Historian's Corner

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Manned Maneuvering Unit (MMU)
The Russians Had One Too
By Paul Bingham

Manned Maneuvering Unit (MMU) Description -

The MMU project was follow-on to the M509 project that had an MMU-type device "flying" inside the Skylab. I had done some analytical work on the M509 project years ago.

Martin Marietta had a small contract to build a MMU in the late 1970's and early 1980's

Astronaut Bruce McCandless is shown below in his space suit with a manned maneuvering unit.

The MMU) is a maneuvering unit used by NASA on three Space Shuttle missions in 1984. The MMU allowed the astronauts to perform untethered extravehicular activity (EVA) spacewalks at a distance from the shuttle. The MMU was used in practice to retrieve a pair of faulty communications satellites, Westar IV and Palapa B2. The MMU was developed and built by Martin Marietta in the late 1970s and early 1980s in Littleton.

The unit featured redundancy to protect against failure of individual systems. It was designed to fit over the life-support system backpack of the Space Shuttle Extravehicular Mobility Unit (EMU). When carried into space, the MMU was stowed in a support station attached to the side wall of the payload bay near the airlock hatch. Two MMUs were carried on a mission, with the second unit mounted across from the first on the opposite payload bay wall. The MMU controller arms were folded for storage. After an astronaut backed into the unit and snapped the life-support system into place, the arms were unfolded.

To adapt to astronauts with different arm lengths, controller arms could be adjusted over a range of approximately 5 inches. The MMU was small enough to be maneuvered with ease around and within complex structures. With a full propellant load, its mass was 326 pounds.

Gaseous nitrogen was used as the propellant for the MMU. Two aluminum tanks with Kevlar wrappings contained 13 lb. of nitrogen each, enough propellant for a six-hour EVA depending on the amount of maneuvering done. Typical MMU delta-v (velocity change) capability was about 80 feet per second.

There were 24 thrusters mounted in triads placed at each of the eight corners on the MMU. To operate the propulsion system, the astronaut used his fingertips to manipulate hand controllers at the ends of the MMU's two arms. The right controller produced rotational acceleration for roll, pitch, and yaw. The left controller produced translational acceleration for moving forward-back, up-down, and left-right. Coordination of the two controllers produced intricate movements in the unit. Once a desired orientation was achieved, the astronaut could engage an automatic attitude-hold function that maintained the inertial attitude of the unit in flight. This freed both hands for work. Initially, the work to be done was replacing insulation tiles on the Space Shuttle damaged during launch.

MMU First Flights –

The MMU was first tested on February 7 during mission STS-41B by astronauts Bruce McCandless and Robert L. Stuart. The test flights were flawless and gave us test data on propellant usage and many other details including that they flew exactly as predicted.

Two months later during mission STS-41-C, astronauts James van Hoften and George Nelson attempted to use the MMU to capture the Solar Maximum Mission satellite and to bring it into the orbiter's payload bay for repairs and servicing. The plan was to use an astronaut-piloted MMU to grapple the SMM with the Trunion Pin Attachment Device (TPAD) mounted between the hand controllers of the MMU, null its rotation rates, and allow the Shuttle to bring it into the Shuttle's payload bay for stowage. Three attempts to grapple the satellite using the TPAD failed. The TPAD jaws could not lock onto Solar Max because of an obstructing grommet on the satellite not included in the blueprints for the satellite. A lack of configuration control caused this.

This led to an improvised plan that nearly ended the satellite's mission. The improvisation had the MMU astronaut use his hands to grab an SMM solar array and null the rates by a push from MMU's thrusters. Instead, this attempt induced higher rates and in multiple axes; the satellite was tumbling out of control and quickly losing battery life. SMM Operations Control Center engineers shut down all non-essential SMM subsystems and with a bit of luck were able to recover the SMM minutes before total failure. The ground support engineers then stabilized the satellite and nulled its rotation rates for capture with the orbiter's robotic arm, the Shuttle Remote Manipulator System (SRMS). This proved to be a much better plan. Their successful work increased the lifespan of the satellite.

The final MMU mission was STS-51-A, which flew in November 1984. The propulsion unit was used to retrieve two communication satellites, Westar VI and Palapa B2, which did not reach their proper orbits because of faulty propulsion modules. Astronauts Joseph P. Allen and Dale Gardner captured the two satellites and brought them into the Orbiter payload bay for stowage and return to Earth.

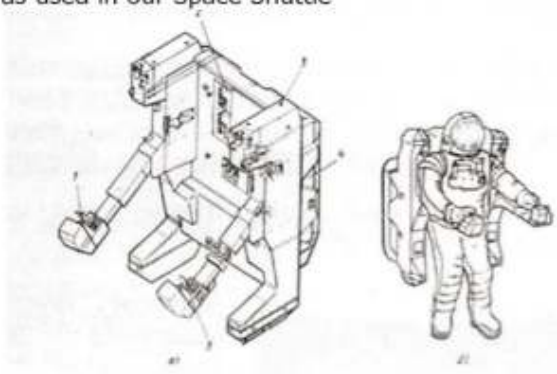
NASA stored the two MMUs that had flown, #2 and #3 in a clean room at Lockheed Martin in Denver through 1998. NASA transferred flight article #3 to the National Air and Space Museum in 1998, which now hangs suspended in the hall above the Space Shuttle Discovery. In 2013 flight article #2 was displayed next to the Space Shuttle Atlantis in its new home at the Kennedy Space Center Visitor Complex.

Dr. Guy Ilyich Severin, Father of Russia's MMU -

In October 1986, I went to the 37th International Astronautical Federation Congress in Innsbruck, Austria to present a technical paper on our MMU (October 4–11, 1986).

After my presentation a pair of Russians asked me to have a meeting with them the next day. At the meeting one spoke English and interpreted for the other who spoke only Russian. At the outset, they gave me a book. Скафандры и системы для "EVA, Space Suits and Systems for EVA." It is a textbook that Dr. Severin and three others wrote in 1984.

On page 230 is a description and diagrams of our MMU as used in our Space Shuttle



The Russian who did not speak English turned out to be, I figured out later, Dr. Severin. He was an academician of the Russian Academy of Sciences, Doctor of Technical Sciences, Professor, full member of the International Academy of Astronautics, who contributed a significant number of publications about life rescue systems and space suits. Severin was also General Director of JSC NPP Zvezda and the company's General Designer.

From 1964, Dr. Severin served as Chief Designer,

General Designer and, eventually, General Director of the joint-stock company NPP Zvezda, located in Tomilino. Under his direction, the company developed space suits; life support systems and rocket emergency escape slides for all USSR/Russia spacecraft and orbiting space stations, starting from Vostok 1, including the special inflatable EVA airlock of the Voskhod 2. His company, Zvezda, developed the USSR's MMU-type systems, and also some of the ISS's modules.

Soviet Solid Propellant MMU - UPMK

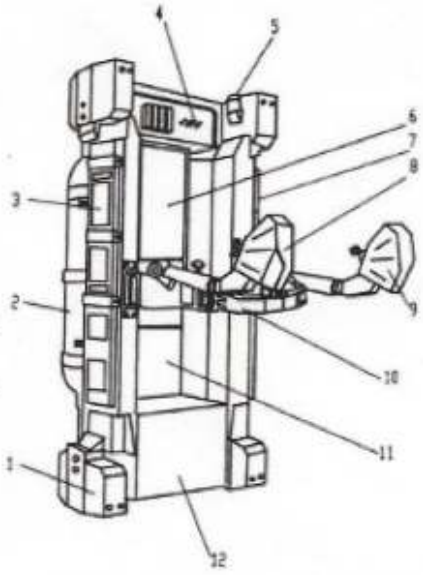
In this same chapter are descriptions of their MMU-type systems, one of which was propelled by 48 tiny solid propellant thrusters, as shown below. We do not know that it was ever flown.

MMU Soviet 21KS -

The Soviet Union also used a cosmonaut propulsion system on flights at their space station Mir. The UPMK unit was replaced by the 21KS unit that was larger than our Space Shuttle MMU, was propelled by oxygen instead of nitrogen and was attached to a safety tether. Despite the tether, the 21KS allowed the cosmonaut, wearing the self-contained Orlan spacesuit, to "fly around" the orbiting complex, allowing access to areas nearly impossible to access otherwise.

This system was similar to our MMU. It was automatically stabilized, used 6 degrees of freedom, had a delta-v of about 98 ft/s, practical speed of 3 ft/s, and an emergency mode that allows for rotational acceleration of 8 degrees per second. Total Mass: 480 lb.

21 KS
1- 24 thrusters
2- Propellant
3- Battery
4- Dist'n Assy
5- Lights
6- Movement Control
7- Battery
8- Rotation Hand Control
9- Transfer Hand Control
10- Waist Frame
11- Angular Sensor
12- Actuator Units



In case of a malfunction, it remained connected by a tether attached to a winch on an EVA mast installed near the Kvant-2 exit hatch of Mir. The 21KS was used on only two EVA's, at distances of up to 45 m from the station. Unlike the shuttle MMU, it was only flown tethered to the station. Like the shuttle MMU, it was retired after a few tests.

In February 1990, the cosmonauts A. A. Serebrov and A. S. Victorenko tested the 21KS during their EVA from the Mir orbiting station, going out 100 ft. and 145 ft. respectively. It was planned to use the 21KS on Mir and in the Buran reusable space system.

Though tested on Mir in 1990, the cosmonauts preferred using the Strela crane (equivalent to the Mobile Servicing System). The 21KS, which was left attached to the outside of their Mir, was destroyed when Mir re-entered the atmosphere after decommissioning.

Russian MMU in Museum in Oregon -

In 2010, my wife, Betty, and I were in the Evergreen Aviation and Space Museum in McMinnville, OR where Howard Hughes' "Spruce Goose" now resides.

In the Space Building we encountered an unlabeled showcase containing what appeared to be a spacesuit.

I asked the docent about it and was told he didn't know what it was. So I told him it was a Russian 21KS, equivalent to our MMU attached to their Orlon-DMA space suit. He was interested; so I told him I'd send him some information about it so they could, at least, label it.

It is a wonderful museum that I recommend visiting for airplanes, space history, and they have the best collection of rocket engines I've ever seen.

Later, I found out, it, and some other Russian space equipment, came on loan from the Cosmosphere in Hutchison, Kansas. With the Soviet Union dissolution on December 26, 1991, much of their space heritage was lost in various ways. Some were simply sold. Some of it came to the USA, and some of that to the facility in Kansas.

The End Result of the Whole MMU Thing -

The end-result of the MMU work in both the USA and Russia is that the MMU lives on in a device called SAFER. It is a smaller unit, with some components of the MMU, which is capable of moving an astronaut around – but only in an emergency

SAFER is designed to be used as a self-rescue device if, in spite of precautions such as tethers, safety grips, and the robot arm, an EVA crewmember gets separated and no vehicles can provide rescue capability. SAFER is worn by every ISS crewmember using an Extravehicular Mobility Unit. The SAFER was the design solution for the Shuttle Program's requirement to provide a means of self-rescue should an EVA crewmember become untethered during an EVA.

SAFER was first flown on STS-64 September 9, 1994, where an untethered flight test was performed, first by astronaut Mark Lee and then Carl Meade. Both astronauts flew the SAFER up and around the Shuttle's Robotic Arm along with a demonstration test of the SAFER's automatic attitude hold feature. This feature arrests uncontrolled rotation of a detached crewmember expected in an accidental separation. SAFER has a mass of approximately 83 lb and can provide a total change in velocity (delta-v) of at least 10 ft/s. It was also tested during flight STS-92 when astronauts Wisoff and Lopez-Alegria performed test maneuvers, flying up to 50 feet while remaining tethered to the spacecraft.

MMU Team Awarded the Collier Trophy -

The **Collier Trophy** is an annual aviation award administered by the U.S. National Aeronautic Association (NAA), presented to those who have made "the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air or space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year."

Citation: 1984 NASA AND MARTIN MARIETTA CORP for the development of the MMUI and the NASA industry satellite rescue team and to Astronaut Bruce McCandless, NASA"s Charles E. Whitsett, Jr., and Martin Marietta"s Walter W. Bollendonk.