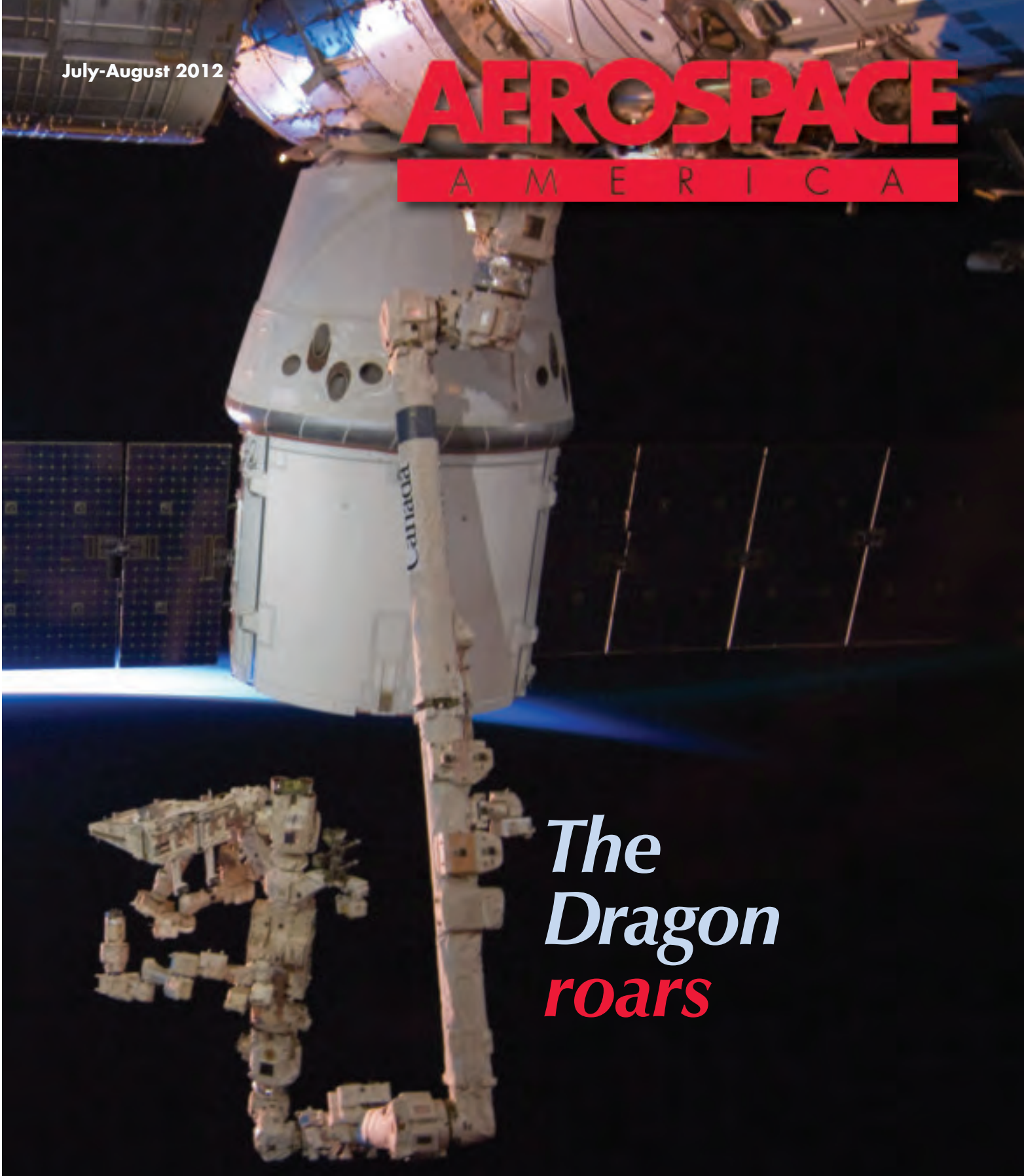
July-August 2012

AEROSPACE AMERICA



The Dragon roars

Mars Science Laboratory: Going for a touchdown

A conversation with Norman R. Augustine

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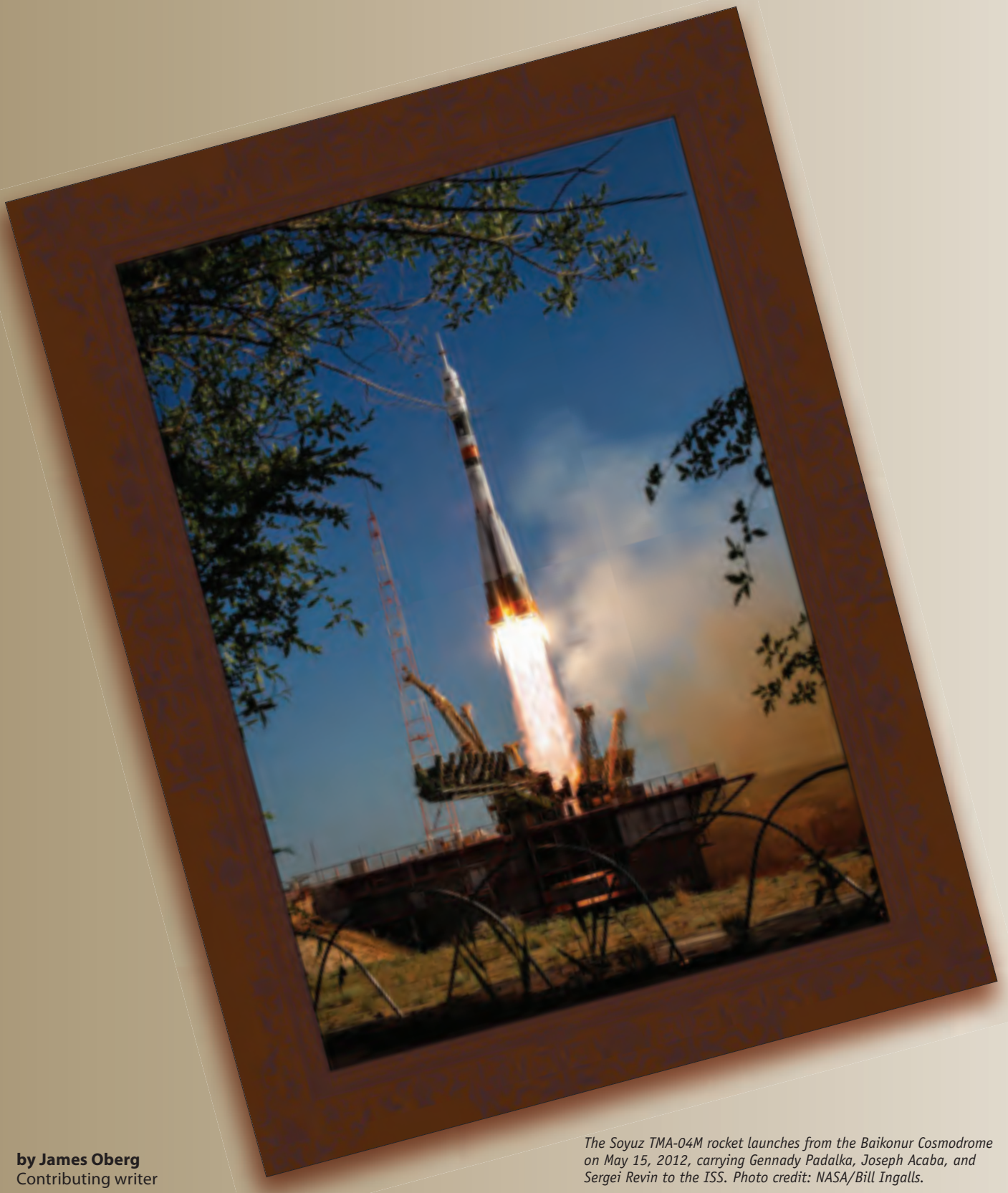
Russian space



The Soyuz TMA-04M rocket launches from the Baikonur Cosmodrome on May 15, 2012, carrying Gennady Padalka, Joseph Acaba, and Sergei Revin to the ISS. Photo credit: NASA/Bill Ingalls.

by James Oberg
Contributing writer

program recovers

Russia's space enterprise has been on a roller-coaster ride since a string of major failures began last year. The resulting shock and chaos led to high-level investigations that have uncovered serious problems, both technical and managerial, of long standing. Recommended remedies have begun to turn a disastrous situation around, but fully addressing the root causes will take time, modernization, and money.

Between July and December 2011, the Russian space program took a wild ride from exultation and exuberance to despair, then back to determination. Marking the end of the U.S. space shuttle program, the Russian Federal Space Agency, or Roscosmos, boasted on its website, "The Age of Soyuz has arrived—the era of reliability." Within a month came the shock and dismay at the first-ever failure in the 30-year-long Progress space station resupply series. This was followed by gradual restoration of confidence leading to the successful resumption of both unmanned Progress and crewed Soyuz launches.

That recovery, however, was buffeted by embarrassing failures in other major programs: A new generation of communications satellites suffered a launch mishap; and what was intended to be the flagship of Russia's return to interplanetary exploration, the Phobos-Grunt mission, ignominiously tripped and fell on its face right out of the starting gate on November 9, 2011.

Then, despite the resumption of full staffing aboard the ISS in late December, the year ended on a glum note when another unmanned Soyuz booster failed to launch a Meridian military communications satellite. The booster broke down, apparently coincidentally, during the same third-stage firing sequence that had doomed the Progress mission in August. The Soyuz failure, which showered fragments near the Siberian city of Novosibirsk, was followed by the fiery crash to Earth of the stranded Phobos-Grunt probe in mid-January.

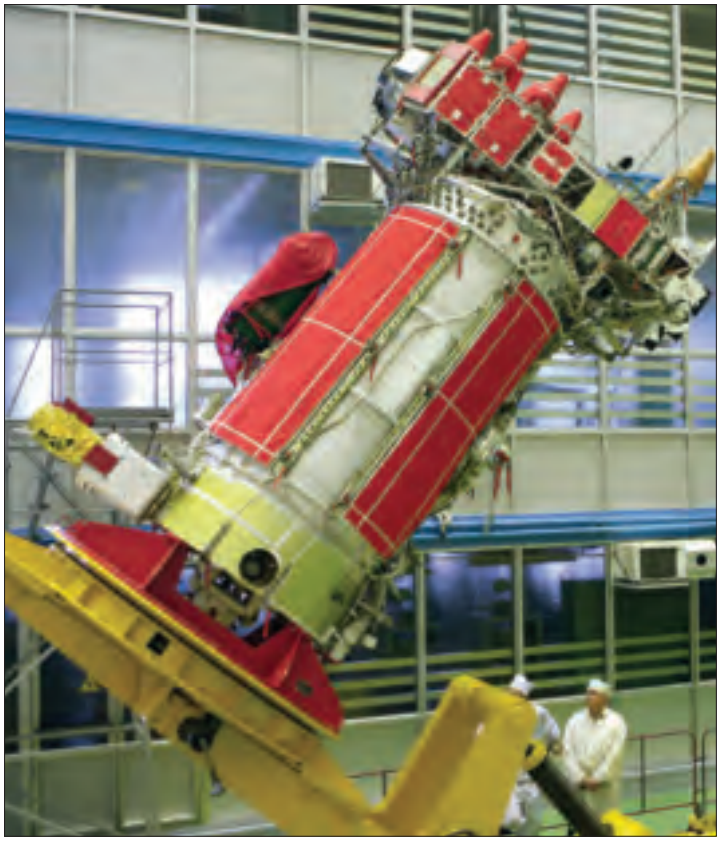
Addressing the crisis

Vladimir Popovkin, the recently appointed head of Roscosmos, grimly admitted at a news conference on December 23 that Russia's space program was indeed in a deep crisis. The issue was elevated to the level of Deputy Prime Minister Dmitry Rogozin, who was tasked with alleviating the reliability and quality-control problems throughout the military industry. The widening of the assignment threatened to bump spaceflight to a level of secondary importance.

The loss of specific focus on the space industry has direct ramifications beyond the scope of Popovkin's duties, since he had not been speaking for his own country alone. The U.S. decision to rely exclusively on Russia's space transportation services for crew rotation to the ISS has made any Russian space crisis into an American space crisis as well. And the emotional roller-coaster ride the Russians had experienced was reprised among U.S. space officials, with the added burden that NASA was merely a passive passenger on this journey and had little input, or even insight, into the steering.

Gauging safety

Progress 44 was launched August 24, 2011. Early in the third-stage burn, the RD-0110



The general prosecutor's office concluded that four Glonass satellites had failed because builders had used microcircuits that were not radiation hardened.

engine shut down and the vehicle fell back into the atmosphere and disintegrated.

On August 29, a Roscosmos official described "irregular functioning of the gas generator" leading to "nonstandard pressure in the fuel tank." On September 8 the official commission announced that the gas generator's failure was due to "partial clogging" of the fuel pipe to the generator.

Extensive review of handling procedures and fueling systems uncovered no signs of anything that could have caused the introduction of a "foreign object."

In terms of safety, the Soyuz and its booster remain acceptable mainly because of a robust 'defense-in-depth' design. This means it tolerates failures whose occasional occurrence costs performance or mission success, but never—for over 40 years—crew loss. Had the August failure (or the December failure of the Meridian) occurred during the launch of a crewed vehicle, the crew would have survived a strenuous high-*g* descent into the mountainous region. A Soviet cosmonaut team lived through an almost exact duplicate of that event in April 1975.

Popovkin admitted as much at a September 16 press conference in Moscow. "We do not know the exact location of any alien item," he admitted. "It would be desirable to find the material part in order to be able to say for certain where the production process went wrong, where this alien item was located, and what it was," he continued, but the destruction of the third stage made that impossible.

There is even evidence that ad hoc workarounds intended to counter hypothetical problems can themselves introduce new hazards. How modifications to standard processing procedures can negatively impact safety became clear following a discovery made after the September 16, 2011, landing of the Soyuz TMA-21: Temporary screws had not been removed from cooling system fluid connectors between the command module and the orbital module that was jettisoned during descent.

"The presence of these screws may cause off-nominal separation," a NASA activity report noted. That possibility necessitated a 4-hr inspection of the interface on the still-in-flight Soyuz to ensure the screws had not also been left in place (they had not been). Removing them was necessary "to ensure safe conditions for a nominal landing," a tacit admission that the TMA-21 landing had *not* been safe, because of a human error by the ground crew.

The failure to remove the screws was due to a "vehicle processing" change made after damage was suspected following a railway accident that occurred during transport to the launch site. The spacecraft had to be replaced by the next-in-line production vehicle, whose checkout had not been completed at the factory. The replacement was rushed to the launch site, where the error (and who knows how many other errors) occurred during the checkout process.

The threat of 'off-nominal' separation is serious: Repeated flaws in pyrobolts had caused two earlier missions to suffer loss of stable attitude at the beginning of entry.

Less visible failures

Crashing rockets are spectacular causes of failed missions, but the Russian program has suffered even more expensive losses when boosters succeeded but payloads failed. Early in 2011, the general prosecu-

"A generation was lost for the space industry, when it was struggling to survive...." Georgiy Grechko

tor's office in Moscow concluded that four Glonass satellites (each valued at $25 million) had failed in 2009 after reaching orbit because builders had used Taiwanese microcircuits that were not radiation hardened. With Russia's spacecraft fabrication facilities relying on foreign components for well over half their avionics because in-country vendors have lost the ability to manufacture the appropriate circuits, this is a vulnerability that promises to linger for years, if not indefinitely.

The poster child for this problem was the Phobos-Grunt debacle, which the official accident investigation board blamed on "non-space-qualified" foreign microchips—even though the far more likely cause was program management error in validating the flight software.

After each new failure, Russia had no shortage of experts eager to offer their own diagnoses of the collapse of the Soviet-era space industry. One news media favorite, and a legitimate expert, is former cosmonaut Georgiy Grechko, who also had an honorable career in the spacecraft fabrication industry.

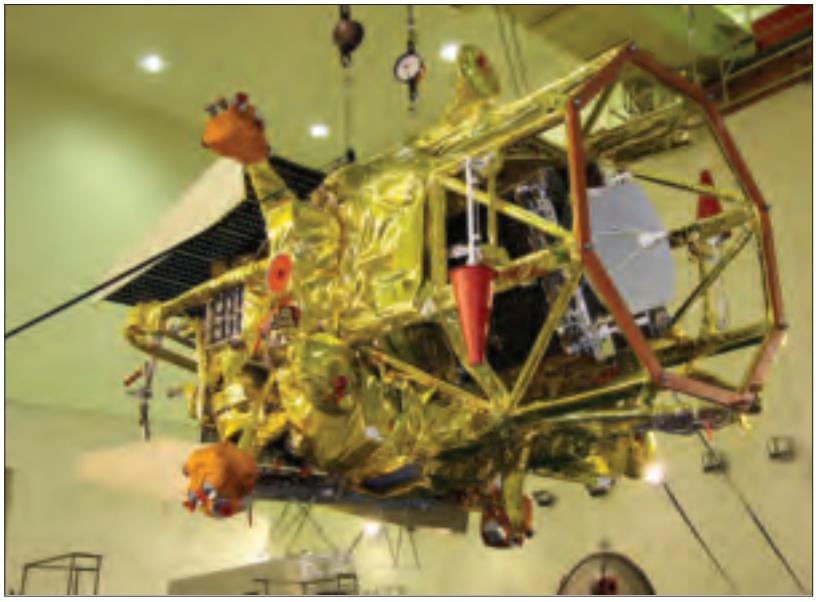
On August 26, he told Interfax news agency, "This is precision technology that borders on fine art, yet young people are not being trained and old people are leaving." Interviewed after loss of the Phobos-Grunt probe on November 9, he repeated his refrain: "The scariest thing is that in 20 years everything was brought to ruin, so now no matter what they do, no matter what they pay to save it, nothing will be accomplished in 20 days....You need at least 10 years to rebuild everything."

"The staff employed are either over 60 or under 30. There is no intermediate age group," he later added. "A generation was lost for the space industry, when it was struggling to survive....People, most of them young, energetic and talented, would seek higher earnings in other places. The space industry could not offer them any decent salary."

Concerning the failure of Phobos-Grunt he said, "We last launched such a sophisticated system some 25 years ago. Think what the 25 years mean for the space industry. A shift of generations occurred."

Investigations and skepticism

Meanwhile, the 'magic clog' explanation for the Progress failure did elicit some skepticism. Russia's counterpart to the U.S. attorney general's office performed a criminal investigation of the accident. Contrary to claims that the failed engine was fabricated correctly, the probe found that records showed "multiple deviations from the design documentation" for the engine processing. It also complained that the initial investigation had only involved 'insiders' from the enterprise whose quality of work was under investigation, sparking suspicion about the "objectivity of the conclusions."



The loss of Phobos Grunt was originally blamed on the use of "non-space-qualified" microchips.

Another demurral from the official conclusion came from Igor Lisov, a respected space journalist with *Cosmonautics News* magazine. In an August 29 interview, he referred to inadequate investigation of a persistent 10% failure rate for the Briz upper stage. "Often they don't even have the source data needed for analysis," he stated, "and they accept easily fixable malfunctions as true causes." The accidents have continued, and Lisov urged: "We need to find out if it's due to design errors or defective parts," since without an accurate diagnosis, any 'fix' will have only a placebo effect on future launches. This was another prescient warning of disasters yet to come.

Similar suspicions were attributed by Interfax on August 26 to "a member of Baikonur Cosmodrome's management," who told them (without allowing use of his name) that no new "task force" would resolve the problem of quality, because of fundamental changes in the quality control process over the past 20 years.

"The current quality assurance system was created in Soviet times," the source explained. "Quality is controlled at all stages of launch vehicle, upper-stage, and space-

A Russian Soyuz rocket launches the unmanned Progress 44 cargo ship from Baikonur Cosmodrome on Aug. 24, 2011, to deliver fresh supplies to the ISS. The rocket and spacecraft crashed in eastern Russia just over five minutes after liftoff. Credit: RSC Energia.

craft production and assembly. It is the plant's technical control department and military representatives, that is to say representatives of the armed forces in civilian organizations, that give the go-ahead for the finished, assembled product to be shipped to the spaceport."

The difference today is that these former military inspectors are now paid by the civilian companies. So the greater the amount of hardware shipped, the better their relations with their management, and the bigger their bonuses will be. Thus they have become reluctant to make a fuss if a fault is found with a rocket or satellite. Instead, the source reported, "everything is settled internally."

"It is simply impossible to tackle this job in task-force format," the source believes. It would be ineffective, creating yet another management structure and spreading responsibility for quality control "even more thinly," he said. The recommendation also is unworkable, he continued, because it does not explain where to get the required staff of hundreds of trained experts—the kind of workers that "virtually every company is now short of."

Instead he recommended the acquisition of computerized quality control systems, to be "introduced from the bottom up, on site" in all stages of fabrication and testing. "This process is expensive and not quick, but there's hardly another way."

Attention from the top

With the failure of the Meridian launch last year, Prime Minister Vladimir Putin finally gave more than lip service to concerns over the chain of mishaps. He appointed a new deputy prime minister, Dmitriy Rogozin, and tasked him with revitalizing the entire defense industry, of which the space program is only one segment.

On December 26, state-owned Russian news channel Rossiya 24 showed Putin telling Rogozin: "As regards the rocket and space sector, as you can see yourself, a certain negative potential has accumulated there, too. Recent breakdowns, a whole range of breakdowns, speak for themselves.

"These problems should be thoroughly examined and investigated, and appropriate proposals should be submitted," Putin continued. "Some things are on the surface. After we abolished military acceptance in the rocket and space sector, in connection with the separation of military issues from it, unfortunately many things have gone worse. This does not mean that we need to return to previous methods of regulation, but it is completely obvious that the existing ones are not sufficient".

Defense Ministry-controlled Zvezda TV, Moscow, on December 26 showed Rogozin telling Putin: "I am ready to submit to you, in the very near future, proposals about reviving the defense-industrial complex. One of the most important aspects is, in fact, a new industrialization of the defense-industrial complex, which should serve as a locomotive for the growth of the entire Russian economy and industry. The second aspect, of course, is people, the human factor. Moral and material incentives should be created to attract young people, highly qualified personnel to the defense industry."

Recommended remedies

Illustrating one route to recovery was the successful effort to overcome a years-long series of frustrating and apparently random failures in the development of the Bulava sea-launched ICBM. Roscosmos managed the project, which by the end of 2011 had had several successful launches in a row.

The problems were solved by tightening control over its production, Gen. Nikolai Makarov, chief of the General Staff of the Russian Armed Forces, told the Moscow Echo radio station on February 20. "We are speaking of production technology," he was quoted as saying. After several launches failed, "we suspended the tests and looked into the cause. The cause was also hidden to a certain extent, attributable to human factors—to people not doing their job professionally," he said.

"Often they don't even have the source data needed for analysis, and they accept easily fixable malfunctions as true causes." Igor Lisov

"We assigned military acceptance officers to key positions where they could monitor every process. And after that all the launches [of Bulava] succeeded. That's all! We realize that there is a very serious problem in our defense industry; that a person, a worker, should do his job conscientiously. Unfortunately, we have to check them and what they are doing very closely. And we are intensifying the process."

These conclusions were confirmed in a long, candid interview with Yuriy Koptev, an emeritus space program manager who had been the first head of the then-newly formed Russian Space Agency in 1992. As published in the March 30 issue of *Kommersant*, Koptev pointed out the organization responsible for developing the missile was also responsible for reviewing its flight readiness before each test. "An institution of independent expertise must be restored immediately and provided with corresponding funding through the agency of lead institutes," he wrote.

Responding to criticism about imposing a "new oversight bureaucracy," Koptev argued it was the long-overdue restoration of a former system that had served well. "Nothing has to be invented!" he emphasized. The rocket-space sector, which began operating on an industrial basis in 1946, already has endured regulations and statutes in all directions in rocket and space technology. The process was precisely defined and documented.

"As soon as we began violating these canons, we ended up with unpleasantness and accidents," he argued. "The function of Roskosmos is to ensure unconditional fulfillment of the arrangement specified by a normative document. I support Popovkin's decision to establish a representation of lead institutes in each organization of manufacturers—then who is doing what and how really can become visible."

As for applying the 'Bulava solution' to the rest of the space industry and the high-tech military industry beyond, Rogozin was true to his word. By mid-February he had completed his diagnosis, and on February 28 he presented an insightful status report to the Russian government delineating the problems and offering a recovery plan.

Massive investment in acquiring new fabrication equipment will be needed to replace obsolete and worn-out tools across the entire military industry, said Rogozin. "We have to radically modernize the production-technological and experimental-test base," he told the Duma. Specifically addressing Roskosmos and its supporting contractors, he said, "I cannot ignore the question of why failures have become more frequent in the missile-space sector, especially as there have been calls in this connection to demonstratively punish corrupt officials and careless individuals." Rogozin endorsed Popovkin's recovery strategy.

"Problems connected with rocket-space equipment…are caused both by the absence of a domestic electronic component base with appropriate characteristics and by a significant reduction in the institution of military representations at enterprises," he explained. "On the whole, we are talking about the systemic nature of problems in industry and in the cadre training area."

As part of the get-well plan, he continued, "we already are taking steps to increase the responsibility of heads of organizations for performing their assigned tasks and achieving measurable results. Certainly displays of negligence and ignoring of the already existing regulatory legal base must

After a series of frustrating failures, the Bulava submarine-launched ICBMs have now had a string of successful launches.

not go unpunished. We intend to continue to give special attention to the level of executive discipline. However, punitive measures in themselves will not ensure increased reliability of domestic equipment."

But the main thrust of Rogozin's plan involved the return of end-user inspection teams to all production enterprises, including space but mainly military systems. However, he did give a warning: "The system of military representations in itself is no panacea. It is a necessary but still insufficient condition for improving the quality of manufactured products. A system of unique quality management must exist and function in parallel with military representatives at all enterprises, without exception, participating in the manufacture of military products."

At least one rocket plant seems to have fallen into disrepair. Photo by Lana Sator.

While these are laudable goals with a reasonably high likelihood of success in the long run—especially if sufficient young talent is induced to enter the aerospace labor market—the priority in terms of attention and resources given to the defense-related industries may leave the spaceflight industry recovery underfunded and undermanaged, even with Popovkin's best efforts. And the "long run" implies that many of the factors that contributed to recent problems remain in effect, even if somewhat diminished. The lamentably long list of recent Russian space setbacks—and their worldwide consequences—may not be complete.