Building TCTE: The perfect combination of enthusiasm, spare parts and resources

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The Total Irradiance Monitor is used to measure solar irradiance on the TCTE and SORCE missions. Credit: LASP, University of Colorado

Building and delivering an instrument ready for spaceflight in five months was achieved with a little bit of luck, ingenuity, determination and available spare parts. Scientists had to act quickly in order to find a way to continue the total solar energy output measurements that NASA began in 1978.

The instrument is the Total solar irradiance Calibration Transfer Experiment (TCTE), built by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado for the National Oceanic and Atmospheric Administration (NOAA) under a NASA contract. TCTE launched aboard U.S. Air Force Space Test Program Satellite-3,Tuesday, Nov. 19, from NASA's Wallops Flight Facility in Virginia.

NASA, NOAA and the science community use these measurements to determine how solar output influences Earth's climate. Continuous space-based measurements are needed to determine if the sun's energy output is changing.

Scientists were worried about a pending gap in the data record due to an aging satellite beyond the end of its intended life span, and discovered through networking that a space was available on a U.S. Air Force STPSat-3 satellite that was scheduled at the time to launch in less than a year. To meet that deadline, the team had to work fast.

The idea to build TCTE was hatched during a January 2012 project meeting. In about three months, NOAA funding and NASA contracts were in place and the LASP scientists and engineers started TCTE work. "There was a great sense of urgency because TCTE had to be the firstinstrument put onto the spacecraft," said Kevin Carmack, TCTE project manager for NASA's Goddard Space Flight Center in Greenbelt, Md.

It was no small feat to have the instrument ready for integration onto the spacecraft by early September 2012. "This five-month schedule for instrument refurbishment, calibration and environmental testing is unheard of in the current space program environment, where three years for this effort would be the norm," said Greg Kopp, instrument scientist for TCTE at LASP.

This is a long-exposure photograph of the Nov. 19, 2013, Minotaur I launch, as seen from Annapolis, Md. Credit: Copyright Ed Campion

Throughout the development process the LASP and NASA team faced skepticism. "Never underestimate pure enthusiasm," said Kopp. By gathering resources here, there and everywhere, an instrument able to maintain the climate record came to be.

Total solar irradiance is currently measured by the Total Irradiance Monitor, deployed in 2003 on the LASP-built Solar Radiation and Climate Experiment (SORCE) mission. While SORCE was designed to last for five years, it recorded data for more than 10 years, but the aging satellite is nearing the end of its battery life. Another Total Irradiance Monitor would have flown on the Glory mission that was lost due to a launch vehicle failure in 2011. That is why there was growing concern about a potential gap in the data record.

Assembling an Instrument with Available Parts and Resources

The first bit of luck was that the LASP team had a solar irradiance sensor already built. LASP originally built three full flight models of the Total Irradiance Monitor for NASA's SORCE mission. One of those is the irradiance monitor currently flying on SORCE, another was planned to stay on the ground forwhat is known as a "witness unit" and the third was to fly on a space shuttle mission but was never used.

"We had a perfectly good instrument ready to go," said Thomas Sparn, the TCTE program manager at LASP. "That was one of the keys to making it successful." Because the key part of the instrument was already built, it could be quickly assembled and tested for integration onto the Air Force satellite with four other technology demonstration payloads.

While the components for TCTE were sitting on the shelf ready to go for several years, they were built to full flight qualification levels. NASA classified the instrument as experimental, and as a result, was able to accelerate the review and approval process. It was Steven Pszcolka, TCTE deputy project manager at NASA Goddard, who is credited with championing TCTE's experimental status to speed its qualification for

delivery. "We were able to do this because TCTE does not do full science and is designed to transfer calibration," Pszcolka said.

Additionally, the University of Colorado team leveraged the significant technical progress since SORCE toward the next Total Irradiance Monitor for Glory, and the next one scheduled to fly in a few years. In the years since SORCE launched in 2003, computing power vastly improved, allowing reduced cost and size. While SORCE required a very large $2 million computer, the team already had built a more modern and lower cost "smart" processor for Glory and future missions ready to be adapted for TCTE, eliminating the need for a large, expensive computer.

From the Glory mission development, the Colorado team had at their disposal a sophisticated calibration facility allowing them to calibrate the TCTE instrument more efficiently than the instrument currently flying on SORCE.

There was a technical challenge shoehorning TCTE into the available space on the Air Force satellite. A thermal radiator on the satellite required a view to dark space, and the only place for it was on the sun side of the spacecraft, which created a heat dissipation challenge. Working closely with Ball Aerospace & Technologies Corp. in Boulder, Colo., which built the spacecraft and worked on the instrument integration, engineers found a way to angle the radiator so it views dark space while TCTE views the sun.

With a head start provided by the spare instrument, scientists and engineers from LASP, NASA and NOAA were able to act quickly and use new resources to overcome the technical challenge of integrating TCTE into the existing Air Force satellite. With TCTE, climate researches hope to extend the measurement of the sun's energy input to Earth, and maintain the 35-year record of the solar variations that affect

Earth's weather and climate.

Provided by NASA's Goddard Space Flight Center