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Elizabeth Citrin

Photo courtesy of Chris Gunn

GSFC NEWS

tech transfer

in this issue:

SDO Special Issue

from the chief

The Innovative Partnerships Program (IPP) Office is proud to present this issue of Goddard Tech Transfer News, featuring technologies that are enabling the Solar Dynamics Observatory (SDO) mission. Scheduled to launch in February 2010, SDO is the first mission in NASA's Living With a Star (LWS) program, designed to understand the causes of solar variability and their impact on Earth.

Violent solar events that cause severe space weather can have a destructive impact on NASA missions and the technology that we rely on every day. The safety of an astronaut on a space walk can be jeopardized by exposure to the radiation and high-energy particles emitted by solar flares. Solar storms can disrupt communications systems on planes flying over the poles, GPS signals, and transformers that feed power lines. SDO will provide NASA with unprecedented data—information that will make significant advancements in our understanding of space weather and our ability to protect people and equipment from potential harm.

Several advanced innovations developed at Goddard and in collaboration with outside organizations have made the SDO mission possible. Many of these already have been leveraged for other NASA missions. One example is the High-Gain Antenna System (HGAS), originally developed for SDO, and which was used on the Lunar Reconnaissance Orbiter (LRO) that launched in June 2009, helping LRO meet an aggressive completion schedule. As you will read in this issue, HGAS is not the only SDO innovation that has been leveraged by other missions.

The IPP Office reaches out to inform, learn, share, and leverage technology development and utilization. This magazine explores some of the outstanding technologies and talented people that have made SDO possible, and how innovations on SDO are being leveraged for other purposes. I trust that you will find this issue more insightful of the significance of Goddard's technology innovations beyond their original intent.

Nona Cheeks
Chief, Innovative Partnerships Program Office (Code 504)
NASA's Goddard Space Flight Center ■

A coronal mass ejection (CME) particle cloud blasted from the sun as it impacts Earth and creates an aurora

Jason Hair: SDO Deployment System Lead

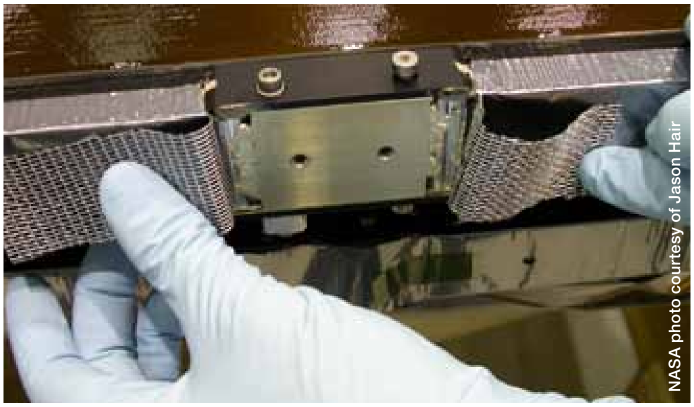

Jason Hair

As the lead deployment system engineer for the Solar Dynamics Observatory (SDO), Jason Hair's responsibilities include the design, build, test, and delivery of SDO's two Solar Array Deployment Systems, and two High-Gain Antenna Deployment Systems for the High-Gain Antenna System (HGAS). These deployment systems include deployment hinges, solar array panels, HGAS booms, and launch restraint and release mechanisms.

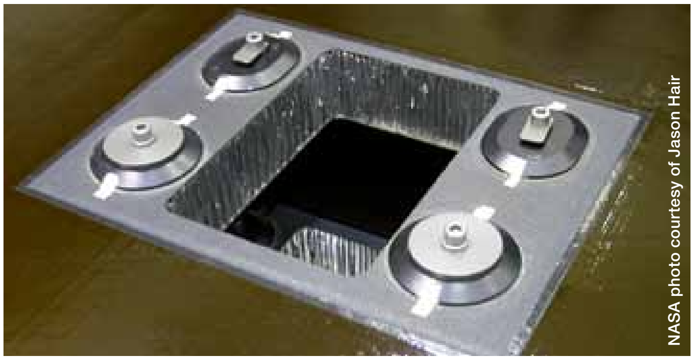
Multiple Material Insert for Composite Sandwich Panels

Hair created a new multiple material insert for composite sandwich panels (GSC-15189-1). The inserts provide a means of structural attachment and mating for graphite face sheets and an aluminum honeycomb core that make up the solar array sandwich panels. Because the solar panels will be exposed to high structural loads and extreme thermal conditions, the strength and performance of the inserts are at extreme risk of degrading from stress. This problem will be greater on the SDO mission because the solar panels are exposed to temperatures ranging from -160˚C to +130˚C and the coefficient of thermal expansion (CTE) in the graphite face sheets is much different than that of the aluminum core.

The SDO deployment team first considered a single material insert, using a material that would minimize thermal stress (in-plane) when bonded to the graphite face sheet by matching its CTE. However, that was complicated and expensive to design and manufacture. The resulting insert would also have reduced load-carrying capability. Their second option was to select a core material for the sandwich panel that matched the CTE of the face sheet. The type of face sheet to be used on the SDO panels made finding a suitable match difficult and expensive.



An edge multiple material insert giving a cross-section view of how the insert is made



Round inserts used to hold the hinges and restraint hardware to the solar array panels

To overcome these obstacles, Hair proposed an alternative. In his new design, the portions of the insert that are in contact with the face sheet of the composite sandwich panel, called flanges, are made from a material with a CTE similar to the face sheet, keeping the thermal stress between the face sheet and flanges within allowable levels. The portion of the new insert that spans the two sides of the sandwich structure and connects the flanges (a block), is made from a material that matches the CTE of the core, preventing overload on the joint because of loads from differential thermal expansion between the core and the block. The flanges and block are bolted together. The bolted joint preload allows external insert loads to be transferred to both flanges, and thus both face sheets of the joint to have increased strength.

This simple and easy to manufacture device is used where hinges and the launch restraint are fastened to the solar panel. A similar but smaller design also is used around the edges of the solar panel for ground support equipment handling and on the tip of the panel to hold the coarse sun sensors. The solar arrays on the Lunar Reconnaissance Orbiter (LRO) use exactly the same multiple material insert design, and the technology has potential to be used on other commercial satellites that are positioned in a geosynchronous orbit.

High-Gain Antenna System Components

Hair also played a key role in the development of two innovations that have been incorporated into the HGAS on SDO. HGAS (GSC-15518-1) uses a waveguide to transmit the radio frequency (RF) signal from the transmitter on board the satellite to the antenna, with minimal signal loss. Because of SDO's thermal environment and the design of the waveguide, SDO engineers identified the need to build flexibility into the 10-foot, aluminum waveguide to allow some bending and motion to mitigate stress in the waveguide.

Hair and SDO RF Engineer Ken Hersey created an RF slip joint that provides axial, lateral, and rotational movement with minimal RF signal loss when inserted between two sections of a rigid waveguide. Two slip joints have been incorporated in the waveguide on SDO's HGAS.

Another of Hair's inventions is a new deployment hinge that is used to fold the HGAS up against the spacecraft for launch and then bend 90 degrees during deployment. The hinge that was used on previous satellites needed to be reconfigured for SDO to accommodate an RF rotary joint. The shaft developed for the hinge has the same strength and rigidity as that of the previous style with a solid one-piece shaft, but it has two pieces. This hinge design was shared with and flown on LRO, and the technology also is being studied for the Orion Project. ■

innovator insights

Elizabeth Citrin is project manager for the Solar Dynamics Observatory (SDO) mission. She talks about her background, SDO, and how the mission will take an unprecedented look at the Sun and provide valuable information about the Sun's impact on space weather.

Elizabeth Citrin

Can you tell us about missions you have led prior to SDO?

My first opportunity to serve as project manager was for the Wilkinson Microwave Anisotropy Probe (WMAP) mission, 10 years ago. I started as the lead systems engineer, and two years before launch, I moved into the project manager position and guided the mission through launch and commissioning. Then I was project manager for the Gamma-ray Large Area Space Telescope (GLAST) mission, up to preliminary design review. I also worked on Constellation-X in a leadership role, but that mission was in pre-Phase A and very different from SDO. For the past 5 years, I have served as project manager for SDO.

How has your previous experience prepared you for SDO?

SDO is similar to some other projects that I have led. It is an in-house mission, like WMAP, so as a project manager, you are closer to the action—closer to the people doing the work, the hardware, and the observatory. It is very exciting.

What do you do as project manager?

The emphasis varies, depending on the phase of the project, but it always involves interacting with the team. Early on, the job requires meetings with engineers about mission design and the trades that are being made from a technical and programmatic perspective. In addition to traditional project management activities—keeping on top of project status and any current or potential risks to the schedule or budget—you also have to form the project team that will be the backbone of the entire mission.

I spend a lot of time in the design phase getting to know all the people, making sure everyone is in the right position, and checking that roles and responsibilities are clearly defined. The pace ramps up in the implementation phase. I constantly monitor to see that everything is on schedule and meeting budget, and I assess what risks need to be addressed so that the quality of work remains high. What we do is never a production job, but during the peak of the fabrication phase, it does feel a bit like we are turning the crank to build flight hardware. Then, we get to put all of the pieces together to make an observatory, and test it—one of the most exciting phases of the project! We test to make sure that the hardware that we designed and built will work properly in a space environment. Testing will continue right up to launch, and even after, during the commissioning phase.

What is your favorite part of being project manager on SDO?

I like being a part of the hands-on work and talking to the many different people who are designing and building elements of SDO. Getting an up-close and personal feel for how all aspects of the project are progressing is an important part of my job and something that I really enjoy. I especially like seeing the hardware being built and tested.

What are the goals of the SDO mission?

First, we want to learn more about the Sun. This is part of our scientific quest for knowledge. We want to know how its magnetic fields are formed and how the dynamo inside the Sun works. Then, we want to explore how this translates into the events that we see around the Sun—flares, coronal mass ejections (CMEs), sunspots—all the violent occurrences that we know happen.

Another goal is to try to improve our capability to study and predict space weather. Can we predict the violent events that occur on the Sun, which cause particles to be hurled towards Earth? For the most part, our atmosphere protects us. But astronauts and satellites are not protected, and these solar events can affect them. If we can learn more about these occurrences and how to predict them, measures can be taken to protect satellites and astronauts. For instance, satellites can be put into a safe mode and not use their high voltage. Astronauts can stay inside their spacecraft until a solar storm passes. Right now, we can't predict with any degree of certainty what the Sun is going to do. We have been studying it for hundreds of years, but space weather prediction still is in its infancy.

How will SDO meet these goals?

The amount of data and the level of definition of images generated by SDO will be unprecedented. SDO will observe the full disk of the Sun, from its deep interior to the outermost layers of the solar atmosphere, at the highest ever time cadence. It will return images in eight different wavelengths every 10 seconds, 24 hours a day, except for a few brief eclipses because of its orbit. SDO will send us about 1.5 terabytes of data every day, and the images that are generated will be 4096 pixels by 4096 pixels, providing details of the Sun and its features that have rarely been seen before.

NASA photo by Bill Hrybyk

The continuous stream of data from this mission will help with modeling, because we will have a full picture leading up to a solar event. So, when an event occurs on the Sun, we will be able to go back a day, or a week, or a month, and figure out what led up to it. Then, we will be able to develop models to help predict space weather. Without this complete data set, it is hard for us to make such predictions.

Did you need to develop new technology to handle all of this data?
One of our driving requirements and most difficult challenges was to develop a system that can handle the amount of data expected to be generated by SDO. We created a high-speed data bus to detect and process images, using 4k x 4k charge-coupled devices and SpaceWire data link technology (GSC-14734-1 and GSC-14761-1) with low voltage differential signaling. This technology has flown before, but not at this level of performance. In fact, the instruments on SDO will produce too much data to be stored on board the spacecraft and we will have to send it directly to the ground. So we built our own ground station to receive the data and we moved into the Ka-band spectrum to be able to send the data back to Earth.

SDO's High-Gain Antenna System (HGAS) was developed for tracking, telemetry, and command of the SDO spacecraft. It was also used as the basis for a similar system on the Lunar Reconnaissance Orbiter (LRO) mission that launched in June. The ground station in White Sands, New Mexico, which also serves as the ground station for LRO, has dual Ka- and S-band, 18-meter antennas that will be constantly receiving data from the satellite. Developing the hardware and software to capture, process, and distribute this amount of data was a sizeable job.

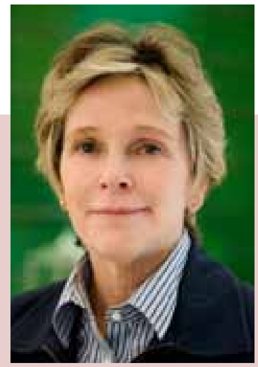
Editor's Note: For more information on the SDO ground, propulsion, and MIS systems, along with more new SDO technologies, see separate stories on pages 6-11.

What other important innovations have been incorporated into SDO?
Our ground system team created a remote controlling system for the antennas at White Sands. The system was not part of the original design, but once we put the antennas out there, we determined that we could remotely control the antennas from the Mission Operations Center, reducing maintenance staff and costs. The system has been tested and is working great.

SDO has the first bipropellant propulsion system that has ever been developed at Goddard. It was built at Goddard using vendor-supplied components. SDO has a single-fault tolerance requirement that we were able to meet because of the development of this new propulsion system.

Also, the management information system (MIS) that was developed for SDO is just wonderful. We have become so dependent on this system—it handles all of our documentation, configuration management and control, our libraries, and vendor packages. We sometimes take it for granted, but we are very lucky to have such a great system. Several other Goddard missions have recognized what it can do and have borrowed this system for their MIS needs.

As project managers, we are often hesitant to incorporate new technology because it can be risky. But in some cases, technology needs to be developed to meet mission objectives. It is exciting to do something that has not been done before, and sometimes a little bit of excitement is a good thing.



Elizabeth Citrin

code: **464**

years with NASA: **28**

field of research: **Computer Science**

birthplace: **Clarksburg, WV**

education: **BA in Economics, Duke University**

Masters in Computer Science, Johns Hopkins University

What is SDO's role in the Living With a Star Program?
NASA's Living With a Star (LWS) program was formed in 2001, to learn more about the Sun and expand our understanding of space weather. LWS will include several missions that will surround and explore the Sun in ways never done before. Two groups of mission spacecraft comprise the LWS Space Weather Research Network: solar dynamics elements, including SDO and sentinels that will observe the Sun and track the disturbances originating there through the heliosphere; and geospace dynamics elements, consisting of spacecraft located in the magnetosphere and ionosphere that will define the geospace response to varying solar and solar wind inputs.

SDO will be the first LWS mission to launch, so all eyes are on us. It is an exciting opportunity to look at the Sun like never before and share this view with the world. ■

Key SDO Technologies

The Solar Dynamics Observatory (SDO) employs many advanced innovations developed at Goddard and in collaboration with other organizations. The benefits of these technologies impact other projects and missions, inside and outside the center. Several important SDO innovations are highlighted on the next six pages.

NASA photo courtesy of Tim Gregor

One of the SDO mission's 18-meter Ka- and S-band antennas at NASA's White Sands Complex in New Mexico

The SDO Ground System

The Solar Dynamics Observatory (SDO) ground system will allow monitoring and control of two ground stations and a data distribution system (DDS) as well as the spacecraft, all from the Mission Operations Center (MOC) at NASA's Goddard Space Flight Center. Prior to SDO, components of ground systems for Goddard missions have always been operated from separate locations. This highly automated and powerful new system will provide improved efficiency and performance.

Two ground stations at NASA's White Sands Complex (WSC) in White Sands, New Mexico—the White Sands Ground Terminal (WSGT) and the Second Tracking and Data Relay Satellite Ground Terminal (STGT)—will service SDO. Each station has a dual, 18-meter Ka- and S-band antenna, capable of receiving the 150 megabits per second of data that will be captured by SDO and returned continually to Earth through the High-Gain Antenna System (HGAS) on the spacecraft. SDO's antenna design was used as the basis for the single ground antenna that was developed for the Lunar Reconnaissance Orbiter (LRO) and is located 200 feet in front of the SDO2 antenna at STGT. The SDO2 antenna not only serves the SDO mission, but serves as the primary Ka-band back-up antenna for LRO. The SDO1 antenna is 3.3 miles away at WSGT.

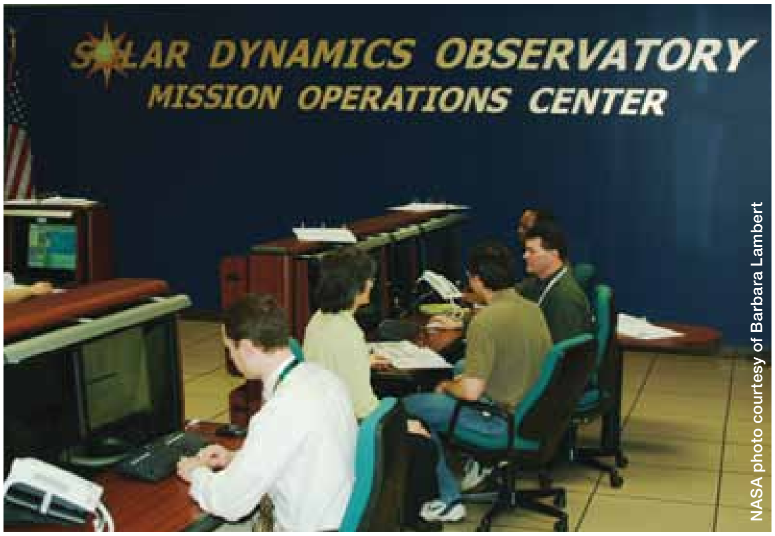
Another component of the SDO ground system is the DDS, which acts as both a connector and storage facility for data that is transmitted throughout the system. After a signal from SDO passes through both ground antennas in parallel, the DDS will review both signals, decipher which signal is clearer, and then send the raw data to a database archive at the WSC. Then, the DDS will strip out non-essential information and send the data through OC-3 fiber optic and T3 lines directly to science operations centers (SOCs) located at Stanford University in Palo Alto, California and the University of Colorado in Boulder, Colorado. The data will be transmitted through the DDS in real time, and a copy will be archived for up to 90 days. The SOCs will ultimately transform the data they receive into a format that can be used by the scientific and space weather communities.

The SDO in a clean room at NASA's Goddard Space Flight Center in Greenbelt, Maryland

The SDO being lowered to a horizontal position to provide access for testing

New technology that provides enhanced automation is the key to allowing these ground system functions to be controlled from the MOC. For example, an alert notification system (ANS) will provide full-time monitoring of the spacecraft and all components of the SDO ground system at the MOC. If the defined limits on any of the subsystems are reached, ANS will send out an alert by text message and e-mail. Also, automated ground station antennas and a remote control feature will allow engineers at the MOC to make any necessary adjustments to the antennas or the DDS.

"The automated ground system will allow us to monitor and control multiple mission functions from Goddard, with a staff of approximately 10 people working bankers' hours," said Raymond Pages, Chief of the Ground System Management Office (Code 450.2) at Goddard. "Our ground system can do three times the amount of work that has been done on previous missions, with a smaller staff."



SDO team members prepare to monitor mission functions at the SDO Mission Operations Center

Propellant Slosh Analysis for SDO

The effect of propellant slosh on the attitude stability and pointing performance of the SDO spacecraft is of great interest to attitude control engineers. Because of the large amount of liquid propellant used in SDO, detailed slosh analysis was required prior to launch, to ensure the tight pointing budget for SDO could be satisfied. Even minor jitter because of unforeseen slosh dynamics could corrupt science data, and larger disturbances could have significant consequences.

The Propellant Slosh Analysis for SDO (GSC 15118-1) is a software-based tool that was developed specifically for SDO to analyze and predict the effect of slosh during main engine and attitude control subsystem (ACS) thruster maneuvers. The analysis tool approximated the fluid slosh effects via the movement of a point-mass pendulum in a modified version of a standard equivalent mechanical model. Incorporating specific data on SDO's fuel tanks supplied by the vendor in a MATLAB® numerical computing environment, attitude control engineers were able to simulate and then analyze the force or torque on the fuel tanks and, therefore, on the SDO spacecraft. The readings from the slosh analysis assisted with tank design and led to incorporation of a propellant management device in the fuel and oxidizer tanks to reduce the effects of propellant slosh. The final analysis concluded that slosh will not hinder the stability of the spacecraft or the performance of its instruments.

The propellant tank arrives and is inspected by staff.

Most high-fidelity slosh analysis and simulation have been performed previously via computational fluid dynamics. Even though the method is very accurate, it requires significant computational effort and specialized knowledge, and it is difficult to incorporate these models into simulations of the overall spacecraft and its environment. For Scott Starin and Paul Mason, the Goddard innovators that developed the SDO slosh analysis tool, the next step will be to build on SDO advances and make the next mission-specific slosh analysis tool faster, easier, and more accurate.

MATLAB is a registered trademark of The MathWorks, Inc.

SDO Propulsion System

Mission requirements call for the SDO satellite to observe the Sun full time and remain in constant contact with the ground station, so that data can be continually collected and returned to Earth. To meet these requirements, SDO has been assigned to a geosynchronous orbit (GEO), circling the Earth once every 24 hours. Although a GEO is common for commercial satellites, this is the first time Goddard's Propulsion Branch (Code 597) has been asked to build a propulsion system that can fly to this distant orbit. They responded to this challenge with a bipropellant propulsion system that is powerful, efficient, and provides maximum redundancy for safety of the spacecraft.

The bipropellant propulsion system, in which liquid fuel and an oxidizer are combined and react hypergolically to create the needed power for the thrusters, is the first of its kind ever created at Goddard. The system will use a lot of propellant—1,409 kg of monomethyl hydrazine fuel and nitrogen tetroxide oxidizer, weighing almost as much as the spacecraft itself—but it will be much more powerful and efficient than a monopropulsion system, in which hydrazine flows over a catalyst bed and into the thruster to create heat and thrust.

To minimize jitter from such a large propellant load, each of the SDO propellant tanks is equipped with a propellant management device to allow gas-free propellant delivery throughout the mission and control propellant movement.

The power generated by SDO's propulsion system will be comparable to that of commercial satellites that fly in a GEO. But the SDO system includes several features that are designed to provide redundancy and guarantee uninterrupted performance in case of failure—features that most commercial spacecraft do not have. For example, SDO has two parallel, series-redundant pressure regulators. In the event of a primary stage failure or large leak in a regulator, the redundant stage will take over and regulate downstream pressure at a slightly higher pressure than the primary stage set point. This completely redundant regulation system was included to eliminate the pressure regulators as a single-point failure source. The propulsion system also is fitted with redundant

Assembling the low pressure module on the propulsion system

The propulsion module before integration

attitude control subsystem thrusters, with thrust chambers and nozzles that are machined from solid platinum and rhodium, similar to the mixture used for making platinum jewelry. This design will make the nozzles harder and allow the thrusters to burn longer and hotter. As a result, all of the propellant can be run through a single thruster without burning out, creating a reliable backup should the main engine fail.

> "There is no doubt that what we learned on SDO will benefit future in-house builds and other projects that are assigned to our branch.
>
> — **William Dewey Willis, *SDO Lead Propulsion Engineer, NASA's Goddard Space Flight Center***"

Another innovation related to the SDO propulsion system grew out of the need to develop a reliable method for welding titanium used in the tubing that connects system components. Titanium is more difficult to weld than stainless steel, which has been used on previous Goddard propulsion systems. Goddard innovator Michael Wilks developed a system using dead end welds that is comparable in quality to techniques used on stainless steel and better than other previous commercial titanium welding techniques. A patent has been filed for this invention—Hardware and Technique for Dead End Welding of all Types of Tubing (GSC-14960-1)—and it has potential for commercial applications.

Pulsating Deionized Water Precision Cleaning System

Goddard innovators developed a new method for cleaning titanium tubing on the SDO propulsion system that is cheaper, faster, and much safer for the environment than previous methods. In the past, such tubing was cleaned with brushes and by flushing the tubes with large amounts of isopropyl alcohol (IPA). The new Pulsating Deionized (DI) Water Precision Cleaning System (GSC-15820-1) uses DI water instead of IPA for the bulk of the cleaning process that takes place during fabrication.

The tubing that carries gas, liquid fuel, and oxidizer to the thrusters in the SDO propulsion system must be free of all contaminants. Failure to properly clean the tubing could allow particles to clog a filter or lodge in a thruster valve during flight, causing propellant leakage, loss of attitude control, or even loss of the mission. In this new cleaning system, DI water is first created by feeding tap water through a series of filters. Then the DI water is routed into 35-gallon, stainless steel tanks, pressurized with nitrogen, and fed into a cavitation panel. The panel sends a pressurized mixture of pulsating gas and water through the tube, agitating the inner tube surface, and cleaning it effectively and quickly. In a final step, a small amount of IPA is flushed through the clean tubing and a sample of IPA is taken to verify that the tubing meets the required cleanliness levels.

The DI water cleaning system is capable of cleaning tubing to higher standards and in less than half the time than an IPA-based process. It uses 90 percent less IPA—an expensive, flammable liquid that must be disposed as a hazardous waste. The Pulsating DI Water Precision Cleaning System has been adopted as the only cleaning system used by Goddard's Propulsion Branch. It has helped save time and money for the SDO and Lunar Reconnaissance Orbiter (LRO) missions, as well as for the Sample Analysis at Mars (SAM) mission. Goddard engineers plan to use it during the fabrication of propulsion systems for the Global Precipitation Measurement (GPM) and Magnetospheric Multiscale (MMS) missions.

The deionized water precision cleaning system is faster, cheaper, and safer for the environment.

MTASS Attitude Determination and Sensor Calibration System

The Multi-Mission Three-Axis Stabilized Spacecraft (MTASS) Attitude Determination and Sensor Calibration System (GSC-15811-1) that is used on SDO originally was developed in the mid-1990s by Goddard innovators Richard Harman and Mike Lee. They sought to provide a more efficient and cost-effective multi-mission software system for ground attitude determination and sensor calibration and to transition existing software systems from mainframe computers to workstation platforms.

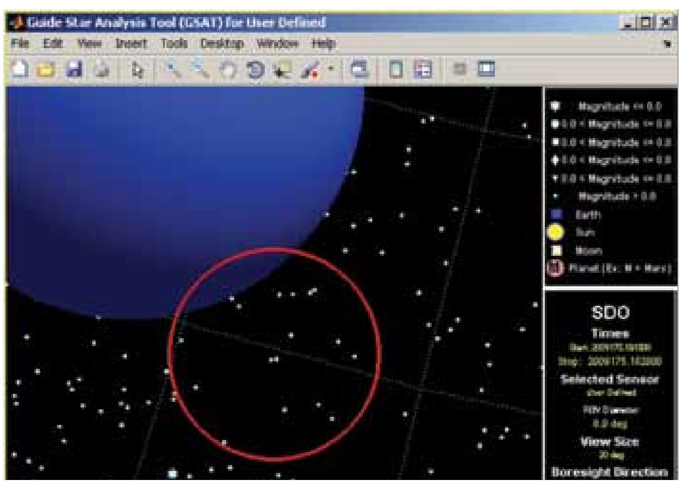
Prior to the development of this innovation, new ground attitude determination and sensor calibration systems were developed for mainframe computers—a costly and inflexible way of doing business. Using the MATLAB® engineering package, Harman and Lee were able to develop a patented graphical user interface-based, multi-platform software system that has been incorporated into 21 planned or on-orbit missions. Beginning with the Rossi X-ray Timing Explorer satellite mission in 1995, MTASS has been constantly updated to meet evolving mission needs, saving considerable time and resources.

MTASS is the standard software package that Goddard uses for attitude determination and sensor calibration. On SDO, it will analyze and compute information from on-board sensors and other reference data, and then will provide precise readings about spacecraft orientation. It also will be used to calibrate sensors on board, which can become misaligned because of launch vehicle movement, entry into the vacuum of space, and changes in temperature on orbit. MTASS will help to maintain the very stringent attitude required to provide reliable data and images.

The version of MTASS to be utilized on SDO includes an upgrade in the system's real-time capabilities and a new module that was developed to calibrate SDO's High-Gain Antenna System. These enhancements, originally developed for the SDO program, were modified and incorporated into the Lunar Reconnaissance Orbiter mission that launched in June 2009. This is one of many examples of how MTASS is constantly being updated and used to enhance NASA missions, providing value for NASA and the taxpayer.

"The IPP Office has been very helpful to the Software Engineering Division of the Mission Validation and Operations Branch at Goddard (Code 584), which develops ground systems for scientists and flight software for scientific instruments. This division in particular has been a focal point for software use agreements and efforts to provide software to agencies that need it, within and outside of Goddard.

— **Richard Harman,** ***MTASS Innovator and Associate Branch Head, Mission Validation and Operations Branch, Code 584***"



Screen shot display of Guide Star Analysis Tool

MATLAB is a registered trademark of The MathWorks, Inc.

SDO Management Information System

A team of Goddard engineers originally created a blueprint of the optimal management information system (MIS) for SDO, based on their experience with previous missions. The system needed to have an internal Web site, offering hundreds of staff and vendors working on SDO 24-hour, remote, secure access to a vast database. It also had to be interactive, so that users could review, comment, electronically approve documents, and receive alerts.

When the team did not find an existing MIS that could be tailored to meet these unique needs, they decided to design their own system. Working with Goddard's Enterprise Solutions Division (Code 750) and its support contractor, INDUS Corporation, they created a Web-based system to manage the mountain of documents, drawings, and procedures for SDO. The system has been so successful that 16 other Goddard projects have already adopted it.

The SDO MIS performs several important functions for SDO personnel. It can control storage of the mission's flight and non-flight documents and drawings by providing configuration change control. Change requests can be created automatically, triggering a review process that allows document or drawing revisions to be released when they have received necessary approvals. The system also manages work order authorizations (WOAs), which are detailed, paperless instructions that outline the steps necessary for development or integration of the spacecraft's hardware. The MIS provides seamless traceability between documents and drawings referenced in the WOA, and it helps manage response to action items that are triggered by a WOA. The system notifies users about action items through custom, user-specific alerts that actively display pending reviews and responsibilities. This alert system was created when the design team determined that standard e-mail alerts were too easily missed or confused with spam.

The records in the extensive MIS library—including documents, drawings, change requests, and WOAs—can be accessed via a powerful search engine that allows users to quickly find and access the information that they need. Other special features include a calendar tool that can be expanded to manage conference room schedules and lists of events. A list of project documents, including organizational charts, phone lists, and travel vouchers, also can be displayed on the home page of the application, under the Quick Launch section. Because of these special features, the MIS is used as the SDO mission's Intranet home page.

The SDO MIS is easily accessible for all SDO personnel, regardless of their locations, and all files that are uploaded to the system are encrypted to prevent leaks and break-ins from hackers. Best of all, the system is easily adaptable for other projects, saving other missions the hassle and cost of creating new systems from scratch.

The SDO Intranet home page houses the Management Information System, which can be used to access documents via a powerful search engine.

Coldfire SDN Hardware Diagnostics Technology

Coldfire Subsystem Data Node (SDN) Hardware Diagnostics software (GSC-15478-1) is a flexible means of testing and debugging custom computer hardware. It has been used to test the ColdFire® processors on the SDN processor boards that were designed at Goddard for the SDO mission.

The diagnostics software provides a set of routines that collectively serve as a common interface to various parts of the hardware under test conditions. The routines can be used to construct customized tests, to exercise and verify the operation of processors and hardware interfaces prior to delivery. On SDO, diagnostics were run during the early hardware check-up phases to debug the hardware interfaces and ensure that the hardware was performing as designed. The ColdFire diagnostics software identified some problems with the SDO hardware that subsequently were corrected.

This diagnostics software can be customized for use with ColdFire processors and other processors to offer increased flexibility and allow its use on diverse NASA projects. The SDO version evolved from software that previously was used on the Earth Observing-1 (EO-1), Microwave Anisotropy Probe (MAP), Geoscience Laser Altimeter System (GLAS), and Space Technology 5 (ST5) missions. The SDO version has subsequently been used to test hardware for the Express Logistics Carrier (ELC) project, and components of the software are being used in the Global Precipitation Measurement (GPM) and Magnetospheric Multiscale (MMS) missions.

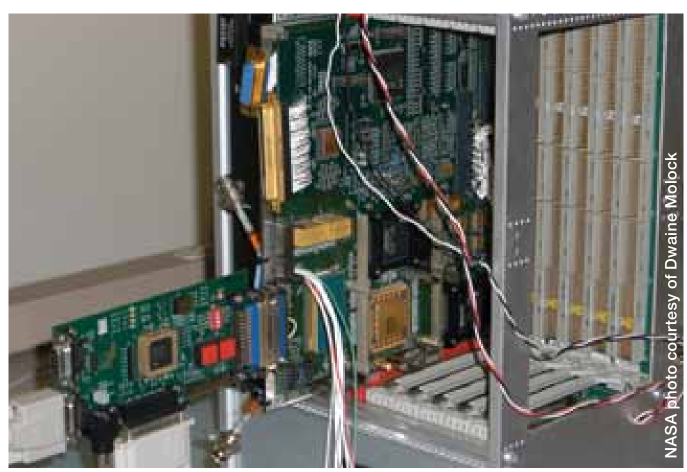
“

The IPP Office supported me through the process of getting this technology registered so that it could be released to the University of Idaho. It is great to see the work that I do being used outside of Goddard.

— Dwaine Molock, *Computer Engineer, Code 582*

”

In 2007, NASA's Headquarters funded a project to develop an enhanced version of the ColdFire processor that is currently being used on NASA missions. The University of Idaho was chosen to complete the design, and the university has been given permission to use the Coldfire SDN Hardware Diagnostics software to test the product it is developing. The new processor could be used in future missions and replace the one currently being used on MMS. ■



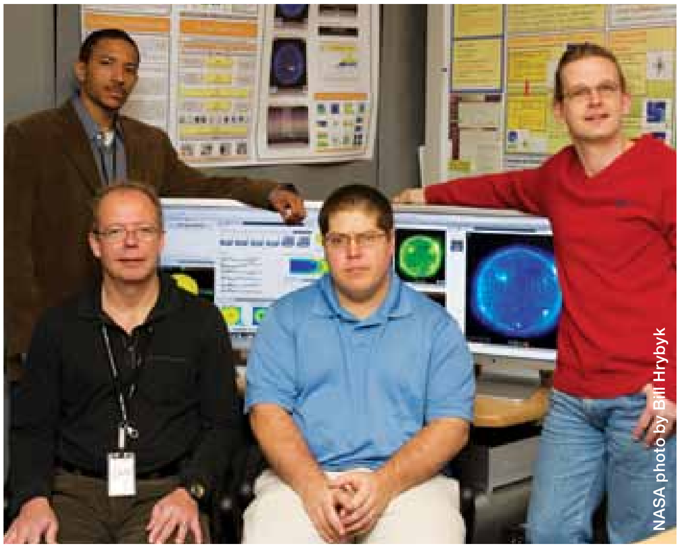
The Coldfire SDN Hardware Diagnostics technology will test and debug computer hardware and can be customized for use with a variety of different processors.

ColdFire is a registered trademark of Freescale Semiconductor, Inc. Freescale Semiconductor is an American semiconductor manufacturer, created by the divestiture of the Semiconductor Products Sector of Motorola in 2004.

Space Weather Data and Visualization Software Improves Information Sharing, Analysis, and Prediction

Severe space weather can influence the performance and reliability of space-borne and ground-based systems, including satellite communications, navigation systems, and Earth's electrical power grid. Magnetic storms triggered by solar activity can also pose a threat to astronauts and impact the scientific data gathered during space missions.

The Space Weather Laboratory (Code 674) and Software Engineering Branch (Code 580) at Goddard have been working together on several projects and technologies that are making significant advancements in NASA's ability to observe, analyze, and forecast the causes of severe space weather—solar activity such as turbulent solar wind, solar flares, and coronal mass ejections (CMEs). This collaborative effort will help make the avalanche of data and high-resolution images generated by SDO easily accessible and understandable, and it will use the data to enhance NASA's understanding of space weather.


NASA photo by Bill Hrybyk

The Space Weather team (from left): Marlo Maddox, Dr. Michael Hesse, Richard Mullinix, and Dr. Lutz Rastaetter. Not pictured: David Berrios and Peyush Jain.

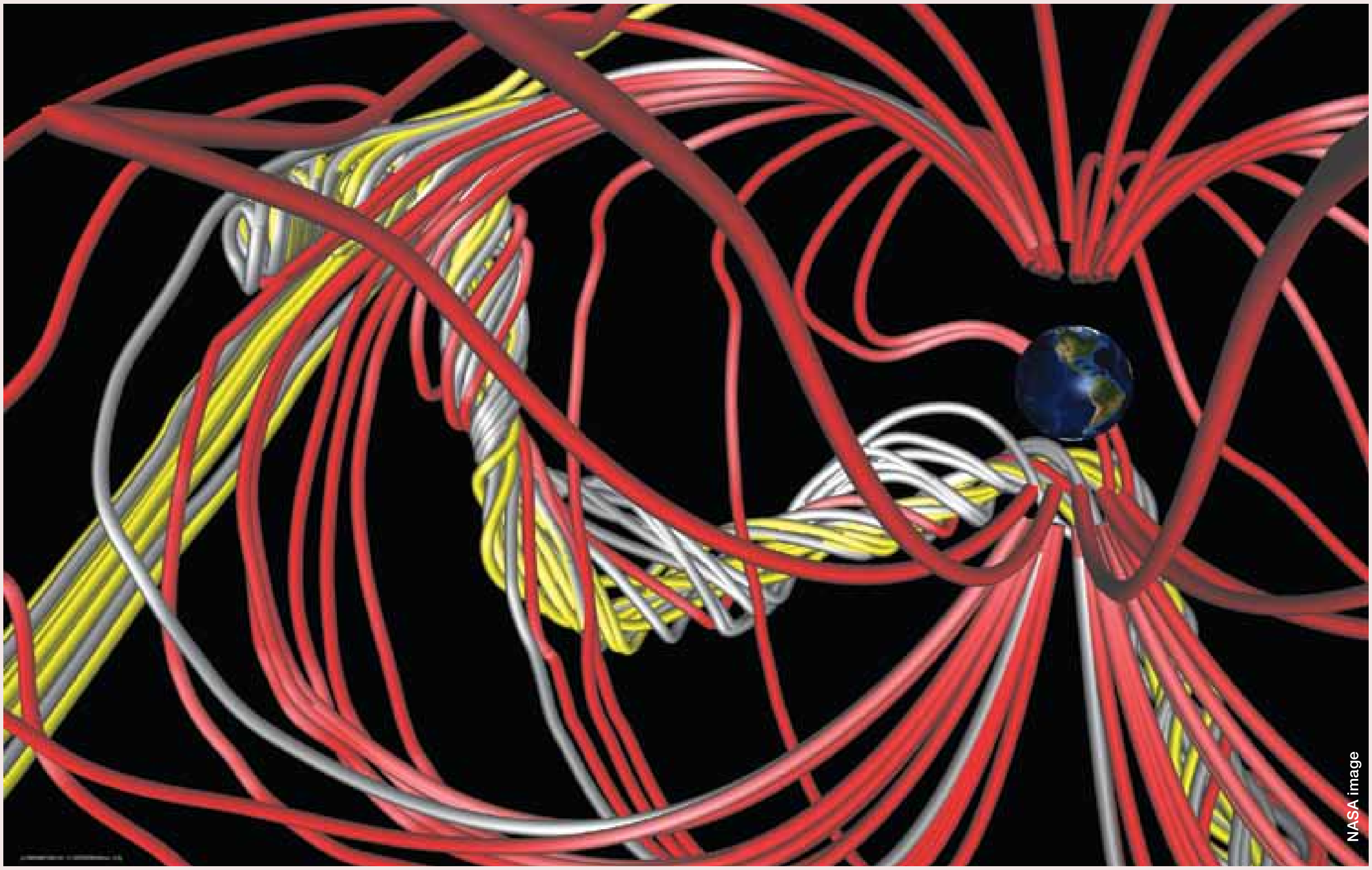
> "Our counterparts in atmospheric weather have a lot more sensors to feed their models than we do in space weather. They have rain sensors, temperature sensors, and wave monitors all over the world. SDO will be a much-needed solar monitor for our observational arsenal and will help us provide accurate space weather forecasts and specifications."
>
> **— Marlo Maddox, *Data Management and Analysis Branch, Code 587***

One recent innovation, the Kameleon software suite, was developed at Goddard's Community Coordinated Modeling Center (CCMC)—a multi-agency partnership managed by the Space Weather Laboratory— to address the difficulty in analyzing and disseminating varying output formats of space weather model data. The Kameleon software suite consists of two separate components. The Kameleon Converter (GSC-15440-1) is a comprehensive data format standardization tool that allows heterogeneous space weather model output to be stored uniformly in a common science data format. The converted files contain both the original model output as well as additional metadata elements to create platform-independent and self-descriptive files. Once the original model output has been converted into a standard format with accompanying metadata elements, the Kameleon Access and Interpolation Library (GSC-15511-1) provides a user-friendly interface to the standardized data for those needing to access it.

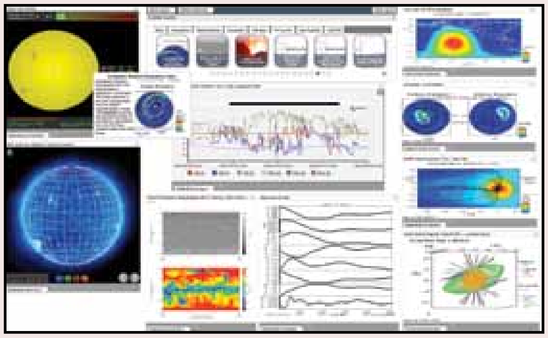
The Space Weather Visualization Application (GSC-15899-1) also was developed at CCMC to allow end users to visualize and analyze data from multiple space weather models that are executed by CCMC and accessed through the Kameleon library. This software tool allows users to visualize multiple space weather models in a single application and view the topology of 3D vector fields of those models quickly and with a high level of detail.

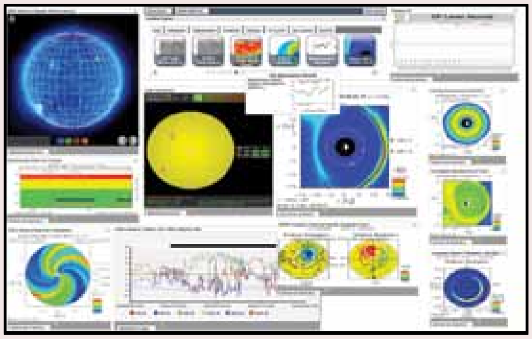
These technologies are improving space weather data sharing within NASA and among other agencies interested in space weather, and they are key tools in Goddard's iNtegrated Space Weather Analysis (iSWA) system. Developed by the Space Weather Laboratory and Software Engineering Division, iSWA is a flexible, turn-key, Web-based dissemination system for NASA-relevant space weather information that combines forecasts based on the most advanced space weather models with concurrent space environment information. iSWA is customer configurable and adaptable for use as a powerful decision-making tool that mission planners and scientists can use to identify and react to space weather events.

For example, some large solar disturbances can heat the upper atmosphere, causing it to expand and create increased drag on spacecraft in low Earth orbit (LEO), shortening the orbital lifetime of the spacecraft. iSWA can provide atmospheric drag warnings for personnel working on these LEO missions, triggering maneuvers to boost the spacecraft's orbit to counteract the drag. Early warning can reduce the total impact of the drag on the



This screen shot illustrates the earth's magnetic field. The twisty rope-like structure is called a flux transfer event, something that was previously difficult to visualize effectively. The colored lines represent magnetic fieldlines and their various connections to the earth.

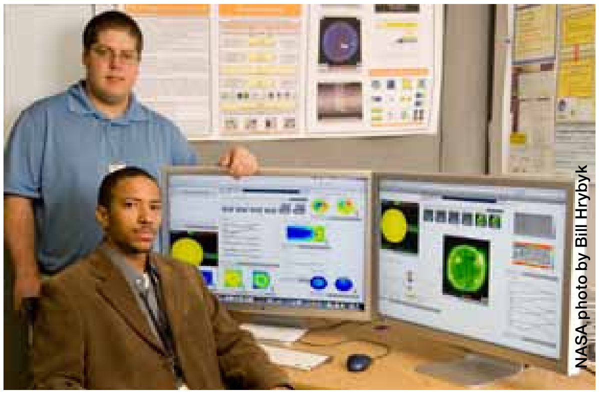




The screen shots to the left illustrate how the main iSWA display panel can be customized using any combination of individual space weather analysis data products/tools currently available in the iSWA catalog. The system can be used to monitor the current space environment in real time or for post-impact and historical analysis.

spacecraft and minimizes the necessary response, saving time and resources. iSWA also allows scientists to look back in time and see if data anomalies can be traced to space weather events.

iSWA incorporates data and models from more than 150 sources to provide unprecedented ability for analysis of the present and expected future space weather impacts on NASA's human and robotic missions. But all of the data currently available to iSWA is only a fraction of what SDO will generate. Thanks to recent innovations such as the Kameleon software suite and the Space Weather Visualization Application, Goddard is prepared to utilize this additional data from SDO to make unprecedented strides in space weather observation, forecasting, and specification. ■



Richard Mullinix (left) and Marlo Maddox illustrate the Space Weather Visualization Application.

SDO: Investigating the Sun and Enabling Scientific Discovery

The primary scientific goal of Solar Dynamics Observatory (SDO) is to better understand and predict solar variations that influence life on Earth and humanity's technological systems. SDO will achieve these goals by determining how the Sun's magnetic field is generated and structured, and how this stored magnetic energy is converted and released into the heliosphere and geospace in the form of solar wind, energetic particles, and variations in the solar irradiance.

The SDO will create approximately 50 times more science data than any other mission in NASA history. SDO will return 150 million bits of data per second to Earth, 24 hours a day, 7 days a week, for 5 years, the equivalent of 500,000 iTunes® downloads per day, every day. That is music to the ears of NASA scientists who are awaiting the onslaught of new data.

"We know the Sun is always changing and producing streams of high-energy particles and radiation that can affect life and electrical systems," said Dean Pesnell, PhD, Project Scientist for SDO. "Although the general process of solar activity and its cyclic behavior are known, many of the details are not. The data provided by SDO will help scientists uncover a lot of these details, allowing us to better understand the causes of solar activity and improve our ability to make predictions about the Sun."

The build up and explosive release of the Sun's magnetic energy causes solar storms such as coronal mass ejections (CMEs) and solar flares that we see here on Earth as space weather.

Solar flares and CMEs are currently the biggest "explosions" in our solar system—with each event potentially approaching the energy released by the detonation of several billion hydrogen bombs. They are the root cause of much of Earth's geomagnetic and ionospheric disturbances.

The charged particles produced by solar storms can damage the electrical systems in satellites and other robotics systems in NASA's space missions. They can even cause city-wide electrical blackouts by producing fluctuations in Earth's magnetic field that can overload transformers. Large solar flares can greatly impact the electron density in Earth's ionosphere, disrupting radio communication with airplanes and certain types of low-frequency navigation.

iTunes is a registered trademark of Apple Inc.

> "We'll see every nuance of solar activity. Because these fast cadences have never been attempted before by an orbiting observatory, the potential for discovery is great."
>
> **— Dr. Dean Pesnell, *SDO Project Scientist, Code 671***

Dr. Dean Pesnell

code: **671**

years with NASA: **15 as a contractor and 5 as a civil servant**

field of research: **Solar cycle prediction and space weather**

birthplace: **Wilmington, Delaware**

education: **BS in Physics, University of Delaware**

PhD in Physics, University of Florida

Solar events can increase the frictional drag on satellites in low Earth orbit (LEO), degrading their orbits and causing satellites to re-enter the Earth's atmosphere sooner than expected. These storms can disrupt communication uplinks and downlinks with NASA missions as well. Exposure to radiation and high-energy particles from space weather events can also pose a risk to astronauts.

Data from SDO will help scientists make much-needed advancements in the ability to predict these dangerous events, and provide sufficient warning to protect equipment and personnel. For example, NASA controllers could respond to warnings by triggering backup circuitry on vulnerable equipment or increasing staffing on the ground to facilitate command changes more rapidly and react faster to system interruptions. Astronauts could delay a space walk or use protective shielding during a space weather event. The Russian module on the International Space Station already provides such protection for astronauts based there.

"Right now, we can make limited space weather predictions, but they are baby steps compared to our ability to forecast weather on Earth," said Dr. Pesnell.

All three of SDO's main instruments will work together to capture data and play a role in understanding and predicting solar storms.

The Helioseismic and Magnetic Imager (HMI) will look inside the Sun to map the flows of plasma that generate solar magnetic fields, using helioseismology to trace sound waves reverberating inside the Sun similar to an ultrasound scan. This data can be used to make determinations regarding events that are occurring on the other side of the Sun or those events that cannot be directly viewed by the satellite. HMI will also be able to measure the strength and direction of the magnetic fields emerging on the sun's surface. With these capabilities, HMI will help discover the mechanisms that cause the solar cycle on the sun that lasts approximately 11 years and is the main source of the solar variations that create space weather. Sunspots indicate areas in which the Sun's magnetic field is twisted and stressed, thought to be the cause of solar flares and CMEs.

The Atmospheric Imaging Assembly (AIA) will take pictures of the Sun's atmosphere where the Sun's magnetic fields change shape and release energy. The images from AIA will be used with HMI's data to link changes on the surface with interior changes. Together, AIA and HMI will provide a broad spectrum of raw data that can reveal how active regions on the Sun concentrate and then violently disperse magnetic fields in the form of solar storms.

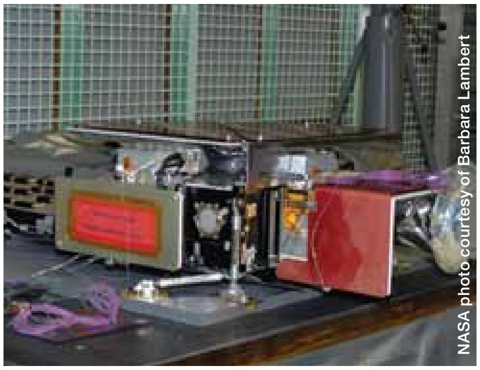
The Extreme Ultraviolet Variability Experiment (EVE) will measure the Sun's constantly changing ultraviolet brightness. Rapid changes in the ultraviolet radiation of the Sun can cause temporary outages in radio communications and electrical systems on satellites orbiting the Earth. EVE will take measurements of the Sun's brightness as often as every ten seconds, providing space weather forecasters with warnings of possible outages that can be used to alert mission teams to take preventative measures to protect their electronic systems. By comparing EVE's measurements with pictures taken at the same time by AIA, scientists can learn where the change in brightness came from and whether it was a flare, a CME, or some other event. HMI will then reveal the magnetic and plasma flow activities behind the event.

The unique types of data provided by SDO—such as HMI's ability to look inside and around the sun through helioseismology—and the ability of the instruments to work together will help paint a more complete picture for scientists to decipher. The unprecedented pace and quality of the images to be captured is another important technological advancement for SDO.

"We'll be getting eight IMAX®-quality images every 10 seconds," said Pesnell. "We'll see every nuance of solar activity. Because these fast cadences have never been attempted before by an orbiting observatory, the potential for discovery is great." ■

The four AIA telescopes will image the solar atmosphere in multiple wavelengths and link changes on the solar surface with interior changes.

The EVE will measure the solar extreme-ultraviolet irradiance with unprecedented spectral resolution, temporal cadence, and precision.



The HMI will measure sound waves reverberating inside the Sun, building up a picture of the interior, similar to an ultrasound scan. HMI will also measure the strength and direction of the magnetic field at the surface of the Sun.

Glossary:

Active regions - Regions of the Sun that are responsible for the production of intense and violent energy bursts, called flares, and events where very large amounts of hot gas, trapped by the magnetic field of the active region, are released from the Sun's atmosphere

CME - Occurs when a cooler cloud of gas above the Sun's surface erupts, sending millions of tons of plasma into space

Corona - The outer part of the Sun's atmosphere

Geospace - The region of space that stretches from about 100 kilometers above the Earth's surface to the outermost reaches of the Earth's magnetic field

Helioseismology - The study of waves in the Sun, how they move through the Sun, and how the waves are affected by conditions inside the Sun

Heliosphere - The immense "bubble" carved into the interstellar medium by the solar wind that contains our solar system

Plasma - A fourth state of matter—neither a solid, liquid, nor gas—in which electrons are pulled free from atoms and can move independently; although the individual atoms are charged, the total number of positive and negative charges is equal, maintaining an overall electrical neutrality

Solar flare - A large explosion in the Sun's atmosphere that releases electromagnetic radiation

Solar irradiance - The radiant energy flux density from the entire disk of the Sun, measured at the Earth

Solar wind - The stream of charged particles (protons, electrons, and heavier ionized atoms) coming out of the Sun in all directions at almost a million miles per hour; the solar wind is responsible for the anti-sunward tails of comets and the shape of the magnetic fields around the planets

Spectral irradiance - The radiant energy flux density of the Sun measured at the Earth as a function of wavelength metrics

Tech Transfer Metrics

Fourth quarter of fiscal year 2009 and first quarter of fiscal year 2010

Software Release Awards: 5

Goddard Mission Services Evolution Center ANSR by Peter Hitchener (Code 583)

Goddard Mission Services Evolution Center Architecture Application Programming Interface (GMSEC Architecture API) [R2] by Mike Butschky (Code 583)

Systems And Methods For Determining Spacecraft Orientation by Richard Harman, Richard Luquette, and Michael Lee (Code 584)

MTASS Attitude Determination and Sensor Calibration System by Richard Harman, Joseph Hashmall, Joseph Sedlak, Richard Coon, Denis Felikson, and Jonathan Glickman (Code 584)

Coldfire SDN Hardware Diagnostics by Dwaine Molock (Code 582)

Patent Application Filed Awards: 3

Apparatus and Method for a light direction sensor by Douglas Leviton (Code 551)

Direct Solve Image Based Wavefront Sensing by Richard Lyon (Code 667)

A two-Axis Direct Fluid Shear Stress by Michael Scott and Edward Adcock (Code 600/LaRC)

Patents Issued: 5

Modular Gear Bearings by John Vranish (retired)

Hybrid Diversity Method Utilizing Adaptive Diversity Function for Recovering Unknown Abbreviations in an Optical System by Bruce Dean (Code 551)

System and Method for Managing Autonomous Entities Through Apoptosis by Michael G. Hinchey (Code 585) and Roy Sterritt (independent inventor)

Device, System and Method for a Sensing Electrical Circuit by John Vranish (retired)

Interferometric Polarization Control by Edward Wollack (Code 665), Samuel Moseley (Code 685), Giles Novak (Northwestern Univ.), and David Chuss (Code 665) [two patents received]

Patent Applications Filed: 18

Methods of Determining Complete Sensor Requirements for Autonomous Mobility by Steven Curtis (Code 695)

Compact Planar Microwave Blocking Filters by Kongpop U-Yen (Code 555) and Edward Wollack (Code 665)

Method of Improving System Performance and Survivability Through Self-Sacrifice by Michael Hinchey and Emil Vassev (both Code 585)

High Field Superconducting Magnets by Thomas Hait and Peter Shirron (both Code 552)

Digital Radar Systems and Methods by Udayan Mallik (Code 564)

Tunable Frequency-stabilized Laser via Offset Sideband by Jeffrey Livas (Code 663), James Thorpe (Code 663), and Kenji Numata (University of Maryland)

Low Temperature Radiometer by Michael DiPirro, Thomas Hait, and James Tuttle (all Code 552)

Step Frequency ISAR by Manohar Deshpande (Code 555)

Systems and Methods for Mirror Mounting with Minimized Distortion by Scott Antonille, Shana Wake, and David Content (all Code 551), and Thomas Wallace (Code 544)

Optimal Padding for the Two-Dimensional Fast Fourier Transform by Bruce Dean, David Aronstein, and Jeffrey Smith (all Code 551)

Discrete Fourier Transform (DFT) Analysis for Applications Using Iterative Transform Methods by Bruce Dean (Code 551)

Sampling Theorem in Terms of the Bandwidth and Sampling Interval by Bruce Dean (Code 551)

Variable Sample Mapping Algorithm by Bruce Dean, David Aronstein, and Jeffrey Smith (all Code 551), and Richard Lyon (Code 667)

Passively Q-switched Side Pumped Monolithic Ring Laser by Steven Li (Code 554)

Hybrid Architecture Active Wavefront Sensing and Control System and Method by Lee Feinberg (Code 550), Bruce Dean (Code 551), and Tristram Hyde (Code 590)

Radiation-Hardened Hybrid Processor by Thomas Flatley (Code 587)

High Precision Electric Gate for Time-of-Flight Ion Mass Spectrometers by Edward Sittler (Code 673)

SWARM Autonomic Agents with Self-Destruct Capability by Michael G. Hinchey (Code 585) and Roy Sterritt (independent inventor)

New Technology Reports: 119

Sealable Microleak for Gas Flow Control by Dan Kelly (Code 553)

Ghost Detection using MTF Analysis by Bruce Dean (Code 551)

Electrospray Ionization for Chemical Analysis of Organic Molecules for Mass Spectrometry by Yun Zheng (Code 553)

Electrical Harness Heat-Sinking Clamp by James Tuttle (Code 552)

A Low-Cost, Helium-Cooled, Black Shroud for Subscale Cryogenic Testing by James Tuttle (Code 552)

IMAGEER (IMAGEs for Education and Research), a NASA Image Database by Jacqueline LeMoigne-Stewart (Code 580)

Active Gas-Gap Heat Switch with Fast Thermal Response by Peter Shirron (Code 552)

A Passive Gas-Gap Heat Switch that Turns Off When the Warm End Temperature Rises by Peter Shirron (Code 552)

Graphical User Interface (GUI) for Phase Retrieval Processing by Bruce Dean (Code 551)

An Instrument Suite for the Vertical Characterization of the Ionosphere-Thermosphere System from 100 km to 700km Altitude by Federico Herrero (Code 553)

Iterative Transform Phase Diversity: An Image-based Object and Wavefront Recovery Algorithm by Jeffrey Smith (Code 551)

Phase Retrieval Approach Using Wavelets by Bruce Dean (Code 551)

Data Compression Algorithm Architecture for Large Depth-of-Field Particle Image Velocimeters by Brent Bos (Code 551)

A Technique for Determining Thermal Window Corrections when Using LIDAR Metrology Systems for Structures in a Chamber by Edgar Canavan (Code 551)

An Innovative Technique for Configuring an Actively Cooled Thermal Shield in a Flight System by Peter Barfknecht (Code 552)

Imaging System Aperture Masks for Image Plane Exit Pupil Characterization by Brent Bos (Code 551)

Aperture Mask for Unambiguous Parity Determination in Long Wavelength Imagers by Brent Bos (Code 551)

Guidance Navigation and Control Flight Software Application Framework by David McComas (Code 582)

Materials and Fabrication Method for Ultrasensitive THz Antenna Circuits by James Chervenak (Code 553)

High-speed Fiber Optic Micromultiplexer for Space and Airborne Lidar by Jun Ai (Luminit, LLC)

An Improved Method of Fabricating Single Crystal Silicon Light Weight Mirrors by Vincent Bly (Code 553)

A Multi-Wavelength, Multi-Beam, and Polarization Sensitive Laser Transmitter for Surface Mapping by Anthony Yu (Code 554)

Vectorized Rebinning Algorithm for Fast Data Down-Sampling by Bruce Dean (Code 551)

Lateral Kevlar Suspension Device (LKSD) by Donald Wegel (Code 552)

SpaceCube Demonstration Platform by Daniel Espinosa (Code 587)

Sampling and Reconstruction of the Sinc(x) Function by Bruce Dean (Code 551)

Integrated Composite—Heatpipe Radiator Panel by Mark Montesano (k Technology Corp.)

Integration Techniques for Dissipative Bolometers and Millimeter Scale Absorbers by James Chervenak (Code 553)

Fabrication of a Kilopixel Array of Superconducting Microcalorimeters with Microstripline Wiring by James Chervenak (Code 553)

Goddard Mission Services Evolution Center (GMSEC) Environmental Diagnostic Analysis Tool by Sharon Osborne (Code 583)

Standards-based Web Access to Climate Model Workflows by John Evans (Global Science & Technology)

Lunar Navigation Determination System (LaNDS) by David Quinn (Code 595)

Harpoon Sample Collection System Test Facility by Don Wegel (Code 552)

Reflective Occultation Mask for Evaluation of Advanced Occulter Designs for Planet Finding by Patrick Roman (MEI)

High-Speed Scanning Interferometer using CMOS Image Sensor and FPGA based on Multi-Frequency Phase-Tracking Detection by Tetsuo Ohara (Nanowave, Inc.)

Radius of Curvature Measurement of Large Optics using Interferometry and Laser Tracker by John Hagopian (Code 551)

iEOC Interoperability by Amanda Hollins (Constellation Software)

Climate Information: Modeling Integration Framework by Gail McConaughy (Code 581)

VSDE2—Virtual Systems Design Environment by Christopher Holtery (CSE Corporation)

Integrated Spatial Filter Array by Jun Ai (Luminit, LLC)

SpaceCube Version 1.5 by Alessandro Geist (Code 587)

New Variables for Iterative Transform Phase Retrieval by Bruce Dean (Code 551)

Determining Phase Retrieval Sampling from the Modulation Transfer Function by Bruce Dean (Code 551)

High SBS-Threshold Highly Er/Yb Co-doped Phosphate Glass Fiber Amplifiers for High Power, Sub-Microsecond Pulsed, Narrow Linewidth, All Fiber-based Laser Transmitter by Wei Shi (NP Photonics, Inc.)

Fastener Capture Plates for Containing On-Orbit Debris by Kevin Eisenhower (Alliant Techsystems)

Photonic Crystal Lens Design with High Imaging Isotropy by Wai Jiang (Omega Optics)

Optical Fiber Array Assemblies for Space Flight by Melanie Ott (Code 562)

Miniature, Rugged, Pulsed Laser Source for LIDAR Applications by Laurence Watkins (Princeton Optronics, Inc.)

Capacitance Tomography Mass Fuel Gauge for Cryogenic Liquid Stored in Tanks Subjected to Zero or Microgravity Conditions by Lawrence Hilliard (Code 555)

Nitinol LHP Coax Lines Can Be Pulled Like Cable by Alfred Phillips (Thermacore, Inc.)

Wavefront Sensing Analysis of Grazing Incidence Optical Systems by Scott Rohrbach (Code 551)

Pressure Controlled Heat Pipe for Precision Temperature Control by Peter Dussinger (Advanced Cooling Technologies, Inc.)

Novel Fabrication Method for Micro-Porous Alumina-based Ceramics by Helen Chan (Lehigh University)

Design and Processing of Silica Nano Molds by Mukund Deshpand (Applied Material Systems)

Boron Nitride, Nano Tube, and Nano Mesh for Non-Charging Space Applications by Mukund Deshpand (Applied Material Systems)

Space Stable, Ultra Low Cost Outgassing p-Carborane Siloxane Room Temperature Curing TP Polymer for Space Applications by Mukund Deshpand (Applied Material Systems)

Software Infrastructure to Enable Modeling and Simulation as a Service (M&SaaS) by Steven Armentrout (Parabon Computation)

Low Cost Synthesis of p-Carboranes by Mukund Deshpand (Applied Material Systems)

Greyhound Middleware by Robert Wiegand (Code 583)

Far Infrared Imaging Camera System by Mani Sundaram (QmagiQ)

Polarizing Lens and Polarizing Lens Array by David Crouse (City College of New York)

Simple Network Management Protocol Agent (SNMP Agent) by Eric Martin (SRA/ICS)

Graphite Composite Panel Polishing Fixture by John Hagopian (Code 551)

Self Deploying Nitinol LHP Radiator by Alfred Phillips (Thermacore, Inc.)

A Single Aperture, High Cross-Pol Isolation, Matched Beam, Dual Wavelength, Dual Polarized Antenna by Dan Schaubert (University of Massachusetts)

Recursive Branching Simulated Annealing Algorithm by David Aronstein (Code 551)

Development of Position-Sensitive Magnetic Calorimeters for X-ray Astronomy by Simon Bandler (University of Maryland)

Miniaturized Double Latching Solenoid Valve by James Smith (Code 544)

Scientific Modeling and Simulation under the Software as a Service Paradigm by Daniel Karipedes (TechX Corp)

GMSEC API Performance Testing Utility by Rick Woods (SRA)

Advanced Technology Cloud Particle Probe for UAS by Paul Lawson (Spec, Inc.)

Method for Selective Clean of Mold Release from Composite Honeycomb Surfaces by Diane Pugel (Code 553)

Novel Ultralow-Weight Metal Rubber™ Sensor System by Andrea Hill (NanoSonic, Inc.)

Goddard Mission Services Evolution Center Architecture Application Programming Interface (GMSEC Architecture API) v.3.0 by Eric Martin (SRA)

3D Space Weather Visualization Application by David Berrios (Code 587)

Electro-optic High-Speed Fiber Multiplexer by Xiaopei Chen (Boston Applied Technologies)

An Approach to Positively Verify Mating of all Flight Connectors which were Considered or Thought to be Not Verifiable by Pandipati (PSGS QSS)

GMSEC Alert Notification System Router (ANSR) version 3.9 by Alvin Thompson (Emergent Technologies)

High-Performance, Space-Qualified, Radiation-Hardened Multi-Core Processor by David Czajkowski (Space Micro)

FPGA-based High-Rate Receiver for Space Applications by Dan Voos (Innovative Communications Engineering)

Determination of Zero-G Figure of Mirrors by Measuring 1-G Figure and Reduced G-Figure by Partial Immersion of Optic Under Test in Fluid by John Hagopian (Code 551)

Test Port for Fiber-Optic Coupled Laser Altimeter by Luis Ramos-Izquierdo (Code 551)

Super Polishing Parameters for Zeeko CNC Polisher by Susan Wilson (Microengineered Metals)

Multi-Layer Far-Infrared Component Technology by Oliver Edwards (Zyberwear)

RHSEG Version 1.45 by James Tilton (Code 606)

Miniature, Variable Speed Control Moment Gyroscope by Robert Kline-Schoder (CREARE)

Automated Beam Balance Scale Logger by Wayne Esaias (Code 614)

n x 10 Gbps Offload NIC for NASA, NLR, Grid Computing by James Awrach (SeaFire)

The Laser Ranging Subsystem on the Lunar Reconnaissance Orbiter by Maria Zuber (MIT)

Sci-Share: Social Networking Adapted for Distributed Scientific Collaboration by Homa Karimabadi (SciberQuest)

Silicon Microchannel Plate Large Area UV Detector Photodetector by Paul Schnitser (Physical Optics Corporation)

Compact Cryogenic Linear Sensor by Kenneth Blumenstock (Code 544)

RAP Figuring Slumped Mirrors to Remove Mid-Spatial Frequency Errors by Pradeep Subrahmanyan (RAPT Industries)

In situ Aerosol Detector by Andrei Vakhtin (Vista Photonics)

Non-Redundant Aperture Solver and Visualizer by Nargess Memarsadeghi (Code 587)

Simple, Scalable, Script-based Science Processing Archive (S4PA) by Mahabaleshwara Hedge (ADNET Systems)

Streamline-based Microfluidic Device by Yu-Chong Tai (California Institute of Technology)

Microchip Cooling Device with Diamond Heat Sink by Oleg Voronov (Diamond Materials, Inc.)

Goddard Satellite Data Simulation Unit by Toshihisa Matsui (University of Maryland, Baltimore County)

GSTS - Gold Standard Test Set by Jerry Cote (Vantage System)

Diagnosable Structured Logic by Sterling Whitaker (University of Idaho)

A Dual Polarized Feed Structure Applicable to a Single Antenna or an Array by Mohammed Sarehraz (USF College of Engineering)

Ultra-Wide Angle, Non-Mechanical Scanning, High Power Planar Waveguide Amplifier Module for LADAR Applications by Scott Davis (Vescent Photonics)

Nano-Particle Enhanced Polymer Materials for Space Flight Application by Tracee Brown (Clark Atlanta University)

Automatic Stability Verification of Microshutters Subsystem of JWST via Wavelet-based Image Registration Algorithms by Nargess Memarsadeghi (Code 587)

Cooperative Observatories for Radiometric Knowledge (CORK) by Lawrence Hilliard (Code 555)

Cooperative Observatories for Earth Science Distribution (COED aka LRNet-H) by Lawrence Hilliard (Code 555)

Inverse Influence Function Shaping for Casted Radius of Curvature Controlled Mirror by Gregory Michels (Sigmadyne, Inc.)

Wireless Integrating the Sciences (WITS) Theatre by Lawrence Hilliard (Code 555)

Multi-Scale Image Reconstruction using Wavelets by Bruce Dean (Code 551)

Compact adiabatic demagnetization refrigeration stage with integral passive gas-gap heat switch by Peter Shirron (Code 552)

Phase Retrieval for Radio Telescope and Antenna Control by Bruce Dean (Code 551)

Phase Retrieval System for Assessing Diamond-Turning and other Optical Surface Artifacts by Bruce Dean (Code 551)

SOHO Integrated Trending and Plotting System (ITPS) Release 5.0 by Sheila Ritter (Code 583)

FERMI/GLAST Integrated Trending and Plotting System (ITPS) Trending and Analysis Software Release 5.0 by Sheila Ritter (Code 583)

Perl Module for Serialized RESTful Client interactions by Curt Tilmes (Code 614)

Use of CCSDS packets over SpaceWire to control hardware using hardware compatible with the software bus utilized within the core flight executive (CFE) by William Yuknis (Code 561)

Active bond control for a zero micro-meter distortion bond by Ryan McClelland (Code 543)

Microgravity Robot by Kenneth Moses (Code 695) ■

Metal Rubber is a trademark of NanoSonic, Inc.

Goddard IPP Business Networking and Recognition

Goddard IPP's Melissa Jackson shows off the mini-demo game that is part of the upcoming MMO educational game "Astronaut: Moon, Mars and Beyond" at the PRIOR Technology Challenge.

MAPLD Conference
(August 31-September 3, 2009 – Greenbelt, MD)

Ted Mecum and Irene Tzinis exhibited Goddard innovations and programs at the Military and Aerospace Programmable Logic Devices (MAPLD) Conference. As a result of discussions they held with companies and other government agencies about Goddard technologies and partnership opportunities, two Space Act Agreements are being drafted.

IPO Annual Meeting
(September 13-15, 2009 – Chicago, IL)

Nona Cheeks and Ted Mecum attended the Intellectual Property Owners Association (IPO) annual meeting. The event provided insights into IP portfolio management, including strategies for building, protecting, and getting the most value out of the patent portfolio in today's economic climate.

FLC MAR Annual Meeting
(September 15-17, 2009 – Gettysburg, PA)

Darryl Mitchell moderated a panel on the "Human Element of Technology Transfer" at the Federal Laboratory Consortium (FLC) Mid-Atlantic Region (MAR) annual meeting. The FLC is responsible for standardizing government technology transfer practices and facilitating intra-governmental transfer of technologies.

LES Maryland Chapter Meeting
(September 23, 2009 – Fort Meade, MD)

Enidia Santiago-Arce and Ted Mecum participated in the Maryland chapter meeting of the Licensing Executives Society (LES), held at the National Cryptological Museum. They networked with other licensing and technology management professionals, identifying new business concepts and potential partnership opportunities.

SBIR Beyond Phase II Conference & Technology Showcase
(September 21-24, 2009 – Orlando, FL)

Dr. Jim Chern represented Goddard at this event, which showcased the technologies of SBIR Phase II awardees and provided a forum for commercialization opportunities. The event brought together the SBIR companies with key technology and acquisition personnel from government and industry, enabling the transition of SBIR-funded research and development into government and private sector applications.

International Astronautical Congress
(October 12-16, 2009 – Daejeon, South Korea)

Nona Cheeks co-chaired a session on "Technology Transfer Trends" and presented papers on "Managing the Utilization of Software" and "Leveraging NASA Technology."

LES Annual Meeting
(October 18-22, 2009 – San Francisco, CA)

Darryl Mitchell gave a presentation on "Doing Deals with National Labs and Federal Agencies." LES brings together a global network of IP asset managers to discuss best practices, experiences, and opportunities for licensing technologies.

17th Annual New Technology Reporting Program
(October 29, 2009 – Beltsville, MD)

Over 100 people attended this event to celebrate Goddard innovations. The event included the presentation of 33 patent awards and the James Kerley Award for Innovation and Technology Transfer, presented to Dr. Mike Hinchey from the Software Engineering Division. The keynote speaker was Greg Moores, vice president of construction engineering at Black & Decker Corporation (Towson, MD). Mr. Moores gave a historical perspective of Black & Decker's drill technology evolution over several decades, highlighting the impact of the NASA moon drill requirements on the company's product line.

National SBIR/STTR Conference
(November 2-5, 2009 – Reno, NV)

Dr. Jim Chern, Nona Cheeks, and Dwight Norwood met with representatives from industry, academia, other federal laboratories, venture capital firms, and angel investors. Discussions were held on how to further technology development for early- and advanced-stage ventures such as SBIR/STTR awardees.

IPP Art Contest Winner Recognition
(November 13, 2009 – Ellis Island, NY)

Goddard IPP presented the U.S. Department of Interior's National Park Service with the winning image from the "Goddard Celebrates 50 Years of Technology Spinoffs Art Contest" held in spring 2009. The image was created by Ja Hyun "Ashley" Lim of North County High School (Glen Burnie, MD). Ms. Lim painted a juxtaposition of the Statue of Liberty (maintained by the Park Service) and a Kennedy Space Center launch pad to represent a coating technology developed at Goddard. The coating was first used on the launch gantries and later on the Statue of Liberty. Approximately 200 students participated in the event from two NASA Explorer Schools: Dr. Albert Einstein Academy (Elizabeth, NJ) and the Steinway Intermediate School (Astoria, NY).

Maryland SBIR Conference
(November 17, 2009 – Greenbelt, MD)

Ted Mecum held one-on-one sessions with several of the more than 100 companies attending the "Innovation and Investment" event. The companies expressed interest in working with NASA to help meet mission needs in areas such as nano-particle materials, cryo-fiber optics, high-speed computer data systems, 3D imaging data for tomographic reconstruction, and freeze-dried foods for space.

Next Steps in Managing Innovation Workshop
(December 8, 2009 – Boston, MA)

Goddard's IPP hosted the second of these workshops. Goddard technologists, NASA prime contractors, and other partners responsible for managing innovation discussed NASA technology requirements and how potential solutions could be leveraged for commercial applications. More than 30 SBIR/STTR companies and small high-tech firms attended, as well as representatives from several northeast universities.

PRIOR Technology Challenge
(December 9-12, 2009 – Guaynabo, PR)

At this annual event of the Puerto Rico Institute of Robotics (PRIOR), Nona Cheeks gave a presentation on NASA spinoff technologies, and Darryl Mitchell presented information on the NASA massively multiplayer online (MMO) game initiative that is under development. Additionally, Darryl Mitchell and Enidia Santiago-Arce served as judges in two robotics competitions. Goddard IPP also hosted an exhibit featuring spinoff products from across the agency. An estimated 15,000 individuals attended the event. ■

In Remembrance: Dr. E. James "Jim" Chern

Dr. E. James "Jim" Chern, Goddard's Small Business Technology Manager, passed away unexpectedly on December 1, 2009 while on business travel in West Virginia.

Jim earned his PhD and MS in Physics from the College of William and Mary in Williamsburg, Virginia, and a BS in Physics from Soochow University, Taipei, Taiwan. Prior to joining NASA in 1989, he worked as a research scientist for Martin Marietta Laboratories and as a principal engineer and project leader in Combustion Engineering for General Electric Aircraft Engines.

Described by his colleagues as passionate, widely respected, funny, and deeply committed to NASA, Jim joined the agency in 1989. He initially worked in the Materials Engineering Branch, evaluating technologies for space flight assurance. During his years in the Materials Engineering Branch, he worked on inventions related to detecting residual stress in materials and eddy current testing. Jim held six patents and was an expert in the field of non-destructive evaluation.

In 1997, Jim began managing Goddard's Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs. He was dedicated to ensuring Goddard's SBIR/STTR requirements were aligned with mission technology by managing the solicitation development, proposal evaluation, contract monitoring, technology utilization, and outreach activities. His deep knowledge of the research and development projects across NASA guided his daily activities and made the Goddard SBIR/STTR program a critical technology resource for Goddard missions' needs. He is deeply missed. ■

Solar Dynamics Observatory Mission

NASA photo courtesy of Pat Izzo

Goddard Tech Transfer News **http://ipp.gsfc.nasa.gov**

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