

Console Handbook

SPARTAN

Station Power, Articulation and Thermal Control

Electrical power is one of the most important resources on the International Space Station (ISS). It is used to power lights, fans, motors and scientific research, among many other needs.

The Station Power, Articulation and Thermal Control (SPARTAN) flight controller supports the electrical power system on the International Space Station (ISS) by managing the operation of the hardware and software on the United States On-orbit Segment (USOS), the United States' portion of the ISS. This flight controller oversees four main functions: conversion of solar power to electrical power; and control, storage and delivery of electrical energy to the ISS. Other duties include supervision over several thermal systems (which store energy on the ISS) and the removal of heat as it is generated.



SPARTAN

Station Power, Articulation and Thermal Control

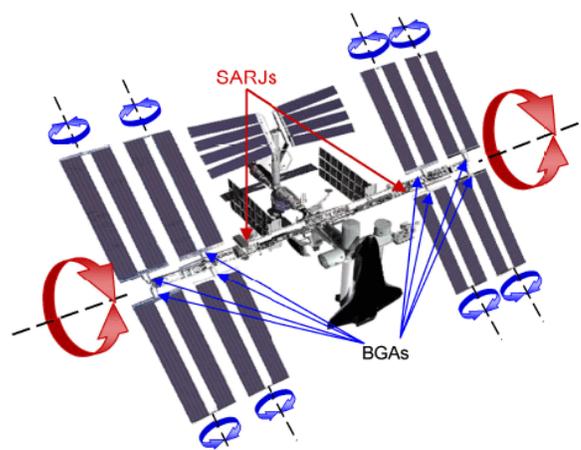
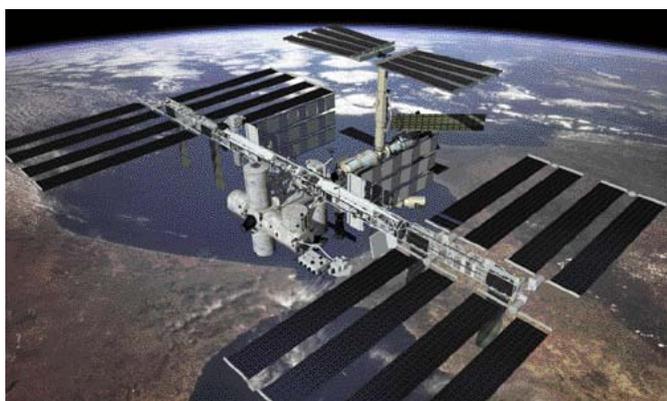
Systems Managed: Electrical and Thermal Systems

Converting Energy

How is electrical energy generated from solar energy on the ISS?

Solar energy is converted to electrical energy through solar arrays. Solar arrays are paired solar panels which absorb solar energy from the Sun. There are eight, large solar arrays located along the ISS truss (a long frame which makes up the “backbone” of the ISS) – each over 100 feet (30.5 meters) in length.

Because the ISS is always moving in orbit around the Earth, the solar arrays require two different types of rotating joints to allow them to face the Sun. The Solar Alpha Rotating Joints (SARJs) allow for rotation of either entire arm of solar arrays, while the Beta Gimbal Assemblies (BGAs) allow for rotation of each separate array.



As part of his or her duties, the SPARTAN flight controller continually monitors these joints to ensure the arrays are facing the Sun and receiving solar power, when possible.

Controlling Energy

How is heat removed from the ISS?

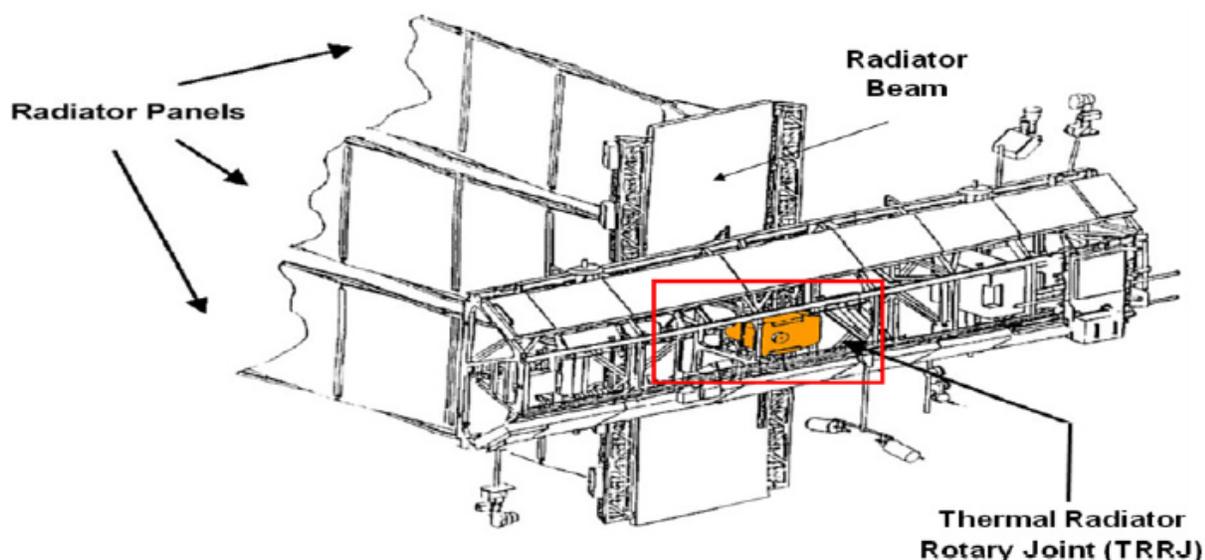
The ISS has both an internal and an external thermal control system. The Internal Thermal Control System (ITCS) uses water to transfer heat inside the ISS to the External Thermal Control System (ETCS), and is controlled by the ETHOS flight controller. (For more information on the ITCS, refer to the ETHOS handbook).

The SPARTAN flight controller oversees the ETCS, which is located outside the ISS. This system is made up of several subsystems which collect, distribute and dispose of extra heat from the ISS.

The temperature of materials in space can vary tremendously. If the ETCS used water as a cooling liquid (as the ITCS does), the water would easily freeze when the ISS is away from the Sun (in the Earth’s shadow). Therefore, the ETCS uses ammonia to cool the ISS, a liquid coolant with a freezing point much lower than water.

On Earth, most heat in the air is transferred by either conduction (the transfer of thermal energy from a substance from high temperature to a lower temperature) or convection (the transfer of thermal energy by circulation or movement of the heated parts of the liquid or gas). Since there is no atmosphere or air in space, air does not rise and heat does not conduct. The heat the ISS creates cannot be carried away by the air. In order to remove the heat, the ammonia is pumped through “coolant loops” to the ISS radiators. Radiation is the ultimate way to remove heat from the ISS – eventually all excess ISS heat must be radiated away.

These coolant loops work similarly to a home air conditioning unit, pumping coolant out to cool hot parts and returning the warmed liquid to a radiator to be cooled again. On the ISS, cool ammonia reaches the warmer areas and the heat is transferred to the coolant loop by conduction. The heated ammonia is then pumped through the loops to two sets of thermal radiators on the ISS. Each radiator has a joint called a Thermal Radiator Rotary Joint (TRRJ). Each of these joints are used to move three, large radiator panels so as to face away from the hot Sun.



As part of overseeing the ETCS, the SPARTAN flight controller monitors movement of these joints, ensuring the radiation panels are positioned to push the heat into space (away from the ISS). This helps the ETCS maintain a proper temperature range at all times, and allows the cooled ammonia to cycle back through the loops, continuing the cooling process. The SPARTAN flight controller also ensures that the ETCS pumps are running properly, and that ammonia is not getting too hot or too cold.

Storing Energy

How does the ISS maintain its power supply away from the Sun?

As the ISS orbits Earth every 90 minutes, it spends about one-third of this time in Earth's shadow. During this time, the arrays do not have access to the Sun to receive solar energy.

In order for the ISS to continually maintain electrical power, the SPARTAN flight controller oversees a set of batteries for each of the eight independent power “channels” (one for each solar array). Under this system, the solar arrays transmit power to charge nickel-hydrogen batteries to provide continual energy to the ISS while it is in orbit, but away from the Sun. Less than half of the energy generated by the solar arrays is actually used by the ISS crew or equipment. The remaining electrical energy is stored into these batteries.

The Photovoltaic Thermal Control System (PVTCS) ensures these batteries do not overheat as they are used. The use of a battery creates heat – like a cell phone creates heat during its use. To remove

the heat generated from the batteries and other nearby components, the PVTCS pumps ammonia through the coolant loops located near the batteries. The heated ammonia is then transported to radiators (located behind the solar arrays), where the heat can escape into space. The PVTCS systems are separate from the ETCS discussed earlier.

Delivering Energy

How do the ISS crew and equipment receive power?

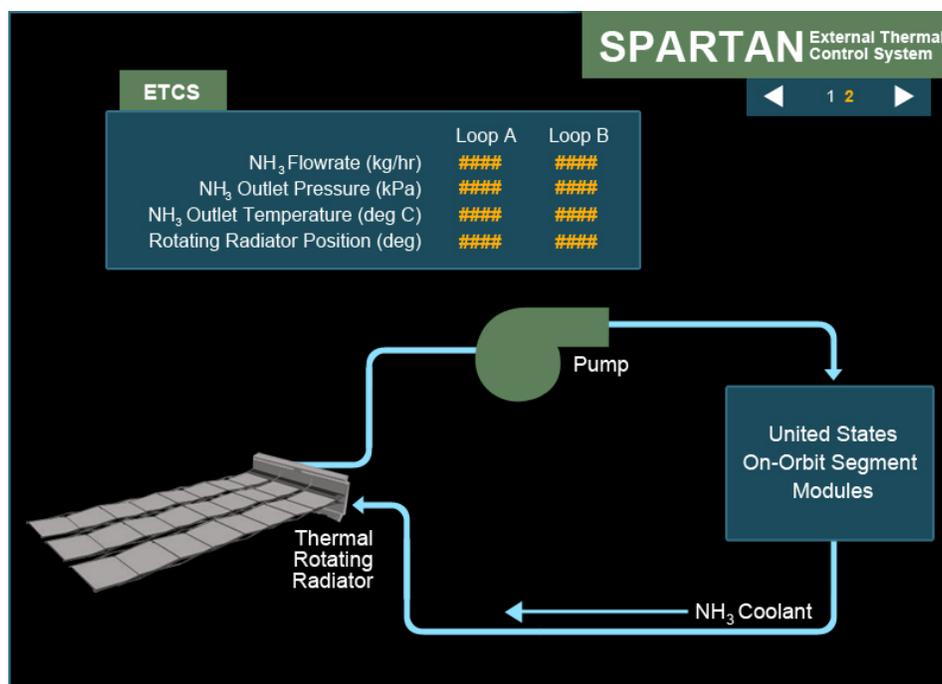
While a home microwave uses about 1kW, the solar arrays can generate up to 31 kW (31,000 watts) of electricity each. Together, they could generate more than 200 kW, of direct current (dc) electricity at 160 volts (V) for the ISS – enough to power over 200 houses on Earth.

The power management and distribution systems supply 160 V dc of electricity around the ISS through a series of converters and switches. These switches are controlled by software and are connected to a computer network which runs throughout the station. Since 160 V dc exceeds the voltage required for most operations on the ISS, the voltage is lowered to 120 V dc, forming a secondary power system for servicing equipment.

To learn more about how solar power is converted to electrical power, or how electrical power is controlled, stored or delivered on the ISS, return to the International Space Station *Live!* (ISSLive!) website at <http://spacestationlive.jsc.nasa.gov>. Select “Interact”, and then select “Visit Space Station”.

SPARTAN Console Displays

A wireless signal sends data from the ISS to the Mission Control Center. This data is updated on the SPARTAN console displays. The SPARTAN flight controller checks the data on the console displays to make sure the electrical power system and ETCS are working as expected.



Pictured above is a simplified version of a SPARTAN console display. To view this display, return to the ISSLive! website at <http://spacestationlive.jsc.nasa.gov>. Select “Interact”, and then select “Explore Mission Control”.

Space Station Live Data

Would you like to know more about the live data streaming from the ISS to the SPARTAN console displays? Return to the *ISSLive!* website at <http://spacestationlive.jsc.nasa.gov>. Select "Resources", and then select "Space Station Data". There you will find a table which includes the names and brief descriptions of all the data values used to update the interactive Mission Control Center console displays.

The "Space Station Data" table has live data values which let the SPARTAN flight controller know the exact pressure, temperature, flowrate of ammonia and the radiator positions of the ETCS on the ISS.

Acronyms and Abbreviations

BGA	Beta Gimbal Assembly
dc	direct current
ETCS	External Thermal Control System
ETHOS	Environmental and Thermal Operating Systems
ITCS	Internal Thermal Control System
ISS	International Space Station
kW	kilowatt
PVTCS	Photovoltaic Thermal Control System
SARJ	Solar Alpha Rotary Joint
SPARTAN	Station Power, Articulation and Thermal Control
TRRJ	Thermal Radiator Rotary Joint
USOS	United States On-orbit Segment
V	volt