

International Space Station USOS Waste and Hygiene Compartment Development

Dwight E. Link, Jr. and Steven F. Balistreri, Jr.
The Boeing Company

Karen Gelmis
NASA Johnson Space Center

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ABSTRACT

The International Space Station (ISS) currently provides human waste collection and hygiene facilities in the Russian Segment Service Module (SM) which supports a three person crew. An additional set of Russian hardware, known as the ACY system, is planned for the United States Operational Segment (USOS) to support expansion of the crew to six persons. Integration of the Russian ACY system into the USOS incorporates direct Environmental Control and Life Support System (ECLSS) interfaces to allow more autonomous operation as well as maximized water recovery. An interface has been added to provide water directly to the system for flush purposes as well as a urine delivery interface which will result in less crew time for system maintenance. The direct urine interface will be used to recover water within the urine processing system. Development and qualification testing of the ACY system has been completed by RSC-Energia and NASA and integration into an ISS equipment rack structure is in process in support of a planned 2008 launch date. This paper reviews the current status of the USOS compartment design and development, results of the Russian ACY system qualification program, and lessons learned from the integration of a Russian-provided system into the USOS.

INTRODUCTION

While most space exploration missions have a specific task or objective that must be supported by the spacecraft design, design of systems that support the crew members that carry out these missions is just as important. Life support system design must address all human needs in a closed environment, including food preparation and consumption, air revitalization, a safe

water supply, and metabolic waste collection and disposal.

Since the year 2000, the United States and Russian space agencies have operated an internationally occupied spacecraft that has successfully supported permanent crews so that valuable research can be conducted. The ISS program achieved this by implementing a combination of proven hardware designs with new systems. The ISS human waste collection system is an example of how hardware with a long legacy of successful and reliable operation is being implemented and enhanced to provide additional capability and functionality for future exploration missions.

The ISS currently provides a waste and hygiene compartment which is capable of supporting waste collection and disposal for a 3 person crew. The waste collection system, or ACY, is located in the Russian segment's Service Module. This system has been developed and improved upon since the Soviet MIR program, with each step building upon the previous to improve capability. This system design approach has proven to yield safe and reliable hardware. In order to support expansion of ISS crew to six crew members, the ISS program elected to implement a second ACY system in the USOS. In doing this, additional crew member capability can be added with minimum program risk.

USOS WASTE AND HYGIENE COMPARTMENT OVERVIEW

In the USOS, the ACY system will be contained in a single equipment rack volume which allows the system to be integrated and tested on the ground and delivered



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to the ISS as a single operating equipment rack. The rack includes a deployable cabin, which provides privacy for the crew while using the system.

The ACY system diagram is shown in Figure 1. The system is activated by opening a manual valve on the urine inlet funnel. This action activates the system fan which provides approximately 250 l/min airflow that mixes the urine along with a preservative solution. The combined mixture passes through an air/liquid separator that separates the preserved urine and sends it to the urine processing system. The system airflow also provides approximately 400 l/min of suction flow for the solid waste collection tank. A single-use perforated fecal collection bag is affixed at the tank inlet, just beneath the seat. Wipes are placed in the bag, and the top is sealed with an elastic chord by the crewmember. The used bags are then collected inside the tank. The airflow exiting the solid waste tank is passed through a static liquid separator along with the urine collection airflow to remove any residual moisture. The air is then discharged inside the equipment rack volume after passing through an odor filter. A summary of the detailed ACY operation is provided by Broyan (2007).

As mentioned earlier, the USOS ACY system builds upon the existing system in use on the Russian segment. The preserved urine mixture is sent to the urine processing system which recovers water which in turn is re-processed as potable water. In the SM, the urine mixture is manually stored and transferred to the Progress module for disposal, and no additional water is recovered. The ACY system also receives water from the USOS potable water bus, an interface which currently does not exist in the SM. The ACY system uses water from a storage tank which is continuously monitored by the electronic controller. As the tank level decreases, it is sensed and automatically refilled from the station water supply, eliminating the need for a crewmember to perform this function. These direct interfaces to the USOS result in less system maintenance and are also intended to demonstrate that the systems can successfully be operated together which is an important step toward more advanced systems required for long duration space exploration.

The USOS ACY system rack, known as the Waste and Hygiene Compartment (WHC), is contained in a single ISS equipment rack. The rack is designed to facilitate frequent maintenance by maximizing access to the ACY system hardware while providing a usable volume for system operation. The cabin volume provides approximately 50 cubic feet for crew members to use the system or perform hygiene functions, if desired. Figure 2 shows the System rack packaging design and component placement and Figure 3 shows the volume inside the WHC rack and outside the cabin.

The equipment volume rack also houses several essential operational systems. Along with the ACY controllers, a 120V to 28V DC to DC power converter is located inside the rack equipment volume which provides a constant power supply to the ACY system. The power supply and ACY separator are cooled by air which is circulated from the crew cabin to the equipment volume by a cooling fan. The power and cooling systems are continuously monitored by the USOS Command and Data Handling (C&DH) system. The ACY also has critical telemetry signals available to the C&DH system, although this capability is not planned to be implemented immediately on the USOS.

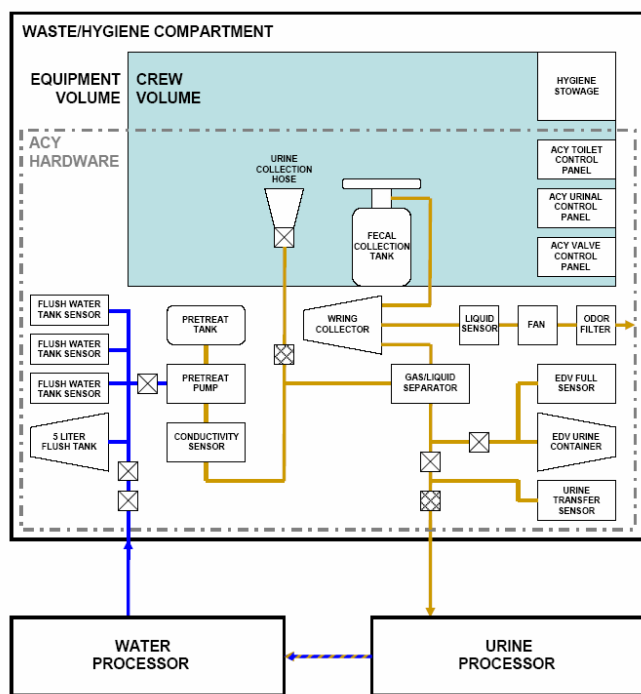


Figure 1. ACY System Diagram