Technological Progress: A Function of User Necessity

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Conducting the myriad of space launch preparations more effectively with specialized tools that improve existing processes or address new issues requires innovative technologies. Although the mission of the Applied Physics Lab at NASA's Kennedy Space Center is to deliver gadgets to support these launch missions and operations, it is the verdict of the end users of these technologies that dictates which ones succeed and are used.

For example, the External Tank (ET) Vent Hood Alignment Tool is used to align the vent positioned on the ET tip. This "Beanie Cap," prevents ice from forming on the vent, avoiding harm to the orbiter during launch. The tool came to be used because of the enthusiasm of the end user, engineer Jorge Rivera, who accepted it for use, because he recognized that it would align the vent safer and faster than before. Despite management's concern that it needed additional capabilities, Jorge recognized that it would meet the need and perform the job.

Having technicians working while strapped inside the hood was considered a hazardous operation. With the tool, alignment can be quickly and safely performed from outside the hood, not only before any External Tank propellant load occurs, but also after a load from a scrubbed launch. It can eliminates the need for safety harnesses and reduces the 80 hours to do the job originally,

A tool that aids in the crucial task of providing leveling to an orbiter in the Orbiter Processing Facilities after missions was also in demand because massive access platform system could damage the vehicle. The end user, a NASA contractor from the United Space Alliance (USA), Mike McClure, recognized the need for an improved leveling tool.

This Improved Orbiter Jack and Leveling System using laser rangefinders was memorable because when funding was tight, the users and APL took it to the KSC Shuttle Processing chief, Michael Wetmore, and fought for upgrades together. End user Mike McClure, worked "hand in hand" with the lab to develop it, remembers Youngquist. "Without Mike's support, technically and politically, the system would never have been built."

"The idea for such a system came about many years ago, but no one was willing to champion it until I came into the group," said Mr. McClure. "That is usually what makes or breaks a good project: a champion. You have to be willing to keep pushing."

And it is clear why this determination was needed. The orbiter needs to be raised accurately to the height of the servicing platforms by jacks installed forward and aft. This operation requires a 1/8 inch precision or else the orbiter could not get serviced. The previously used method of using calibrated measuring sticks was time-, cost-, and labor-consuming, and not to mention, hazardous to the safety of the tiles. "It took 25% longer than with either of our laser systems," recalls Mr. McClure. "From a time-savings standpoint, the laser systems were significant, especially when you add up the number of technicians and Quality Control inspectors involved with our operations."

The system uses Leica laser rangefinders positioned at the four corners, under the jacks, and transmits the height readings to a central computer. It is literally a vital tool for the orbiter's safety and would not have come about without the push from Mr. McClure's group.

Sometimes the lab assists the users in improving the equipment they already use. During Return to Flight, the STS-114 Discovery mission, several problems with the ET liquid hydrogen pressurization system occurred. First, a Tanking Test indicated excessive helium pressurizing gas usage resulting in a second tanking test and the decision to replace the Tank. Next, the launch itself nearly scrubbed when the tank again appeared to use more helium than normal.

"The system was never designed to measure helium, only control pressure. But everyone wanted to know how much helium was actually being used," said Stan Starr of the APL. He worked with Tom Clark of USA to propose a unique calibration of the existing system.

The quantity of helium is controlled by an orifice; but not the kind that can be used as flowmeter. Replacing the existing orifice would solve the measurement problem, but all of the legacy flow performance would be lost. "We talked to the top people in the field and they said the existing orifices couldn't be calibrated, and even the best lab in the country initially refused to test them," said Starr. In the end, the testing was successful and now the quantity of helium is known within 5%.

Similarly, the Water Extraction Tool (WET), a vacuum system for drying multiple orbiter tiles, is "a case where hardware is needed for contingencies," said Dr. Youngquist. The tool was designed to remove water from Orbiter tiles after the March 2001 Atlantis Orbiter mission, which was rain soaked after landing at Edwards Air Force Base in California. The WET was developed as a five times faster method than that used for Atlantis, drying by heating with infrared lamps.

Speeding up drying prevents launch delays and tile damage to the 20,000 tiles spread over180 square meter area on the orbiter. The tool now dries 150 tiles in two hours, not days as before, by sucking water out through the waterproofing holes in each tile. What's more, the vacuum system makes use of the facility's vacuum cleaning system rather than needing extra power for the heat lamps. "The Thermal Protection System (TPS) team laughed when we first demonstrated the system, it was so much easier to use, recalls Starr.

TPS, approved of the tool but after we developed, tested, and then delivered it, they"kindly asked us to keep our hardware," said Youngquist, because shuttles are rarely rained upon.

Sure enough, in August of 2005, Discovery landed at Edwards AFB in California and was showered with almost two inches of rain. "When users want something, things can move very quickly", said Youngquist. A request for thc tool was sent to the lab; within two weeks, WET was being used in the field.

Another APL technology that would not have made it into the field without the end user's active involvement was the Reaction Control System, or RCS, nozzle inspection tool. This checks the RCS for chambers defects which cost millions of dollars to remake and repair. "We worked closely with the inspectors and gave them a machined Teflon glove and a Teflon mirror tool with a mirror and eyepiece. It went through a few versions until they were satisfied that it met all their needs," says Youngquist.

The tools are made of Teflon to limit damage to the orbiter surface. Three RCS tools are used today at four sites including White Sands Test Facility that refurbishes thrusters.

Just like NASA Orbiter Maneuvering System engineer, John Peters, who "took a hands-on interest" on the RCS project, lead window inspector, Robin Floyd, took a similar interest in developing the SLOT.

The Surface Light Optimizing Tool (SLOT) similarly saves cost and time by efficiently highlighting tiny defects on orbiter windows. The lab made a small plastic tool in a couple of days that attaches to the window via a suction-cup tool and uses total internal light reflection to trap light in the glass. The light escapes only at defects, and thus the smallest damages on the windows caused by micro-meteors show up as bright points.

According to Youngquist, "the best case is when the end user wants to work with you and develops a vested interest" into making a tool.

Floyd conceived the idea for SLOT independently but had no means of fabricating a field version of it on his own; he teamed up with the APL and jointly produced the tool when a "meeting of the minds occurred," said Youngquist.

The result was the delivery of 14 working SLOT devices and the location of hundreds of potentially risky defects that the previous approach did not. The SLOT will soon be adapted for use on the International Space Station and the Constellation project, which is aiming to send the Ares I and V crew and cargo launch vehicles to the moon and Mars. It is now in its fourth generation.

There have been over total 40 pieces of hardware developed at the APL to assist the safety, efficiency, and cost of shuttle program operations in the 19 years of the lab's operation.

"Technology is a function of how ardent the customer is on getting the product; it is need and personality driven," asserted Youngquist. This may just be the secret to how innovation impacts the Shuttle Program at KSC. That may also be how KSC keeps the aging Shuttle fleet flying.