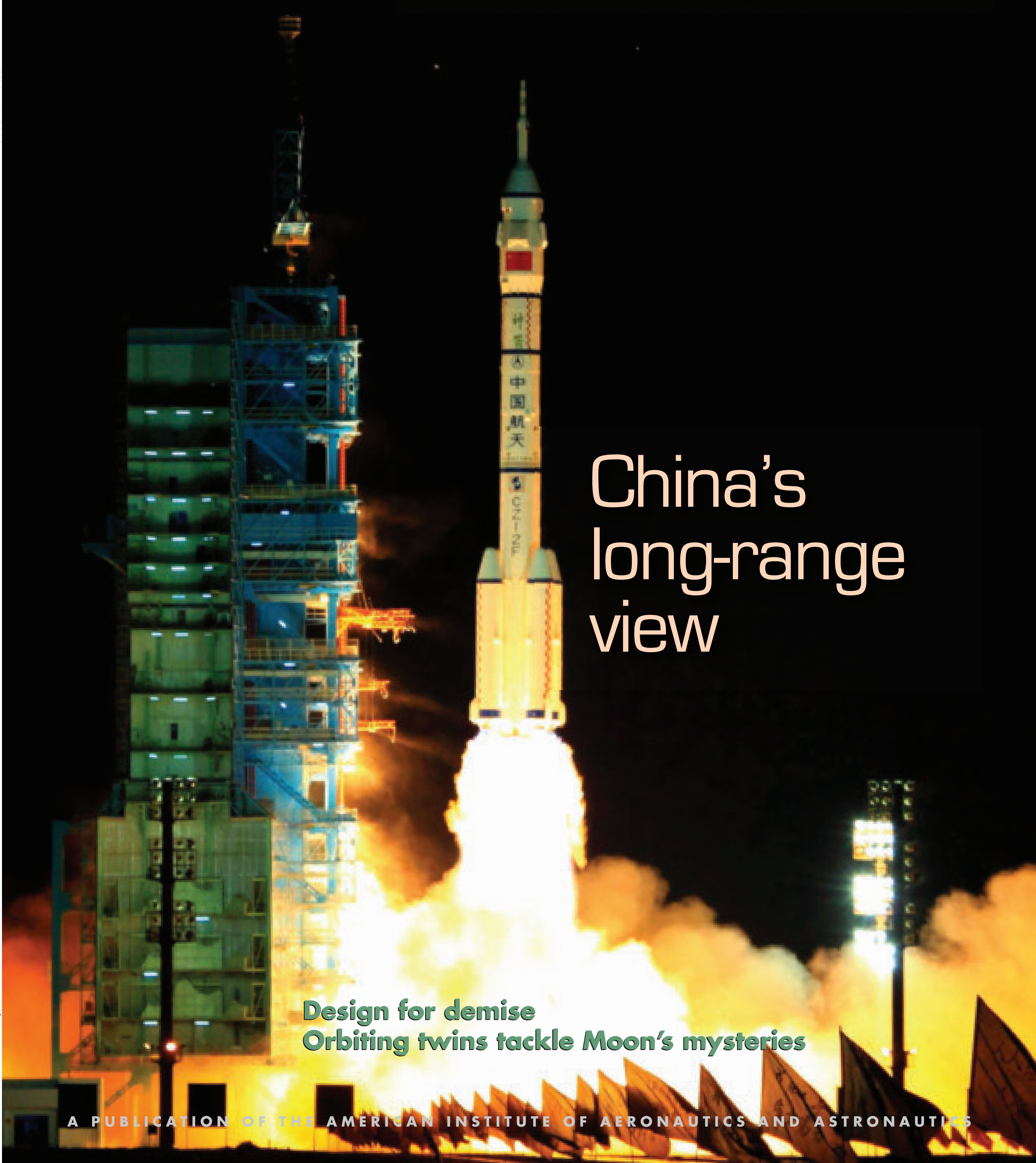
February 2012

AEROSPACE AMERICA

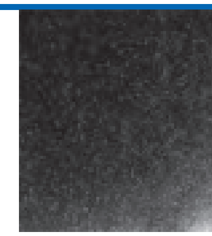


China's long-range view

Design for demise

Orbiting twins tackle Moon's mysteries

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS



Science spacecraft learn self-control

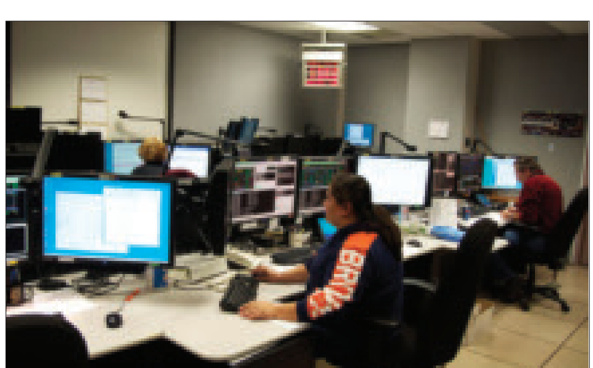
One of the money-saving ideas percolating at NASA is to make even greater use of automated control and multimission operations for scientific spacecraft.

Since May, for example, computerized telemetry and control have enabled NASA to leave the vaunted Hubble Space Telescope unattended after 5 p.m. and on weekends, although the telescope retains its own control center. "The command and control center is empty evenings, nights, and weekends, but can also be largely empty during the day," says NASA's Patrick Crouse, the Hubble operations project manager, in an email relayed through a spokesman.

Still, automation and the bolder step of controlling multiple spacecraft from a single control room have not gained full traction within the agency. The reasons for this are either cultural hesitation or wise engineering, depending on who's doing the talking.

Scripted control

Among the strongest advocates for automation and multimission control are executives at Honeywell, NASA's prime contractor for Mission Operations and Mission Services, or MOMS. Through this contract, Honeywell helped NASA establish Goddard's Multi-Mission Operations Center, known as the MMOC. Over the span of five years, Honeywell engineers worked with NASA's spacecraft developers to write computerized scripts to replace human keystrokes for such command tasks as contacting the spacecraft, preparing for maneuvers, and receiving science data. The procedures were carefully tested before full control of NASA's Advanced Composition Explorer, or ACE, and Wind spacecraft were formally shifted to the MMOC in early 2010. The question for NASA remains whether additional spacecraft will be controlled there, and which ones.



HST flight controllers work at their consoles in the HST Mission Operations Room at NASA Goddard. Photo by Ed Campion.

Even the strongest advocates of automation say there are limits. "One of the golden rules is, if you are burning thrusters or doing some kind of attitude control maneuver, you have to do that manually," says Ed Nace, Honeywell's space sciences mission operations manager at Goddard. Nace oversees 65 engineers, some of whom help run the MMOC. Others are helping the agency automate missions controlled elsewhere.

This caution is necessary because a mistake made during a maneuver could expose an instrument to sunlight, throw the craft out of thermal balance, or shift the angle of its solar arrays, causing a dangerous drop in power. Someone must be on hand to abort the event if necessary.

Nace says pauses are programmed into the automation to allow human operators to step in temporarily to oversee maneuvers but that preparations such as acquiring a spacecraft's signal can be automated.

After all the years of figuring out how to automate operations safely, Honeywell wants to prod the agency, but without offending an important customer. After an initial interview with *Aerospace America,* D.J. Johnson, Honeywell's vice president for space, networks, and communications, sent a clarification via a spokesman: "Automation decisions are based on a balance of where it's practical to reduce cost, and in a way that will not adversely impact mission objectives."

For his part, Nace describes the MMOC as an underutilized asset. It is equipped to control up to 10 spacecraft, he says, but following an operational readiness review in March 2010, it now controls just two very old craft. The first, Wind, was launched in 1994 to study solar wind particles and is now orbiting at the L1 libration point. The other, ACE, carries six high-resolution sensors and three monitoring instruments to sample low-energy solar particles and high-energy galactic particles. Launched in 1997, it has a collecting power 10 to 1,000 times greater than its predecessors, according to NASA. Wind is now the backup for ACE.

A third spacecraft, TRACE (Transition Region And Coronal Explorer), was decommissioned last year after conducting its final observation of the Sun in June 2010.

Old school method

Why are no Earth sciences missions controlled at the Goddard MMOC? "Well," says Nace, "there you get into some politics—the 'not invented here' syndrome."

He points out that NASA's funding for Earth sciences and space sciences, including studies of the Sun, is divided between the two basic mission categories. In Nace's view, the major Earth sciences missions—Aqua, Terra, Aura—have not been subject to the budget pressures that drove NASA managers to place ACE, Wind, and TRACE into the MMOC. Over a five-year period through 2010, he says, annual operating costs were reduced from $20 million to $12 million. "We went from three huge MOCs [mission operations centers] to one MOC. We went from about 250 work station-type computers to Red Hat Linux PCs, which are virtually $500 PCs."

There is no reason something like this could not be done in other areas, Nace says. "Earth sciences people have their own idea about where they want to go. They are still in what we call the old school of flight operations, where they have continuous people coverage 24 hours a day."

Honeywell is pushing, but NASA officials say multimission control and additional automation must be considered very cautiously. A manager in the Earth Observing Systems branch says there are sound technical reasons for keeping human operators on hand and maintaining separate control areas for the major Earth monitoring spacecraft. Aqua, Terra, and Aura are controlled at the same Goddard facility, but each has its own control area within that facility.

"The larger EOS missions are extremely complex and may not be fair to compare with Wind and ACE," Goddard's Eric Moyer writes in an email. Moyer is deputy project manager for technical matters in the Earth Science Mission Operations office.

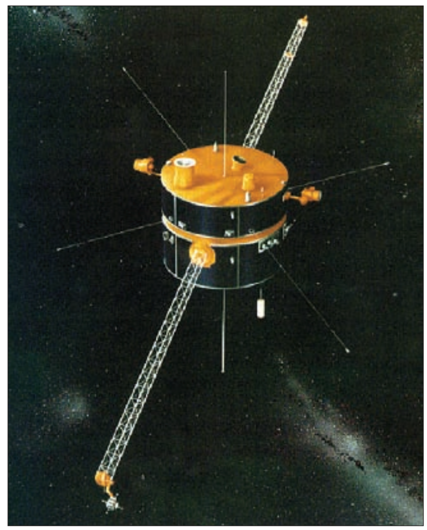
Wind and ACE send their data collections to Earth once a day. "Terra requires the data to be played back every orbit [99 min], or science data will be lost," Moyer says. A person must be on hand to troubleshoot.

In the MMOC, there might not be enough 'reaction time' to fix a problem and avoid loss of data, he says.

A loss of data from Terra or the other environmental satellites could reverberate among global warming researchers around the world, notes another NASA official.

Nace says the staff at the MMOC has thought about this. Automated scripts, he says, can be written with the ability to pause and to alert human operators in the event of trouble.

"You can virtually look on your BlackBerry and see the process you're going through. And if you get a long message that says, 'I'm out of limits,' or 'this command didn't go through,' you'll be paged," he notes. "This allows fewer people to do more work. Even during the day, even though we have people here, they may be in the back room doing something else, and you are going through this automatic script to command your spacecraft. If something goes wrong, it alerts them. They can walk into the next room and take charge," he adds.



Right now, the Wind (above) and ACE (below) satellites are the only ones being managed by the MMOC.

Even if NASA were willing to risk losing some Earth sciences data on an orbital pass—after all, the environmental changes being measured play out over months and years—managers are unconvinced of the technical and financial sense of turning to multimission control.

"Switching to another command and telemetry system for the EOS missions would require significant hours to reproduce the procedures, plots, and display pages, as well as reverify and revalidate," Moyer says. "Unfortunately, this also would add risk, as many of the critical contingency procedures developed were tested with the spacecraft during prelaunch exercises and cannot be accurately tested against the high-fidelity simulators."

A new focus?

NASA managers have no plans to shift control of the major Earth sciences missions to the MMOC, but this does not mean that they dislike automation, or that they are not trying to learn lessons from the MMOC. Last year, NASA engineers modified the data processing algorithms and logic on board Aqua and Aura to play back science data automatically, says Moyer.

More automation might be possible, but for the past several years NASA has focused on modernizing the ground systems for the EOS missions.

"With this multiyear ground system refresh nearing completion for the EOS missions, the focus is turning toward enhancing automation," Moyer explains.

For now, "human involvement is still required" to meet the science requirements and respond quickly to malfunctions or anomalies that could threaten the life of the spacecraft or instruments, he adds. Before launch, Moyer says, the spacecraft were programmed to respond automatically to malfunctions or human errors that could threaten the missions. Fixing less severe problems still requires human intervention on the next contact with the spacecraft.

Engineers are "evaluating how these responses can be automated from modifications to onboard flight software code or ground system scripts," says Moyer.

Though mission managers are hardly flocking to the MMOC, NASA officials have reviewed the processes

(Continued on page 29)

(Continued from page 25)

there as part of a study examining how the agency might make greater use of automation.

Economics

Crouse, the Hubble operations manager, is one of NASA's multimission and automation pioneers, having led the MMOC development effort before moving over to the HST program. He says NASA needs to look closely at the technical risks and economics of moving systems into the MMOC.

"I believe that it is possible to incorporate additional missions into the MMOC and reduce their individual recurring costs of operations," he says.

But which missions? NASA officials cite reasons not to move many of those currently in space. The Solar Dynamics Observatory, launched in 2010 to provide near-continuous observations of the Sun, is not a possibility, because of its 24-hr data requirement. The Earth sciences missions are considered too complex, as are larger observatories like Hubble.

Another problem is that money must be spent in order to save money. Moving the control of an existing spacecraft would require enlisting engineers who understand precisely how that specific craft works. Commands that could inadvertently damage an instrument must be completely understood and avoided in the automation processes.

Next, scripts must be written for the tasks that can be performed safely by computers. As a confidence-building measure, the old control center might have to be run in parallel with the portion of the MMOC dedicated to the transferred mission, as with the ACE, Wind, and TRACE missions.

On top of that, network security must be closely considered in this era of cyber attacks and hacking.

The bottom line, one official says, is that a mission needs to have a lot of life left to justify the transition costs.

"I would expect that a better opportunity for a return on investment would be, for new missions in development, to baseline the MMOC for their operations from the outset," says Crouse.

Nace agrees that multimission control should be designed in from the beginning of new missions. "A lot of the startup cost for a new mission is typically in the $30 million-$40 million for an MOC. We have an existing MOC with an existing architecture," he says.

Among the perceptions Nace is working hard to dispel is that a multimisson center must control similar satellites—for example, different versions of GPS satellites—and that only new spacecraft can be incorporated.

Anticipating multimission control from the start of a project is wise, he says, but this does not mean it is impossible to adapt existing spacecraft. With ACE, Wind, and TRACE, "we're talking about missions that were 10, 12, 15 years old and were very manual," he says. "It's pretty easy to put a brand new mission into an automated environment when you build it with that in mind."

Lessons learned

Nace points to several lessons from his team's experience. The first is to bring in the spacecraft engineers.

"Within our team we did not have a group of software gurus do this. The best people to do this job, we thought, were the people who knew enough about the spacecraft and ground system," he says.

Another lesson, says Nace, is that it makes sense to produce spacecraft in-house—at Goddard, for example—so that the same engineers who make them also become the ones who oversee the automation.

"We have a great opportunity here, where Goddard actually builds some spacecraft in-house," Nace says. "We get to work alongside the Goddard engineers as they develop instruments and put them onto the main bus. Those people will turn into the postlaunch flight engineers, which is a great advantage over a mission [where the spacecraft] is built by some other company and we are then taught how to fly it. You just don't know the intricate workings of the spacecraft the way you do when you help build it and test it."

Ben Iannotta
biannotta@aol.com