Fancy Space Maneuvers
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Jim Oberg, special to ABC News

The crew of the space shuttle Endeavour will face many firsts on the first manned mission to begin piecing together the International Space Station.

Nobody has ever attempted many of the tough tasks ahead, not only with the shuttle's robot arm, but during the three planned space walks as well. Some of those will never have to be conducted again; they're simply needed because of the design features of the first two modules.

Before I left the shuttle program in late 1997, I coordinated the work that led to the flight plan for this Endeavour mission. We had the most complex requirements, uncertain capabilities, and unpredictable variables in any shuttle mission I had worked in my 22 years at the Johnson Space Center.

It also provided the most fun and satisfaction I ever had with any mission, too.

To Sleep, Perchance to Dream

One wrinkle is that the crew must go to sleep within five hours of being launched, thanks to Russian geography and the radio system of the Russian-built Zarya, the first piece of the space station that went up November 20.

Zarya can communicate only with ground sites in Russia. Unlike Mir or the shuttles, it can't use relay satellites to get near-continuous communication. Nor can the shuttle send radio commands to Zarya. (This won't be a problem for later flights. Once the Service Module is attached – scheduled for July 1999 – it can talk to Mission Control via a relay satellite.)

So at the end of the fourth day of the mission, Zarya is to connect with 'Unity', and then NASA wants to allow the Russians one or two final communication sessions in order to configure Zarya for its new life as part of a bigger structure.

Tricky Work

On the day before rendezvous, the crew will use the robot arm to life the Unity module out of its cradle and mount it pointing upwards atop the airlock, which is just behind the crew cabin.

They will guide it to its latching position on the shuttle using both a camera looking upwards from the airlock, and by eyeballing it from the aft windows.

When the time comes to position the just-grabbed Zarya module on top of the Unity Module, however, neither of these techniques will work.

Unity has no upwards pointing TV camera. Neither astronauts' eyeballs nor space TV cameras can see how close – or far – the two latching mechanisms are from each other.

Chasing Zarya

The first trick on rendezvous day is to catch the Zarya, just like the first step in making rabbit stew is to catch the rabbit. The shuttle will fly a standard chase of the Russian module, from below and behind. But once within a few hundred yards, the shuttle must use an unusual final approach.

Because Russian ground commands must reach Zarya, the shuttle cannot fly up from below, since it likely would block the radio signals. Instead, it will fly around in front of Zarya and get above it, and then begin approaching upside down.

But the final approach must wait to reach the Zarya and grapple it with the robot arm just as Zarya comes into range of a Russian ground station. This can be tough to coordinate.

Tougher still are the final few yards of the approach. With Unity sticking above the airlock, the astronauts can't see out the back window. But they'll watch it on TV cameras. This should work too. Such an "in the blind" grapple won't be needed again for the rest of the space station assembly.

So the shuttle has caught the Zarya. Now comes the hardest task – mating the Zarya atop Unity.

Close Fit

The two must be aligned within a few centimeters if they're to latch when the shuttle uses its jets to push Unity against Zarya.

The Canadian Space Agency developed a Space vision System that measures the television-image location of precisely-calibrated dots mounted on the outside of the Zarya, and calculates the precise relative position of the Zarya and all of its equipment. If this works as well as is hoped, the computer will spit out the actual location of Zarya's latching mechanism accurately enough for the robot-arm operator to adjust its position precisely,

If it doesn't work, there are some backup plans. Either way, it may not work on the first try, and it may take a dozen tries before anyone decides to call it quits for the day, and back away and try again the next day.

Once it does work – and the crew and mission controllers have trained hard enough to be confident they will find a way no matter what – it'll be the last time anyone ever has to do it.

So the shuttle crew faces one of the most complex and challenging space missions ever. If they make it look simple, don't believe it ever was.

Notes added in hindsight:

"Once the Service Module is attached – scheduled for July 1999 – it can talk to Mission Control via a relay satellite.)" – That launch was delayed by a year. The relay satellite was

never launched, and later a comm link from the SM into the US modules allowed data to be relayed through the US tracking network.

"They will guide it to its latching position on the shuttle using both a camera looking upwards from the airlock, and by eyeballing it from the aft windows." – Cameras at the back end of the payload bay also had an unobstructed view of the Unity repositioning, the Zarya rendezvous and grapple, and the Zarya berthing position. But it never could observe the actual mating interface because of perspective.

"Either way, it may not work on the first try…" – It didn't, but Mission Control decided it was because the arm was tilting the Zarya slightly off kilter. Before trying the next jet pulse to push the modules together, the astronauts were told to 'limp' the arm – relax all the joints – to prevent an unwanted pushing force. They did so, and the two mechanisms mated smoothly

Illustrations:

Just after final rendezvous with the Russian 'Zarya', it hangs above
the payload bay – and the astronaut view is blocked by the US
Node 'Unity', attached above the airlock.
http://www.aiaa-houston.org/horizons/nov98/shuttle.jpg

Crew patch shows alignment of two station modules post-attachment
http://science.ksc.nasa.gov/shuttle/missions/sts-88/sts-88-patch.jpg