed and trajectory are as planned, however, the biggest decision of the mission will be at hand. To make matters more difficult, Apollo 8 will have been behind the moon, out of radio contact with earth, for more than 10 minutes when its SPS engine must fire to put it into lunar orbit. So the decision to go or not must be made before then.

Once Apollo is in orbit, the SPS engine will be fired again to lower the orbit into a circle some 69 miles above the surface. Then, on Christmas Eve, if there is a Dec. 21 launch, the astronauts will get down to their research tasks.

The main goal is to photograph the planned Apollo landing site—in black and white and color, still and motion pictures, and two and three dimensions —to aid the lunar landing crew in judging the terrain and learning local landmarks. Other tasks include photographing broader areas of the moon, zodiacal light along the plane of the ecliptic and the star field (to study fogging of the spacecraft window due to outgassing of seals and other materials). Live television pictures of the moon, the earth, the spacecraft and the astronauts themselves will be transmitted to earth from lunar orbit.

Then comes the SPS engine's critical burn. On the tenth revolution around the moon, after 19 hours and 52 minutes in orbit, the engine will be fired for 206 seconds. Again, the firing will take place on the moon's far side, leaving half-frantic ground controllers out of touch with the spacecraft for more than half an hour before they find out if the astronauts are on their way home.

The trip back to earth should be fairly uneventful, and certainly anticlimatic. Reentry will be the fastest ever for a manned spacecraft—almost 24,700 miles per hour—but the unmanned Apollo 4 spacecraft proved that the heat shield could take the beating when it reentered at more than 24,800 mph.

Apollo 9, the first manned flight with a working lunar module, will be confined to earth orbit—the LM has been too troublesome to risk sending it to the moon so soon. Apollo 10 will take a LM to the moon, but not to land. Instead, Astronaut Eugene Cernan will fly the spidery module down to about 10 miles above the lunar surface for some close-in reconnaissance.

And then, Apollo 11, men on the moon, still sometime in this decade.

SINGLET OXYGEN

Light on radiation damage

Oak Ridge National Laboratory

Radiation breaks chromosomes

Scientists have known that radiation damages all living things since shortly after Wilhelm Roentgen discovered X-rays in 1895, but they have been unable to find protection or remedy. With the advent of medical uses of X-rays for diagnosis and treatment and the development of nuclear weaponry and nuclear power came intensified efforts to solve the problem—efforts resulting in drugs that protect animals from radiation if they are dosed before exposure and treatment for human beings exposed to limited amounts.

But there are no proven drugs to protect men from nuclear fallout or industrial radiation accidents and none to cure them after total body exposure to large quantities: 400 roentgens (units of radiation) or more.

Radiation is most dangerous to animal life when it hits the whole body. One of its first effects is damage to blood-cell-producing bone marrow. If even a few marrow cells escape injury, they can repopulate the blood, markedly minimizing the threat of radiation sickness.

There has been no real understanding of how radiation destroys cells, making it all the more difficult for scientists to plan rational ways of blocking the destruction.

Now, a finding that radiation-excited oxygen molecules can combine and participate in chemical reactions previously thought impossible makes it reasonable to consider oxygen as an active intermediary in the process of cell destruction—an intermediary that can perhaps be tampered with.

It has long been known that cells rich in oxygen are more susceptible to radiation than those that are oxygen-starved. However, according to Dr.