RSNA Press Release

First Diagnostic X-rays in Space Mark New Era for Astronaut Health

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Sheyna Gifford, M.D.

OAK BROOK, Ill. – A team of crew members aboard a commercial spaceflight acquired the first diagnostic X-rays during an orbital flight. Results of the mission were published today in *Radiology*, a journal of the Radiological Society of North America (RSNA).

"It's been a dream for aerospace medicine to have more than one imaging modality for diagnosing illnesses and injuries in space," said Sheyna Gifford, M.D., lead researcher and an assistant professor of aerospace medicine at Mayo Clinic in Rochester, Minnesota. "X-rays are fast, easy and diagnostically valuable."

For more than four decades, ultrasound has been the only reliable medical imaging modality used in spaceflight. As spaceflight missions increase in duration and distance, increasing the risk of adverse medical events, the limitations of ultrasound have become less acceptable. Ultrasound imaging requires substantial operator training and relies on a sound wave transmitting medium.

"Traditional X-ray machines are very large, produce a lot of radiation, and have a tendency to produce a blurred image if there's movement," Dr. Gifford said. "Because everything in space is constantly moving, the conceit has been that obtaining a diagnostic image in orbit was too technically challenging."

The availability of small, portable X-ray machines offered Dr. Gifford's team the opportunity to test in-orbit X-ray capabilities. In 2022, the flight crew, with minimal medical training, took a portable X-ray machine on a parabolic flight and successfully obtained a digital X-ray of a hand in microgravity.

Dr. Gifford's team partnered with the commercial company SpaceX to investigate the feasibility of using a commercial off-the-shelf portable radiography system on Fram2, a 3.5-day polar orbital flight.

"Portable X-ray machines are in use everywhere — at the Kentucky Derby, on the sidelines of the Super Bowl and around the globe in low-resource areas — because they can run on solar power and can be operated by individuals with no medical expertise," she said. "We believed an off-the-shelf portable system would stand a very good chance of surviving prelaunch testing and be operational in space by crew members with minimal training."

In the prospective study, anatomic and equipment X-rays were obtained both preflight and inflight by crew members using an X-ray system featuring an ultraportable wireless digital X-ray generator. All images were evaluated by independent radiologists.

"A spaceflight-ready radiography system would have profound implications not only for crew health but also for mission-critical nonmedical tasks," Dr. Gifford said. "For sustained human presence in space, X-rays are critical not just for crew members but also for other mission components like electronics and spacesuits. The only way to look inside these objects without taking them apart is to X-ray them."

Prior to the Fram2 spaceflight, three crew members received four hours of training on the portable radiography

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system. SpaceX personnel also conducted impact and compatibility testing on the system for the spacecraft. The crew acquired preflight images, including X-rays of a hand, forearm, abdomen, pelvis and chest.

The Fram2 mission launched on March 31, 2025, on a SpaceX Falcon 9 rocket, entering into a 90-degree orbit at 425 to 450 kilometers above sea level. The mission duration was 3 days and 14 hours, and the spacecraft returned to Earth on April 4, 2025. The X-ray generator sustained superficial structural damage during landing and recovery. However, internal hardware components and X-ray output were unaffected.

Inflight images acquired without ground support included X-rays of a phantom object used to calibrate the system, and a smartwatch, hand, forearm, abdomen, pelvis and chest. These inflight images were immediately transmitted to an onboard computer and reviewed by the crew. Upon returning to Earth, postflight X-rays replicating the preflight and inflight images were also acquired.

All X-rays were evaluated by three independent radiologists for overall image quality, spatial resolution, contrast resolution and positioning. The researchers found no differences in the overall image quality, contrast resolution or spatial resolution between the preflight and inflight X-rays. The inflight image quality achieved a diagnostic level for all X-rays, despite the decreased scores for the positioning of the central body X-rays, including the images of the chest, pelvis and abdomen.

“By acquiring the first human and equipment X-rays in space, our study demonstrates the feasibility of in-orbit radiography and expanded diagnostic capabilities for crew health and hardware evaluation,” Dr. Gifford said. “Acquiring a diagnostically useful X-rays in space is something that anyone can do. Three very talented nonmedical people with four hours of training in one of the harshest environments did it right and did it well.”

Crew members strongly agreed that the X-ray system was easy to use and the imaging protocols were easy to follow. They suggested improvements for the radiography system, including mechanisms to securely mount and clamp the X-ray detector and generator. The estimated radiation exposure for crew members was no greater than that associated with standard clinical imaging on Earth.

Dr. Gifford said more prospective studies are needed to establish guidelines for examination indications, image interpretation and imaging baselines.

“It's my hope that we can further reduce the size of portable imaging systems and improve its ruggedness and usability so they can be included in future missions,” she said.

Other space-related applications for portable X-ray systems include imaging malfunctioning satellites in orbit and equipping lunar rovers to analyze the moon’s surface.

“Disseminating autonomous miniature X-ray systems around the globe could also change the game in public health,” she added. “The sky is not the limit when it comes to X-rays in space and here on Earth.”

“SpaceXray: Feasibility and Diagnostic Capabilities of On-Orbit Medical Radiography.” Collaborating with Dr. Gifford were Michael Pohlen, M.D., Adam S. Wang, Ph.D., David J. Lerner, M.D., Anna Wadhwa, M.S., Michael Cairnie, B.S., Jeanne Walter, B.S., Karim S. Karim, Ph.D., Steven Tilley II, Ph.D., Amol Karnick, M.Eng., Marissa A. Rosenberg, Ph.D., and Lonnie G. Petersen, M.D., Ph.D.

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Images (JPG, TIF):

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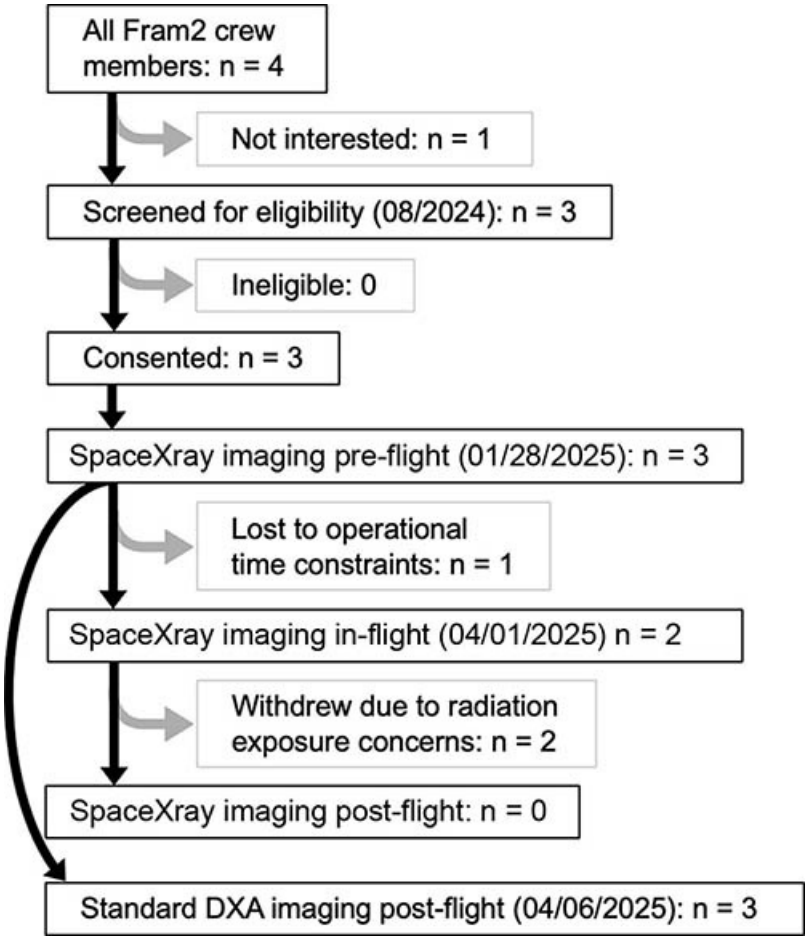


Figure 1. Flow diagram of participants. Date formats are MM/YYYY or MM/DD/YYYY. Three of four Fram2 astronauts participated. All three participants underwent preflight imaging. Only two underwent in-flight imaging due to operational time constraints on-orbit. Due to radiation exposure concerns, all crewmembers opted not to undergo postflight imaging with the SpaceXray system, although they consented to undergo re-imaging at Houston Methodist Hospital as part of the areal bone mineral density research protocol. Non-crewmembers underwent postflight imaging by the SpaceXray system following in-flight protocols to check hardware performance. DXA = dual x-ray absorptiometry.

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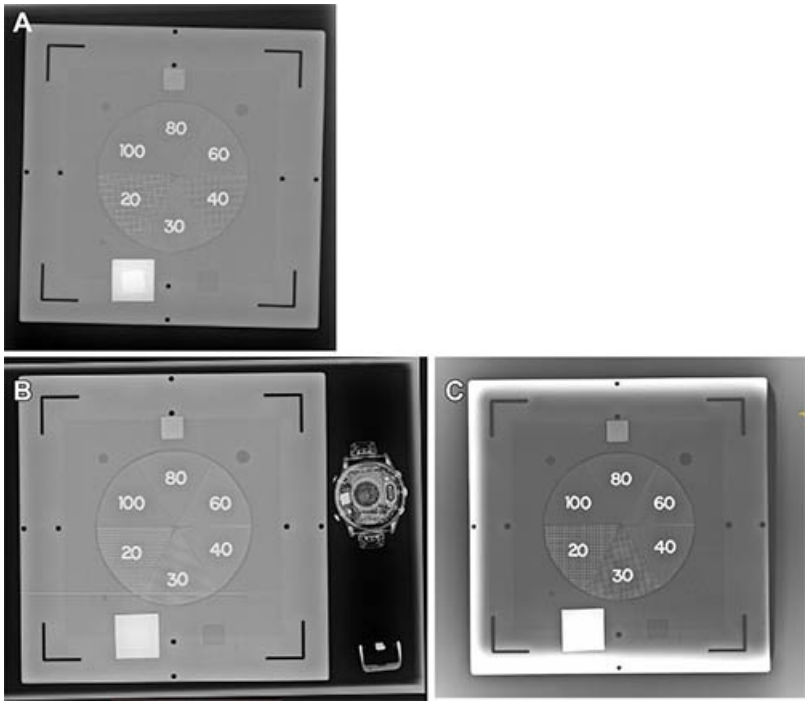


Figure 2. Preflight, in-flight, and postflight nonmedical radiographs. Radiographs of a quality control phantom were acquired **(A)** preflight by crew operators, **(B)** in-flight on day 1 after launch (L+1) by crew operators, and **(C)** postflight by a non-crew operator using the same imaging protocol. Numbers on the phantom represent the number of lines per inch to monitor resolution quality. Similar image quality was observed in preflight, in-flight, and postflight phantom radiographs.



Figure 3. Representative preflight, in-flight, and postflight hand radiographs. Radiographs of the hand were acquired **(A)** preflight by a crewmember, **(B)** in-flight on day 1 after launch (L+1) by a crewmember, and **(C)** postflight by a non-crew operator using the same imaging protocol.

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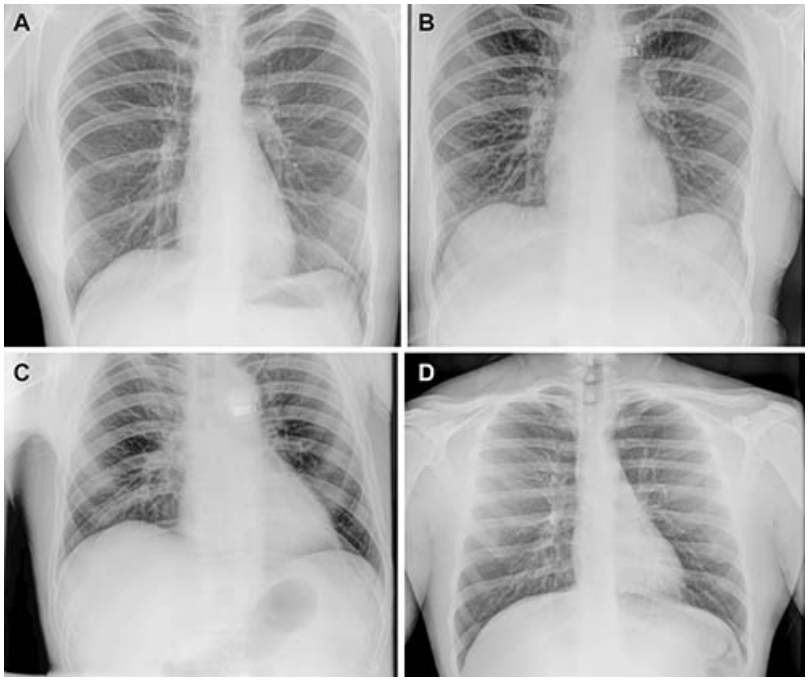


Figure 4. Representative preflight, in-flight, and postflight chest radiographs. Radiographs of the chest were acquired **(A)** preflight by a crewmember, **(B, C)** in-flight on day 3 after launch (L+3) by a crewmember, and **(D)** postflight by a non-crew operator using the same imaging protocol.

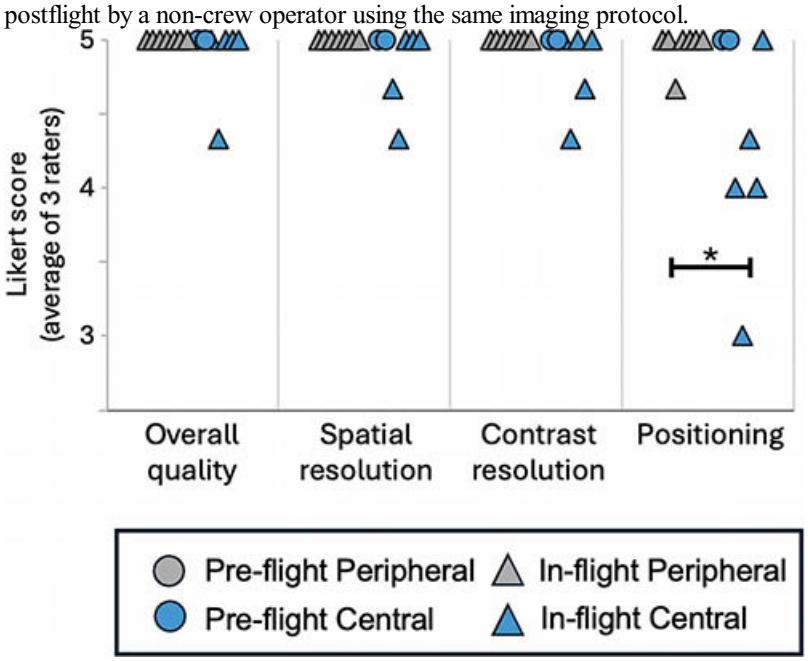


Figure 5. Graph shows comparison ratings for preflight and in-flight radiographs. Preflight and in-flight radiographs were acquired by crewmembers and independently evaluated on four characteristics: overall image quality, spatial resolution, contrast resolution, and positioning. A 5-point Likert scale was used, as follows: 1 = uninterpretable (nondiagnostic), 2 = poor (nondiagnostic), 3 = acceptable (diagnostic), 4 = good (diagnostic), and 5 = excellent (diagnostic). All radiographs scored greater than or equal to 3 for all characteristics, indicating diagnostic quality. Horizontal positioning of points within each category is for visual clarity. Comparing in-flight radiographs with preflight radiographs, no evidence of differences was found in overall image quality, contrast resolution, or spatial resolution, with a nonsignificant trend toward worse positioning in-flight. * = Wilcoxon rank sum P = .03 when comparing central radiographs (seven of seven preflight radiographs, five of seven in-flight radiographs).

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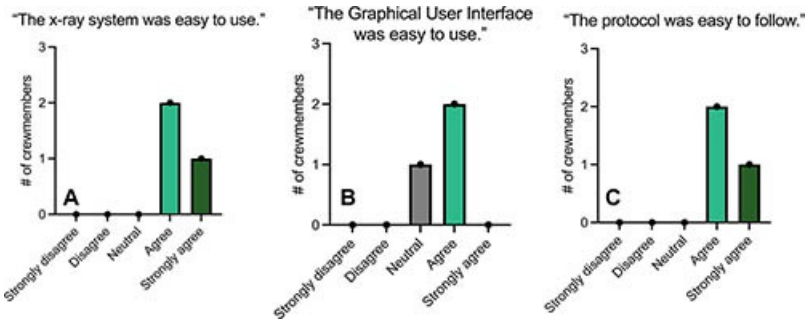


Figure 6. Charts show crewmember survey results regarding the operational use of the x-ray system (n = 3, 2 days after return [R+2]). All three crewmembers who used the system completed a survey at R+2 that included a five-option Likert scale: "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." The three questions were as follows: **(A)** "The x-ray system was easy to operate," **(B)** "The Graphical User Interface was easy to use," and **(C)** "The protocol was easy to follow."

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