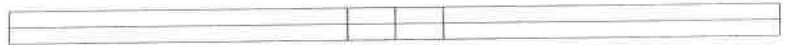


PICTURE WINDOW



With his head aimed up (or was it down?) NASA astronaut Michael Foale floated weightlessly through the hatch into the *Destiny* laboratory module of the International Space Station (ISS), focused even more than yesterday, determined to find the source of their problem once and for all. They had spent almost every waking hour in the past 10 days trying to locate the air leak. Next to a fire or collision with another object, the greatest danger they faced while circling Earth at 17,000 miles per hour was the loss of their atmosphere into the vacuum of space inches away on the other side of the wall. Technical experts on the ground believed they detected signs of declining air pressure in the station, a situation which, if not addressed, could have dire consequences in time. Technically speaking, it was Sunday, Michael Foale's official day off, but there was no doubt in his mind that the only thing to do on this day was work the problem. The hunt for the leak had gone on for far too many days; now was the time to find the source of their troubles.

The first sign that air was escaping from the station came on January 2 when ground controllers in Houston concluded they were losing internal atmospheric pressure. Michael Foale and his lone fellow crewman, Alexander Kaleri of Russia, were told of the situation in calm tones during the next voice communication with the ground. The crew need not be alarmed, at least not yet, said the controllers, but, until they understood the problem and found a solution, other activities on the station

had to be put on hold. What the ground controllers were seeing, Foale and Kaleri were told, wasn't an explosive fall in pressure, like what would happen if a valve or hatch blew out. To the contrary, this leak was slow, kind of like an air mattress on a camping trip that didn't seem as firm in the morning as it did the night before. It was a subtle problem but, nonetheless, one that would eventually jeopardize the crew and the station if they did not sort it out.



ISS was designed to maintain a constant internal pressure of 14.7 pounds per square inch, the same pressure that exists at sea level down on Earth. The fall in air pressure had been both slow and small, so slow and small, in fact, that some Russian technicians in Moscow felt that what NASA had concluded to be a problem was, in fact, only the normal fluctuation in pressure expected of a large pressurized craft aloft in space. Everyone acknowledged that the station was never designed to be perfectly sealed like a glass sphere; its complex surface was comprised of welded joints and compressed gaskets and closed valves that would naturally lose a little air over time. The space station's air pressure, the argument went, rose and fell slightly all the time, especially in response to the alternating heating and cooling each time the 30-billion dollar football-field-size craft orbited the Earth 17 times each day flying alternately through the sun's bright rays and Earth's cold shadow.

But a careful check of the historical data beamed down to Houston proved otherwise. There was, in fact, a leak, and not only had they been losing air pressure since January 2, an analysis of old data showed that pressure had been dropping for at least 10 days before, for a total of three weeks. Instead of having the sea-level equivalent of 14.7 pounds per square inch,

the International Space Station's pressure had fallen over these weeks to 14 pounds per square inch, the equivalent of an altitude of 2,500 feet above sea level. Perhaps the analogy to the leaky air mattress was not that far off the truth.

For more than a week, Foale and Kaleri had been checking the hundreds of possible sources — hatches, windows, ports, and vents. There was even the possibility that the space station had been punctured by a microscopic object as they orbited Earth, but this seemed unlikely in view of the lack of any other signs that they had had a collision, no matter how small. No, Foale and Kaleri both felt that the problem would ultimately be traced to a piece of equipment, perhaps a seal or a small part and hopefully, of course, not to one of the large main seals between the many large modules that made up ISS. Like tightening the tourniquet hard around a hopelessly mangled leg of an accident victim to save his life, they would have to close off one or more of the large hatches and abandon key modules in order to save the station if the leak was in a hatch or seal between two large modules. The two astronauts and everyone supporting them on the ground had worked somewhat nervously for days, hoping that the situation was not so acute that drastic measures like this would be necessary, but they knew it was a distinct possibility.

Upon receiving instructions from the ground, Foale and Kaleri had already closed off compartments at the remote ends of the station to begin the process of isolating the leak. All readouts showed that the pressure falloff had continued, meaning, unfortunately, that the leak was more centrally located and not within the remote areas they had sealed off first. In the meantime a bit of finger pointing was taking place back on Earth, where some in the American camp were suggesting that a Russian air-purification unit was the culprit: each time they switched it to a different operating mode there appeared to be a change in air pressure. As the undisputed masters of long-

duration space flight, the Russians insisted that none of their equipment could possibly be responsible. Sometimes their designs may have appeared crude by NASA standards, but it was difficult to dispute the proven reliability of their basic components. But regardless of whom, if anyone, was to blame, they had made no progress solving the problem; NASA had come to a harsh decision, a decision for Foale and Kaleri to methodically close off modules and essentially shut down the entire International Space Station until they isolated and fixed the leak. This would all take place within the next few days. The grand space station habitat would become an uninhabitable 30-billion dollar piece of space debris within a few hundred hours if they were not successful.



Unlike some of their American and Russian counterparts on the ground, Foale and Kaleri had gotten along splendidly throughout the duration of their extended flight in space. He was much too humble to say it himself, but Foale was widely regarded as an astronaut's astronaut: a man who possessed the requisite knowledge and skill to do a difficult and dangerous job and get along fabulously with every person he met and every situation he faced. His quick mastery of the Russian language and past space flights didn't hurt matters. Alexander Kaleri, known by friends as Sasha, was also highly likable and possessed the even temperament and global view that is so important in a long-duration space mission. Since the *Columbia* disaster and the grounding of the remaining space shuttles, Russian spacecraft had been called into service to transport crews and supplies to and from ISS. Crew size aboard the station had been reduced accordingly. All in all, there was perhaps no other pair of individuals in the astronaut and

cosmonaut ranks who could have accomplished so much under such circumstances.

Now inside the American-made *Destiny* laboratory module, Foale floated to the main window, possibly the most optically perfect window ever made and most certainly the clearest window ever installed in a spacecraft. It was round and a little over two feet in diameter, and its surrounding circular framework was a seriously engineered structure encasing the layers of glass and seals. The window was the station's main viewing and photographic port for astronauts and cosmonauts to gaze at the Earth or out into space and take undistorted pictures with their cameras and high-powered lenses.

Each large window on ISS had to have multiple layers of glass for strength and safety. On any such window — especially a window to be used as a scientific viewing port — it was essential that the narrow space between the layers of glass be kept free of moisture and air and that there be absolutely nothing between the glass to impair visibility through the window. The growth of mold or mildew in the inaccessible space would render the window's special optical properties worthless. The Russian solution to this problem was to fill the inter-glass space with super dry nitrogen and seal it off, thereby keeping it dry and sterile, and the Russian-made parts of ISS made use of this design approach.

But the American-made *Destiny* module reflected a different philosophy, all due to the goal of creating the best window ever made. Instead of filling the inter-glass space with molecules of nitrogen gas, American designers filled the space with *nothing*. No, not air, and not an inert gas. *Nothing*. A limitless supply of *nothingness* was only inches away on the other side of the window. What better for filling the inter-glass space? Accordingly, next to the *Destiny* module's window at about the 10 o'clock position was a small port and valve, about the size of

a small water faucet, linking the inside of the space station with the vacuum outside. A foot-long loop of strengthened metallic hose stuck out of the wall into the interior of the *Destiny* module, made a tight U-turn, and reattached to the hefty metal frame of the window a few inches away. This created a small but direct path between the vacuum of space and the inter-glass space via the U-shaped hose. The technical name for the loop of hose was a *vacuum jumper*. The result was the presence of *nothing* between the window's glass layers, a near-perfect vacuum where no moisture could accumulate and no organisms could grow to ruin the view through the world's most perfect window.



Had it not been his day off, Michael Foale might have been floating leisurely in front of this very window on his own time, his camera held in his right hand, his left hand holding on to something — anything — to try to keep stationary and not float away when he snapped the shutter to capture a picture of the ever-changing view outside. Gazing out this window and snapping photos was the favorite pastime of most visitors to the International Space Station. Foale had already inspected the *Destiny* module on a previous day of their search, but Kaleri, who had good instincts, had a hunch that they should return for a second look. So now Foale was back again, going over the *Destiny* module for a second time.

And this time he held a special listening device, not a camera, in his right hand. It worked like a doctor's stethoscope and helped him hear the faint sounds of vibrations within objects via a headset. The objects were the hatches, walls, windows, frames, hoses, and machinery linked to the surfaces of the space station, surfaces that might conduct the faint sound of air escaping out a small hole or slit. With each contact of his

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probe to a solid object he hoped to hear the vibrations of a hiss or a whistle in his ears, the sound of air flowing out of their pressurized environment into the void. He listened for anything other than the constant spinning of small motors, fans, and parts that made an incessant low-level drone that might mask the whistle of escaping air out into space.

Then, quite unexpectedly, only days before the entire structure had to be sealed off and essentially shut down, just days before the 30-billion dollar enterprise would be declared inoperative, he heard it. Astronaut Michael Foale had the probe of the listening device touching the loop of silver hose that connected the frame of the picture window and its encased plates of glass to the small port leading to the vacuum on the other side of the wall. He touched the hose with his other hand and moved it gently. The pitch of the sound rose and fell in concert with each slight movement of his hand and the associated opening and closing of a small tear in the hose as the International Space Station's pressurized atmosphere escaped through it and out into space.



In the days that followed, the Russians made public an expansive album of photographs spanning many many months. Each picture featured an astronaut or cosmonaut joyously absorbing the view of Earth while suspended weightlessly in front of the *Destiny* laboratory's picture window. In every case the right hand held a camera and the left clutched the silver-colored metallic hose connecting the vacuum of space to the panes of the best picture window ever made, the space-faring photographer holding steady as the shutter was snapped in the weightless environment of space. The hose was not designed to be a handle, but it was perfectly positioned for the purpose.

Picture Window

NASA acknowledged that a structural handhold and rack system designed to mount over the *Destiny* module window had never been put into orbit and installed in the International Space Station due to the grounding of the space shuttle fleet. Michael Foale and Alexander Kaleri installed a temporary replacement for the hose, and it was later replaced with a permanent part sent up to the International Space Station on a Russian spacecraft.

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