Air and Space this Week

Item of the Week

CHRISTA MCAULIFFE AND BARBARA MORGAN

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"The future is not free: the story of all human progress is one of a struggle against all odds. We learned again that this America, which Abraham Lincoln called the last, best hope of man on Earth, was built on heroism and noble sacrifice. It was built by men and women like our seven star voyagers, who answered a call beyond duty, who gave more than was expected or required and who gave it little thought of worldly reward." - President Ronald Reagan's introductory remarks in the Rogers Commission Report on the Challenger *Disaster, January 31, 1986*

TEACHER IN SPACE PROGRAM

NASA has always had a "Science isn't finished until it's shared" approach to the support of both formal and life-long learning.

In my experience, I've found that there are five general topics that engage the educational process for young people, across the entire spectrum of the American public (and those abroad, too): Dinosaurs, Ghosts, Space, the prevailing Fad of the moment, and, well, the opposite gender. Dinosaurs aren't NASA's thing, and ghosts don't exist, so they weren't suitable to use to motivate learning. If one built out a program based on the Fad of the moment, it'd be obsolete by the time it hit the classroom. And, of course, we cannot use the fifth factor!

Space exploration was a natural way for NASA to engage the education process. And what better would there be to help give students of all ages a feeling of having a personal stake in NASA's exploration endeavors than to have one of "their own" fly in Space and return to tell of their personal experiences?

That was the thinking behind NASA's Teacher in Space Project (TISP), a NASA program enthusiastically announced by President Reagan on **August 27**, 1984, thirty-nine years ago this week.

CHRISTA MCAULIFFE

Sharon Christa Corrigan was born on **September 2**, 1948, in Boston. Her early years were spent there, then her family moved to Framingham, Mass, where she went to high school, graduating in 1966. She went to Framingham State, earning a bachelor's degree in 1970, shortly afterward marrying Steven McAuliffe, moving to Georgetown near DC, getting her first teaching job, and starting a family.

Christa was teaching history at the local junior high for the next eight years, but she was also acquiring a Masters degree in education supervision and administration from Bowie State University. Her husband finished his law degree and took a position as an assistant to the New Hampshire Attorney General, so off to Concord they went. She began teaching at the high school level in history and social studies. She also taught a course of her own design on the contributions of women to American society. She believed in the value of field trips, access to subject matter experts, and sharing the impact of ordinary people on history. How prophetic!

Christa McAuliffe's background, experiences, and mindset made her a natural fit for the new Teacher in Space project, and she took great interest in it when it was rolled out by President Reagon in 1984. She quickly became one of over 11,000 applicants for the program.

NASA did not operate the application program itself; rather, a non-profit organization of public education officials in state, territorial, and agency positions. Their sieving of the applicant pool resulted in 114 semi-finalists, at least two from each state. The 114 came to JSC on July 7, 1985 for medical examinations and additional interviews. A senior NASA advisory panel reviewed the data, and recommended to NASA Administrator James Beggs two names for the Teacher in Space and their backup, to be announced by Vice-President Bush on July 19.

Christa McAuliffe was selected, with Barbara Morgan as her back-up!

NASA bought out their teaching contracts for one year, and both selectees began training in earnest.

McAuliffe would be a regular crew person, but not an official Astronaut. Her job was classed as "payload specialist," and her primary duties would be to (help) conduct many of the on-board experiments and also to conduct two 15-minute class segments from Space, including a tour of the Space Shuttle.

Teacher McAuliffe proved to be a public-relations "natural," appearing on several popular newsy TV shows such as *Good Morning America*, the *CBS Morning News*, the *Tonight Show with Johnny Carson*, and other similar programs. She became quite well-known to the public, more so than most of her Astronaut colleagues.

Teachers and students alike were absolutely thrilled that someone they could identify with would be sharing their Space experience with them! Schools rolled out the necessary AV equipment so that every student could watch the launch of STS-51-L. They hadn't done that since the earliest days of manned spaceflight; the networks didn't even pre-empt the daily soap operas to show Apollo astronauts exploring the Moon's surface in real time during the latter Apollo landing!

But Christa McAuliffe's trip into Space would be different. It was familiar. And it was exciting.

CHALLENGER **DISASTER**

The morning of January 28, 1986 was very cold at the Kennedy Spaceflight Center. It had gotten well below freezing the night before, and there was ice on the gantry and other parts of the launch pad complex. A few of the engineers associated with the launch raised concerns over launch safety, especially for the solid-rocket boosters (SRBs) the Shuttle needed to attain

orbit. But their concerns went unheeded. The flight had already been postponed several times, mostly because of delays in the return to Earth of Space Shuttle *Columbia*, mission STS-61C. Everyone was ready and wanted to see a teacher fly into Space, and everyone knew that Christa and the crew would be featured on that evening's State of the Union speech.

Lift-off of STS-51-L had been scheduled for early morning, but the launch was delayed until 11:38 AM because of the ice on the pad.

I don't think anybody noticed in real time a dark puff of smoke aside one of the solid-rocket boosters when the Shuttle lifted off; it was found later in video data from the launch. The SRBs were manufactured in segments, fitted together like a tootsie-roll. Internal pressure in the SRB could run very high, so the segments were attached to one another and the joint between them was sealed by two giant O-rings. That dark puff was from a leak in one of those joints…

Seventy-three seconds after lift-off, the Shuttle passed through the point of maximum aerodynamic drag. While the world and America's schoolkids watched, the main fuel tank exploded, the two SRBs snaked on their way unburdened, and fragments of the Shuttle began their long fall to the sea. While it was obvious to onlookers, it seemed to take a few moments before their collective brain processed what their many eyes were relaying.

Space Shuttle *Challenger*, and its seven-person crew, had perished horribly.

IMPACT OF DISASTER

The United States had never lost an astronaut in flight before. Several astronauts had died in what should have been routine aircraft flights, and the shock of the *Apollo 1* fire and three deaths during training was bad enough, but this…

And with all those impressionable kids watching! So were 535 members of the press.

Definitively establishing the cause of the accident would take days, which allowed widespread speculations in the media. Since the investigation would be extensive, the loss of *Challenger* would remain a top news topic for months.

The cargo *Challenger* carried included a communications satellite that would be boosted to its higher orbit by an attached rocket, the Inertial Upper Stage. The IUS was one of the first pieces of debris recovered, disproving one notion making the rounds that it was a premature ignition of the IUS that triggered the explosion.

The search-and-recovery effort took three months. The failed SRB joint was recovered on March 1, and the crew compartment was found on March 8. The remains of the crew were recovered.

The *Challenger* was moving upward at Mach 2 at 46,000 feet altitude when the main fuel tank exploded. *Challenger* broke into several large pieces, identified as a wing, the main engines (which briefly continued firing) and the heavily-built crew compartment. The SRBs ran off ahead, and were destroyed by the Range Safety Officer.

The major pieces decelerated quickly, but still traveled upward another three miles before starting to fall back to Earth. The crew compartment had separated from the orbiter more-or-less intact when aerodynamic forces tore *Challenger* apart, but was demolished when it hit the ocean at 207 MPH, 2:45 minutes after the explosion. There is some evidence that at least some of the crew was still alive upon impact, but the impact force was over 200 g …

HOW DISASTER SHAPED NASA

A Presidential Commission was established to review all of the data from the *Challenger* disaster and to determine cause(s) and propose remedies. It was an all-star group, chaired by William P. Rogers (who had served previously as Attorney General and Secretary of State), with Neil Armstrong, famed test pilot Chuck Yeager, first American woman in Space Sally Ride, and the brilliant Cal Tech Physics professor Richard Feynmann, among others stars.

The cause of the accident was relatively quickly ascertained. One of the SRB O-ring sets had failed, leading to a flame leak from the interior of the SRB that acted like a blowtorch on the side of the main fuel tank, leading to the explosion that destroyed the spacecraft. O-rings are made of a tough rubber, and require some measure of flexibility to seal properly. When the rubber is cold, it loses flexibility, and hence, loses its sealing property. This was known by some engineers, that's why they were agitating to postpone the launch.

Who can forget the televised Commission hearings when the O-ring flexibility issue came up? Stating the problem didn't seem to be sinking in with many of the congresspeople present, so Dr. Feynmann took a sample of the O-ring material, dunked it in the glass of ice water in front of him, and then took it out and tried to bend it. The material was noticeably stiff. Such is the power of a great demonstration! [Sheesh. He was arguably the best teacher of Physics who ever lived, winner of the Nobel Prize, and Feynmann is now best known to the public for that simple demonstration! OK, that and his penchant for costume parties…]

The Commission found that both NASA and the SRB contractor Morton Thiokol failed to respond adequately to a design flaw both had known about for almost a decade. They also collectively criticized the decision to launch in weather significantly colder than any previous Shuttle launch. Thiokol had called a meeting the night before the launch and recommended strongly that NASA not launch at temperatures below 53°F. NASA managers disagreed, and Thiokol's senior management sided with NASA, not its own engineers. Feynmann investigated this particular point in detail, and found that there was a terrible disconnect between NASA's engineers and its upper management. He was so shocked about the gross misunderstanding of risk that he saw at NASA that he wrote a separate Appendix to the report. Quoting but one of the salient paragraphs:

> "In spite of these variations from case to case, officials behaved as if they understood it, giving apparently logical arguments to each other often depending on the "success" of previous flights. For example. in determining if flight 51-L was safe to fly in the face of ring erosion in flight 51-C, it was noted that the erosion depth was only one-third of the radius. It had been noted in an experiment cutting the ring that cutting it as deep as one radius was necessary before the ring failed. Instead of being very concerned that

variations of poorly understood conditions might reasonably create a deeper erosion this time, it was asserted, there was "a safety factor of three." This is a strange use of the engineer's term, "safety factor." If a bridge is built to withstand a certain load without the beams permanently deforming, cracking, or breaking, it may be designed for the materials used to actually stand up under three times the load. This "safety factor" is to allow for uncertain excesses of load, or unknown extra loads, or weaknesses in the material that might have unexpected flaws, etc. If now the expected load comes on to the new bridge and a crack appears in a beam, this is a failure of the design. There was no safety factor at all; even though the bridge did not actually collapse because the crack went only one-third of the way through the beam. The O-rings of the Solid Rocket Boosters were not designed to erode. Erosion was a clue that something was wrong. Erosion was not something from which safety can be inferred."

E-freakin'-gad!

The Rogers Commission made many detailed recommendations in their final report. Primary amongst them were: the SRB joints had to be re-designed, the program's management had to be restructured to insulate program managers from pressure to adhere to unsafe organizational deadlines, and that NASA should create a new office for safety that would report directly to the NASA Administrator to oversee all safety, reliability, and quality assurance functions for NASA missions. They also stressed that the pre-accident flight schedule (24 launches per year) was grossly over-optimistic and they also made a number of recommendations for improving the ability of astronauts to escape a disabled Shuttle (not entirely fully-implementable).

The House of Representatives also conducted their own investigation, using the Rogers Commission report as a starting point. The House Committee on Science and Technology (which held NASA's purse strings) agreed that the O-ring failure was the primary cause of the accident and that both NASA and Thiokol had failed to respond to known design problems. They also recommended a full risk management review of all critical Shuttle systems.

The Shuttle fleet was grounded for 32 months while NASA made the recommended changes.

The SRB joints were re-designed and thoroughly test, the launch manifest was trimmed, and the new Office of Safety, Reliability, and Quality Assurance was created at the Directorate Level.

President Reagan made several public statements about the continuation of the Teacher in Space program, but NASA decided in 1990 that the improved Shuttle was still too dangerous to risk a civilian teacher, so the program was canceled and Barbara Morgan returned to her classroom in Idaho.

BARBARA MORGAN

Barbara Radding was born on November 28, 1951, in Fresno, California. After high school, she graduated with distinction from Stanford with a degree in Human Biology. She then obtained a teaching credential from Notre Dame de Namur University in 1974, and then became an in-

service teacher on the Flathead Indian Reservation in Montana. He teaching career also took her to McCall, Idaho, and then for a year in Ecuador, before returning to McCall. She married Clay Morgan there, and they have two sons. Among her other accomplishments, she is a classical flutist and enjoys numerous outdoor activities.

Like Christa McAuliffe, Barbara Morgan saw NASA's call for teachers for the Teacher in Space program in 1985 and applied, and was accepted as McAuliffe's back-up. Both trained for six months at Johnson Space Center. After the *Challenger* disaster, she became the Teacher in Space designee, but the program, at least in its original form, was cancelled, as related above. She remained with NASA for several months, touring the country extolling NASA's educational benefits before returning to Idaho to resume her teaching career. But she still was the TiS designee and did a lot of outreach in that capacity. She also served as the National Science Foundation's Federal Task Force for Women and Minorities in Science and Engineering.

Twelve years after the Challenger disaster, Morgan was selected as an astronaut candidate, and she reported to JSC again for full-up astronaut training. Two years later she was a qualified mission specialist, and assumed a variety of duties for NASA. She was selected to fly on STS-118, scheduled for Space Shuttle *Columbia* in November, 2004. Alas, that flight had to be postponed, because *Columbia* was lost, too, on February 1, 2003, in another tragic accident.

Let's pause and think about that for a minute. Her friend and teaching colleague had died on *Challenger*, and the Shuttle she had been scheduled to fly had also crashed. Everyone in both crews were killed. How much courage do you think it took for her to stay with the program and make the flight of STS-118, which was shifted to the Space Shuttle Endeavor in 2007? Could you have done that?

The publicity around STS-118 was more subdued than it was for McAuliffe's flight, but Morgan did do some pre-flight interviews, some programming from orbit, and recorded lessons for later and ongoing use. She had spent 306 hours in Space!

One of the most poignant things she did on that flight was to collaborate with her crewmate mission specialist Alvin Drew on a 20-minute Q&A radio program from Space hosted by June Scobee, the widow of the commander of the STS-51-L mission.

Morgan participated in a post-flight news conference, where she stated, "You know, there's a great sense of pride to be able to be involved in a human endeavor that takes us all a little bit farther. When you look down and see our Earth, and you realize what we are trying to do as a Human race, it's pretty profound."

Indeed.

LEGACY

Christa McAuliffe received many posthumous accolades, of course, and deserved them all. But I think, perhaps, that the best legacy of her bravery is in the "carrying of the torch" by others serving the same calling she felt.

Barbara Morgan retired from NASA on June 28, 2008, to take a dual distinguished educator-in-residence position at Boise State University's College of Engineering and College of Education. She's still there, representing BSU on policy development, advocacy and fund-raising in STEM. She received a "Friend of Education" award from the NEA and the Women in Space Science Award from the Adler Planetarium, in 2008. A local elementary school was named in her honor.

The painful memories of the *Challenger* disaster would begin to fade in the dozen years following the accident. NASA management, and the public, had recognized the high value of the Teacher in Space program and decided to give it a re-boot, as the Educator Astronaut Project. Instead of using carefully-selected classroom teachers, they would recruit teachers to become actual full-time NASA mission specialists (giving up at least temporarily their teaching careers). Three new mission specialists were hired for the EAP: Joseph Acaba and Richard Arnold, who both flew on STS-119 (March, 2009) and Dorothy Metcalf-Lindenburger, who flew on STS-131 (April, 2010).

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Christa McAuliffe carried six different lessons on *Challenger* that she had planned to deliver from Earth orbit. All six can be used here on Earth to engage students to learn those lessons years later. They are archived here: https://web.archive.org/web/20131104080630/http://www.challenger.org/resources/christas-story

***Challenger* Disaster**

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Legacy

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