

# CHARLIE AND THE AQUANAUTS

How a team of NASA employees made Huntsville, Alabama, the best place to learn about life without gravity.

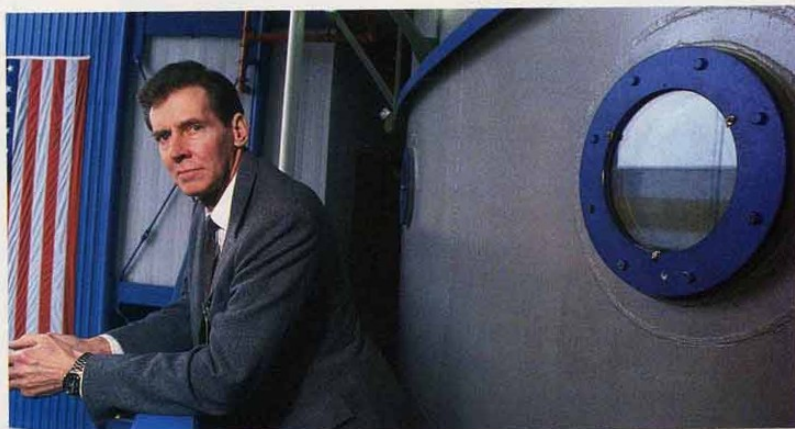
by Homer H. Hickam Jr.

Color photographs by Alan S. Weiner

Every morning, Monday through Friday, Charlie Cooper enters Building 4705, a tall, metal shed-like structure standing on the western rim of NASA's Marshall Space Flight Center in Huntsville, Alabama. Quietly he pads his way to the dressing room in the rear of the building and changes into his running clothes. He no longer works in the facility, but he is allowed a small locker in homage to the pivotal role he once played there. Before he exits for his daily four-mile run, he passes a great gray cylinder rising more than 40 feet off a concrete apron. Bright blue portholes circle it at three levels. Cooper rarely glances in its direction, although it is the triumph of his professional life. Outside, his running shoes slap against the pavement as he leaves behind Building 4705 and its most remarkable invention—an invention that saved a billion-dollar space mission and may yet save another.

In 1965, Charlie Cooper was a 28-year-old electrical engineer working in Marshall's manufacturing engineering laboratory when he learned of a problem in the Apollo Applications Program, a series of spaceflights planned to take advantage of the big boosters and spacecraft left over from the Apollo moon program. All kinds of ideas had been proposed for the AAP, among them the creation of a space laboratory out of part of a Saturn V booster. An early scheme involved launching astronauts into orbit in a standard Apollo command module-booster system; once in space, the crew would step out of the command module, spacewalk up to the Saturn's S-IVB stage, and pull out its fuel tanks and other engine hardware, thereby preparing it for transformation into a space laboratory. But no one had ever attempted such heavyweight work in space before, and NASA engineers weren't certain it could be done.

Marshall had been assigned to design the tools the crews would need to gut the S-IVB, and Cooper's division held some



brainstorming sessions on how exactly the mission would work. "Most of the managers were worried that if anything of any size was moved in zero G it would be pretty hard to stop and might go right through the wall of the spacecraft," Cooper recalls. "Well, I had an opinion just like everybody else and I thought it wouldn't be that hard to work in zero G. So I started to think of some way to prove it."

At the time, Cooper already knew a bit about the problems of working in challenging environments. As a teenager, he had thought about becoming an underwater explorer and had even built some diving suits. After graduating from the University of Evansville in Indiana and coming to Huntsville, he had learned how to scuba dive. More recently, he had served as a volunteer for a small office at Marshall that was studying spacesuit designs. He would put on various suits, get on a treadmill, and see how difficult it was to move. "When I looked at these spacesuits I kept thinking that these things would work underwater too," he recalls. "When this problem with the AAP came up I just put it all together."

The lab where Cooper worked had a small tank of water, eight feet across and eight feet deep, used for forming metal. There was also a heavy object available, a mockup of a 124-pound gyroscope similar to one that the AAP spacewalkers would have to move out of the S-IVB stage. In the spring of 1965, Cooper sold co-worker Charlie Stocks on his idea; when no one was around, the two went over to the sheet metal tank to try it out.

*During his career, Charlie Cooper (above) has seen the technology of simulating weightlessness evolve from a few furtive dips in a small water tank to elaborate rehearsals of extravehicular activities in a huge 40-foot-deep facility (left).*

Getting the heavy ball into the tank was a struggle. “We rolled it in and went in behind it,” Cooper remembers. “Of course we didn’t have a spacesuit to work with. We didn’t even have wet suits, so we just stripped down to our skivvies. Lord, it was cold in there. There was a stopper in the ball that I could take out to let in water. I played with that, letting the ball fill up until it stabilized. Then I started to push it

all around the tank. I could feel the mass of it but it didn’t take much to move it and I could stop it very easily just by hauling back on it. The way I figured it was that we had just demonstrated that a big heavy object could be handled manually by a spacewalking astronaut.

“But now I had to figure out what to do next—how to get this news out,” he continues. “What I had just done wasn’t exactly in my job description.”

Cooper’s boss was Bob Schwinghamer, then the chief of the experimental electronics development branch. He had been traveling when his two employees conducted their experiment. Now Marshall’s deputy director of space transportation systems, Schwinghamer recalls: “Well, as soon as I heard about it I wanted to try it too. It was my tank so I got that ball and just climbed in with it. Charlie was right. I could move it all around. I thought to myself, *This is something! We*

*As Cooper’s supervisor, Bob Schwinghamer (above) firmly supported his employee’s efforts to approximate zero-G working conditions. The early attempts quickly drew in other Marshall engineers (below; Cooper is fourth from the left).*



*ought to do more of this!* The next morning, Schwinghamer called Cooper and Stocks in and raised hell with them for trying their scheme without checking first. While they were absorbing their shellacking he told them to get busy. He would support the idea all the way.

It was clear to both Cooper and Schwinghamer that just going underwater with a mockup would

not be enough to prove anything. What was really needed was for someone to get in wearing a spacesuit. Schwinghamer tried to get a suit through a contact in Houston, but that didn’t pan out. “So I sent Charlie Cooper to the Navy base in Miramar, California, for high-altitude-suit training,” he says. “I knew what he’d do and he did it. He talked those guys out there into letting him borrow two Arrowhead Model IV high-altitude suits.”

When Cooper brought the suits back, he and some coworkers designed a simple umbilical air supply line and prepared for a test dive. But there was one problem: inflated the suits were extremely buoyant. Cooper and his coworkers decided to try weighing the suit down with small lead plates.

Other employees in Schwinghamer’s branch volunteered to help during their off hours. It took them all night to pour the lead to create the plates. Then they borrowed a big pair of coveralls from one of the maintenance men and spent another night laboriously tying the plates on almost every square inch of the garment. In May they were ready for their first suit test. Cooper donned the Arrowhead suit, then the coveralls. When he was finished dressing, Cooper recalls



with a grin, "I was so heavy I couldn't stand up. That was embarrassing. But the other guys grabbed me and dragged me to the tank and kind of slid me in. Before I got in the water the suit felt like it was going to break my back, but after I got in it felt just fine."

Cooper pushed away from the ladder, the only sound the air rushing through the umbilical and the blood pulsing in his ears. The first thing he noticed as he started to move around was how easy it all was. He turned, grasping the ladder and rotating until he was upside down. His boots swung up effortlessly.

In subsequent tests, the group found that they didn't need all of the lead plates. By adding and subtracting weights, they trimmed Cooper out so that he was neutral no matter which way he turned. Still, dives in the tank would never replicate the weightlessness of space perfectly. Explains Schwinghamer: "There is some fluid friction [in water] you don't have in space." Generally, the more rapidly a person tries to move in water, the more the water's viscosity will re-



*During the second year of the informal program, Marshall director Wernher von Braun's support enabled Cooper and his team to carry out their trials in a larger tank (above; Cooper is at right). The far-sighted von Braun immediately perceived the value of neutral buoyancy training; in 1969 he tried it for himself (above right).*

sist his movements. However, if the person slows his movements, he can diminish the resistance. Since most real spacewalks are themselves done slowly, they can thus be simulated quite realistically in water.

Cooper and his crew were making great strides, but their research was all very low key, and without support from the top, it would all be worthless. Fortunately for Schwinghamer and Cooper, Marshall's director, the renowned rocket scientist Wernher von Braun, quickly became a powerful supporter of the tank experiments. Because of von Braun's support, Schwinghamer was allowed the use of a better tank, a 15-foot-deep facility once used for forming parts.

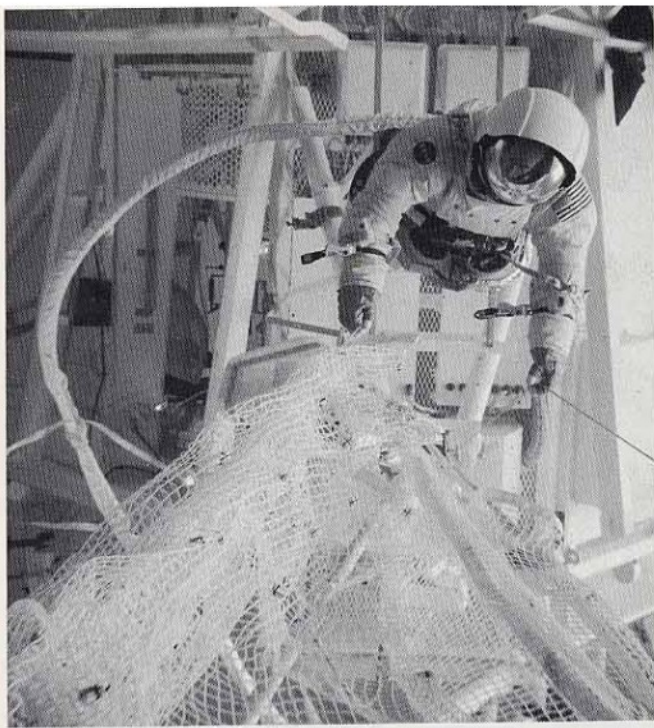
A small group of engineers and technicians, still all volunteers, began coalescing around the effort, offering an as-



sortment of useful skills. One early participant, Marshall engineer Joe Dabbs, contributed his expertise as a scuba instructor. Dabbs taught the group how to dive, then took them all down to Florida for their checkout dives. In the process, he began diving with them. "For a time I left NASA and transferred over to the Army," Dabbs recalls, "but it didn't matter. I still came over and helped out in the tank and nobody asked who I worked for or cared. The thing was to do the job. That was just the way it was then."

In this spirit of informality and enthusiasm, the team began to create the techniques and procedures that would be used in all underwater space simulators. "We weren't spending much money if any at all," Schwinghamer says. "My guys just went out and found what they needed, checked with me on their idea, and then installed whatever it was. They were all eager to work on this thing. I had to remind a lot of them to go home at night. They were in that tank just about every weekend too. It was an exciting time."

While Huntsville was vigorously pursuing the idea on a volunteer, low-cost basis, managers at Houston's Manned Space Center were just starting to think about the possibilities of underwater space simulations. In the fall of 1966, astronaut Scott Carpenter donned a Gemini suit and descended into a swimming pool to demonstrate the feasibility of removing an S-IVB part. But the difference between Huntsville and Houston was that Houston approached the use of underwater space simulations in a more methodical manner, requesting NASA headquarters to fund a facility with full staffing by a contractor. Headquarters put Houston's tank on its wish list, but space program funding was tightening up. By the time Houston realized it wasn't going to get a new facility and decided to go with an existing small tank that had been used to practice splashdowns, Huntsville had forged ahead in neutral buoyancy techniques.



NASA (3)

With Skylab in danger of being broiled by the sun, Marshall staff brainstormed rescue schemes, sketching out some on a blackboard (right). Once the rescuers had designed and cobbled together a "twin-pole sail" to cool the craft, Rusty Schweickart (left) and others entered the Neutral Buoyancy Simulator to practice deploying the device. After the rescue, Schweickart and Cooper practiced one of the EVAs originally planned for the Skylab program (opposite).

Marshall engineer Joe Dabbs (below) contributed to the early research by teaching Cooper's team how to scuba dive.

NASA's AAP Office was now ready to undertake some formal testing of underwater space simulation, and in February 1967 the office decided that for the tests it had in mind, Huntsville was the best center for the job. Houston was not only having problems getting a facility, it also lacked personnel with much experience in neutral buoyancy techniques. It was a quiet victory for Marshall, one that moved the Huntsville center into the arena of manned spaceflight.

Up to this point, all responsibility for human spaceflight had been given to the Houston center, and with the center's mentor, Lyndon B. Johnson, sitting in the White House, the monopoly seemed secure. But now that Marshall's neutral buoyancy simulations were challenging this arrangement, many in Huntsville were pleased. Their town was building the rockets that would take men to the moon, but it was "Houston" that was coming out of the mouths of the astronauts every time they spoke, and it was Houston the American people had started to think of when they thought of NASA. If all seemed serene at the top of the management chains of the two centers, underneath was a charged competition. And the most visible prize of that competition was the astronauts themselves.

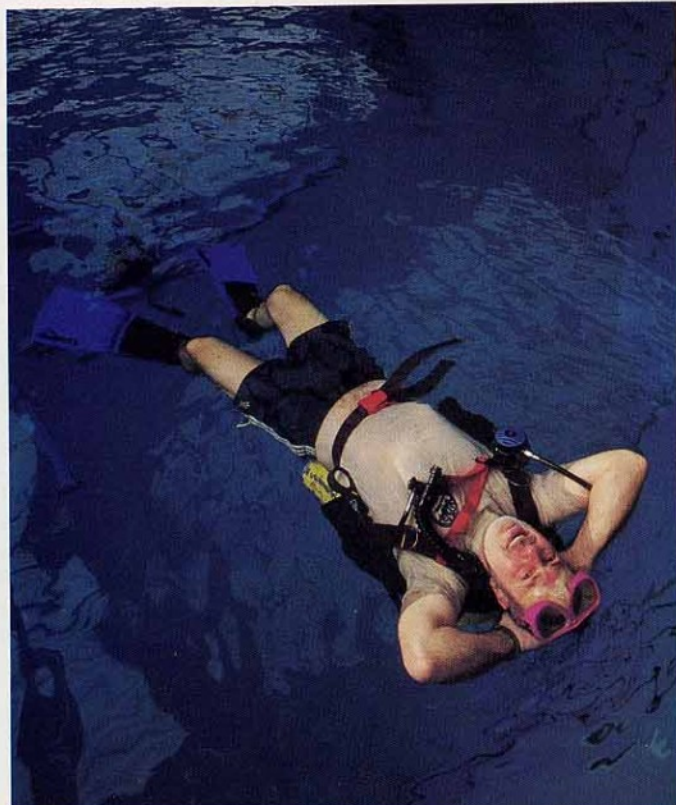
Alan Bean was the first astronaut assigned to come

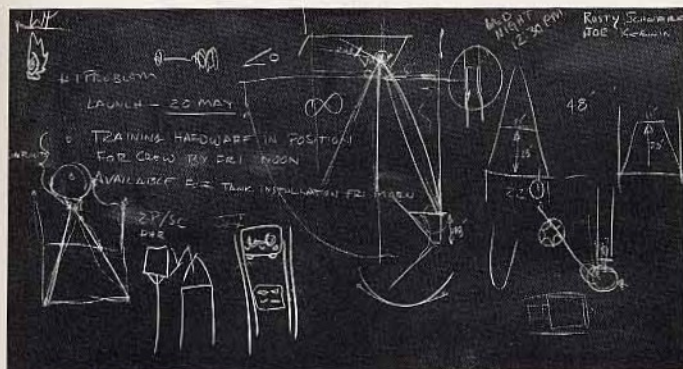
up to Huntsville to try out Schwinghamer's tank. In 1967 Bean began a series of underwater tests using equipment essentially built from salvage. Schwinghamer remembers one memorable day when Bean was in the tank trying to take bolts out of a plate. He had managed to remove a few when suddenly a hole about the size of a silver dollar blew out from under his right armpit. Slowly, his suit began to collapse. Schwinghamer, who had been serving as one of Bean's safety divers, tried to plug the hole but got nowhere. He recalls: "I went to the surface and yelled at the guys to jack up the suit pressure as high as it would go to get him air, but in the meantime Al had calmly walked across the bottom of the tank and got to the ladder. Then he just climbed up and out. He wasn't mad or upset. Like the rest of us he just wanted to fix the suit and get on with the test. That's an attitude you can't beat."

Still, the Marshall team always worried that their work at the tank would be perceived as overstepping time-honored boundaries. "At first, we had an inferiority complex about what we were doing and we felt like we were always on the verge of being shut down," says Schwinghamer. "We always

felt like somebody was looking over our shoulders just waiting for us to make a mistake, to say that we shouldn't be working with the astronauts. But after a while we realized we had become the experts in extravehicular activity. We had done it first here and we had done it in a big way."

Wernher von Braun maintained a fatherly interest in underwater training: in 1968 he managed to get Marshall a new, larger tank—the Neutral Buoyancy Simulator, which measured 40 feet deep by 75 feet across. He greased the way for this expenditure with a little creative accounting. The way such a structure was funded normally depended on whether the item was cat-





egorized as a tool or a facility; since the latter required Congress' approval, von Braun simply opted to call the new tank a tool. "We built the tank ourselves with just NASA personnel because there wasn't enough money to hire a contractor to do it," says Cooper. The tank was completed just two months after the materials were delivered, and at a cost of \$219,000, well under budget.

The facility became an interesting study in job placement. "We hired the same guys who built it to work in it," Cooper says. "It didn't matter if they had been draftsmen or machinists or engineers. Everything was new so what counted most was enthusiasm."

The Apollo Applications Program gradually evolved into the Skylab program, the United States' first manned space station. The mission had changed since it was originally formulated: now the lab would be built on the ground and sent up unmanned, and a separate launch would send a crew up to operate it. In 1969 headquarters gave Huntsville the responsibility to design, develop, and build Skylab.

By the time the station was ready for launch, the Huntsville tank had completed five years of operations, and almost all of the astronauts had trained in it. Although Houston still had the job of training the Skylab crews, Charlie Cooper and astronaut Rusty Schweickart got the primary roles in training the first Skylab crew—Pete Conrad, Joe Kerwin, and Paul Weitz—in extravehicular activity.

On May 14, 1973, the Skylab module was launched aboard a Saturn V. But as soon as the lab had made it into orbit and begun to transmit data, ground controllers knew something was wrong. Not only would the solar panels not deploy, but the temperature inside the station was rising rapidly. A quick analysis revealed the likely scenario. The module had been tightly fitted with a shield for protection against micrometeoroids and other space debris. As the rocket reached an altitude of lower pressure, the relative pressure of the air between the shield and the module climbed. Finally, the pressure grew so high that the trapped air blew off a big piece of the tight-fitting shield. The shield in turn broke off one of the solar panel wings and jammed the other with debris.

The reason the temperature in the module was going up was that the shield, in addition to providing protection from space debris, had insulated the module from the sun's heat. Without this protection, the module's sensitive instruments were being broiled. NASA would have to either abandon the billion-dollar facility or train the lab's crew to fix it.

Rusty Schweickart had spent hours in the tank working out the requirements for the expected Skylab extravehicu-



lar activities, and clearly any repair was going to require additional EVA. "Houston told me to get up to Huntsville and get something organized," Schweickart recalls. Joining the astronaut was Skylab crew member Joe Kerwin. While ground controllers in Houston frantically turned Skylab away from the killing heat of the sun, Schweickart began to chalk ideas on a blackboard for devices that could save the mission.

Cooper remembers the crisis atmosphere of the room: "Whatever we came up with had to be ready in 10 days or less. The Skylab crew was going up on May 25. We just threw the thing open." Ideas were accepted from everyone, including machinists who came in from their workshops to see what was going on. Eventually, Schweickart came up with the idea of a sunshade, and the group began hammering out the details.

The team worked far into the night, trying all sorts of ideas. Finally Cooper joined Schweickart and Kerwin at the board to detail the procedures needed to deploy the suggested sunshade, which the rescuers named the twin-pole sail. They also had to devise a plan to break the jammed solar panel free.

On May 15, the day after the Skylab launch, Cooper was in the water in a Skylab spacesuit going through the motions of the procedures on the Skylab mockup. The next day Schweickart and Kerwin got in. By that evening Marshall machinists had fabricated the twin-pole sail and all of the ropes and pulleys that made it work. On May 17 a mockup of the command module, the Apollo capsule the crew would use to fly up to Skylab, arrived in Huntsville to be put into the tank. Things were happening at lightning speed.

Schweickart recalls the enthusiasm that swirled around the tank: "Some of the tank staff worked 72 hours straight at least, even though I tried to get them to take some time off. I was just as bad, on the phone all hours of the night, calling people all over the country ordering materials, reviewing specifications."

On May 21, after a series of various in-tank trials, Al Bean and astronaut Ed Gibson did a complete end-to-end test run employing the sail. As soon as they got out, staff divers plunged in, readying the tank for another test. Far into the night, Cooper stood in the command module forward hatch and worked to see if he could free the solar panel. He was scarcely out of the tank before Pete Conrad, the commander of the first Skylab crew, and Joe Kerwin got back in.

All the next day Conrad and Kerwin, outfitted with bulky Skylab suits, practiced putting up the sail and using the tools needed to remove the debris pinning the solar panel. Their recommendations for redesigning tools and refining procedures were recorded by Cooper and his group and tried out in the tank two days later. The results were phoned in as the Skylab crew prepared to go to Cape Kennedy in Florida.

On May 25, Conrad, Kerwin, and Weitz were launched. Once inside the Skylab module, the crew first installed a shade through an airlock, temporarily solving the heat problem. But with the solar panel stuck, not enough electricity would be generated to operate the station properly. While Conrad piloted the Apollo module around Skylab he described the damage, and based on that information Cooper and the tank staff plunged back into the water to devise the

best way to free the panel. "We mocked up the piece holding the wing just like Pete described it and then worked on freeing it," Cooper recalls. "Rusty talked the results to the crew. When I got out of the water I stayed in my suit, ready to go back in if I was needed to test some idea."

It was, perhaps, the Neutral Buoyancy Simulator's finest hour. Following the tank's recommended procedures, Conrad and Kerwin went outside Skylab, set up their gear, and levered the solar panel wing loose. An explosion of cheers erupted among the crew of Huntsville's tank.

Because the temporary shade seemed to be keeping the lab's temperature down, and because the crew was worn out from the repair work, mission control decided to leave the erection of the twin-pole sail to the second Skylab crew. After extensive training in the tank, those astronauts—Owen Garriott, Jack Lousma, and Alan Bean—went up on July 28. Ten days later, they successfully erected the twin-pole sail. "Everything we practiced in the tank at Huntsville proved easy in space," recalls Garriott.

Accolades for the tank were to be short-lived. When the third crew returned to Earth on February 8, 1974, the Skylab era came to an end, and for the time being, the United States pulled back from manned space efforts. No matter how well it had accomplished its mission, the tank, like the rest of NASA, would be affected by this retreat. And when the changes came, they came suddenly.

As part of an overall reorganization dictated from headquarters in 1976, the tank staff was decimated. Even though they had helped to build the structure with their own hands and had developed and refined the techniques of EVA, many workers were out of a job or were sent back to the old jobs they had had before their tank assignments. "It was a tough time," Cooper remembers. "I'm convinced it killed one of our guys. At the tank, he was a test director on a first-name basis with the astronauts, and all of a sudden he was back at a drawing board again. It ate him up inside. They said it was a heart attack that killed him. Heartbreak was more like it."

In 1980 Johnson Space Center in Houston opened the Weight-

DENNIS KEIM, NASA



less Environment Training Facility, a tank much smaller than Marshall's. Houston became the focal point for underwater astronaut training. But even though all EVA training was supposed to go to the WETF, Charlie Cooper kept working to keep the Marshall tank busy during the 1980s. One of the jobs he snagged was work on the Hubble Space Telescope, because only the tank at Huntsville was big enough to hold a mockup of both the Hubble and a shuttle cargo bay. The Huntsville tank is now being used to fine-tune the procedures needed to correct the Hubble's nearsightedness. Twenty years after its first rescue, Huntsville's tank may once again save a major NASA mission.

In 1987 Cooper decided he needed a change. "It just wasn't the same anymore," he says. "All the old hands were gone. We weren't doing much that was new. It was time to let the next bunch build on what we had done." So he moved on,

applying his brand of practical engineering to the environmental control and life support systems for space station Freedom.

When asked what he recalls best about that period, Cooper says, "I remember mostly how much fun it all was.... We were all having fun but at the same time we knew what we were doing was important. We didn't do it for the money, that's for sure. We did it because the people over us, Schwinghamer and von Braun and the rest, let us do it. That's what I miss, if anything. The feeling that we could do anything as long as it was good for the program." —

*Water tanks don't replicate the weightlessness of space perfectly, but they are realistic enough simulators to prepare astronauts for most complex missions involving spacewalks.*

