National Aeronautics and Space Administration

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GSFC NEWS

—PHOTO BY NASA

Sharing Earth Science Data

VOLUME 10, NUMBER 3 | SUMMER 2012

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Sharing Earth Science Data

Nona Cheeks

[FROM THE *Chief*

From the Chief

"Seeing is believing," according to the old saying. And in many situations, it's more than that – seeing can also be *understanding*. At NASA Goddard, a database full of comprehensive Earth Science statistics and figures may be of interest to trained climate scientists; but the true meaning behind the data may not be readily understood by much of the general public. Convert this data into an animated visualization, however, and the results can be accessible, compelling, and very informative for many scientific assessments and business decisions.

In this issue of NASA Goddard *Tech Transfer News*, we look at how NASA Goddard visualizes data (such as information collected over the years from various Earth Science missions) and other concepts and models. We begin with an interview of Horace Mitchell, Lead for NASA Goddard's Scientific Visualization Studio Group, the team primarily responsible for creating these animations and videos. We then discuss Hyperwall and Science on a Sphere, two highly creative and advanced systems for displaying animations such as those created by Dr. Mitchell's group. These visualizations, and the systems designed to display them to full advantage, perform a very important knowledge transfer function by presenting NASA's vast wealth of Earth Science data in a way the public can easily comprehend. The visualizations may also inspire students to seek out careers in science, fueling the next generation of scientists, engineers, and inventors. For industry, the visualizations can stimulate innovative methods and perspectives to business models, and can advance new products.

NASA's Earth Science data itself, coupled with several NASA Goddard new technology disclosures designed to help users handle and manipulate it, present many opportunities for technology transfer. These include commercial applications such as building products from the Earth Science data and offering them to insurance companies, investors, community planners and builders, the sports and entertainment industry and others who have a stake in understanding current and potential future climate and ecological trends. This data is currently being used in many other applications, such as fire and flood prediction and monitoring, volcano and tsunami warning, and others that help protect people, property, and wildlife around the world. Such applications provide powerful proof of the enormous practical and tangible terrestrial value returned by our Earth Science missions.

In this issue we also speak with Bryan Guerts, Chief Patent Counsel for NASA Goddard's Office of Patent Counsel, about possible legal issues involving the commercialization and use of NASA's Earth Science data. And we introduce a new regular feature, "NASA Goddard in the News." This briefly highlights a few NASA Goddard technologies that have been featured in the popular press during the last three months that offer potential use beyond their current NASA applications.

If you have any questions about partnering with NASA Goddard, or would like to learn more about NASA Goddard technologies in general, please feel free to contact techtransfer@gsfc.nasa.gov.

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Sharing Earth Science Data

EARTH SCIENCE DATA *Benefits the World*

Earth Science Data

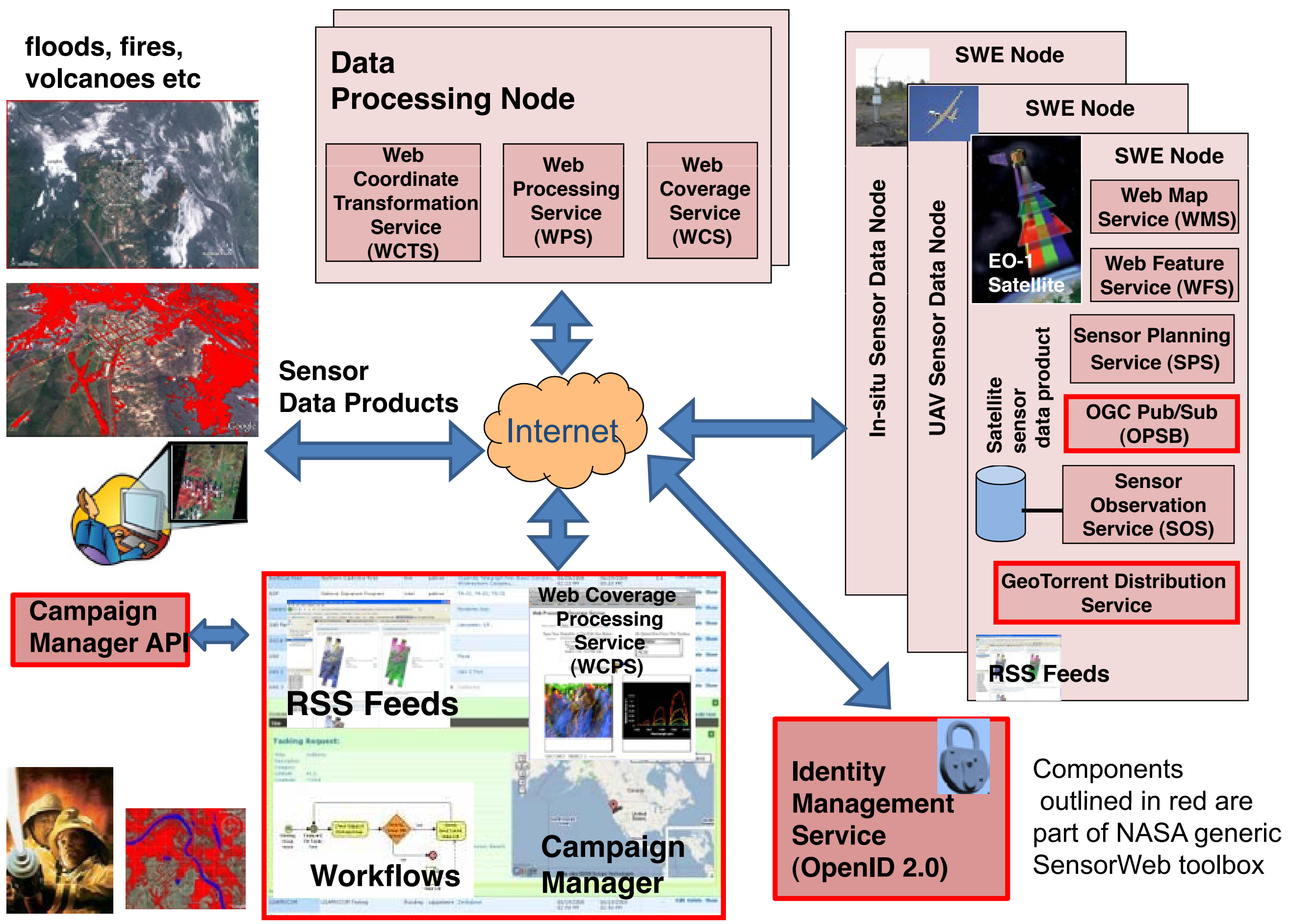
Many people are familiar with visualizations built from NASA's Earth Science data, such as the "Ocean Currents" video that has accumulated millions of views on YouTube. Perhaps not as well-known are all the ways this data has helped protect lives. NASA Goddard maintains a central database for its Earth Science research, and makes this freely available to developers. In addition, NASA Goddard is developing and freely distributing programmatic standards that allow developers to access real-time data provided by NASA Earth Science space satellites and other platforms.

In this article, we look at how Earth Science data is being used around the globe, in applications that provide a remarkable variety of societal benefits. We also discuss ways in which Earth Science climate data, accumulated through decades of missions and maintained in storage systems within NASA Goddard, may offer significant opportunities both publically and within commercial industry.

▶ *On June 10, 2012, NASA's Aqua satellite passed over Colorado and New Mexico and captured smoke and heat from the High Park Fire in Colorado, and the Whitewater-Baldy Complex and Little Bear fires in New Mexico.*

—PHOTO BY NASA

SensorWeb High Level Architecture



Accessing Earth Science data in real time

Many ongoing NASA missions are continually generating Earth Science data, monitoring changes in weather, temperature, ecosystems, ice mass, and many other variables. NASA Goddard makes this data available to non-NASA entities, for a wide array of applications. To ensure application developers have ready access to this data, NASA Goddard has helped develop three software architectures, called IPOPP, Sensor Web 2.0, and Land Information System 6.1, that programmers can incorporate into their code.

- **IPOPP (International Polar Orbiter Processing Package, GSC-15570)** is the primary software package that enables the Direct Readout community to process, visualize, and evaluate Earth Science data from the Aqua and Terra missions, and future Decadal, National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) and NPOESS missions. Direct Readout is the process of acquiring freely transmitted live satellite data. IPOPP maximizes the utility of the data by providing fast access to derivative data products. Virtually any science processing algorithm, packaged within the Direct Readout Laboratory's unique algorithm wrapper, can be integrated easily into IPOPP or run in a standalone environment.

- **Sensor Web 2.0 (GSC-15535)** is a Web services–based software architecture that gathers and assimilates data from a network of space-based, airborne, and ground-based sensors, enabling them to operate as a cohesive whole. This data can then be used to create a three-dimensional assessment of what is happening in a natural disaster, such as a fire, flood, tsunami, or hurricane.

Sensor Web 2.0 allows users who are not particularly software-savvy or skilled in Web components to set up custom sensor webs through easy point-and-click interfaces.

- **Land Information System (LIS) 6.1 (GSC-16290)** is a software framework designed to allow programmers to integrate satellite-based and ground-based observational data products into their modeling forecasts. This provides improved projections for various land surface conditions such as soil moisture, evaporation, snow pack, and runoff. LIS enables the programming community to reuse and share modeling tools, data resources, and assimilation algorithms. Applications include hydrologic research to enable accurate global water and energy cycle predictions, disaster management, water resources management, agricultural management, numerical weather prediction, air quality, and military mobility assessment.

Software interfaces such as IPOPP, Sensor Web 2.0, and Land Information System 6.1 allow NASA Goddard Earth Science data to be used for a broad spectrum of critical real-time applications, including:

- Strategic fire mapping and resource planning. This includes fire monitoring for the Americas (Mexico); forest fire, hot spot and smoke plume detection in Thailand; and flashover fire detection in South Africa.
- Air quality monitoring and tracking, as first response detection for pollution tracking and source identification. This includes aerosol optical thickness measurement to monitor air quality following biomass burning in Indonesia.
- Weather forecasting for severe thunderstorm top detection and tracking.
- Daily and weekly tracking of sea ice for use in Russia and Japan.
- Oil spill monitoring, including use during the Deepwater Horizon incident in the Gulf of Mexico.
- Water measurements to determine mosquito population in Thailand.
- Several flood early warning systems, developing in conjunction with the Namibia Department of Hydrology, Canadian Space Agency, Ukraine Space Research Institute, DRL (Germany), and 18 Caribbean countries.
- Flood potential mapping in Kenya and India.
- Typhoon prediction and monitoring in Taiwan.

For example, a volcano in the Republic of the Congo erupted, prompting local authorities to issue evacuation notices for all surrounding areas. A volcano monitoring system developed from NASA Earth Science real-time data imaged the eruption and executed a lava temperature algorithm that identified the direction of the flow, which turned out to be confined to the west side of the volcano's slope. Based on this information, evacuation for the other areas was cancelled, thereby saving livestock and crops that would have been abandoned had the general evacuation order stood.

Another application serves Namibia. Previously, residents in northern Namibia often failed to heed flood evacuation warnings from the country's Department of Hydrology and subsequently had to be rescued with boats and helicopters, resulting in major loss of farm animals. Authorities demonstrated a system developed from NASA Earth Science data by showing satellite imagery taken during peak flood conditions that revealed how extensive flooding could be. This helped convince residents to heed the next evacuation warnings, which saved lives, livestock, and government funds not spent on rescue efforts.

These are just a sampling of the many ways in which applications built on top of NASA Goddard technologies can utilize Earth Science data to address pressing human needs around the world.

Climate data applications and opportunities

In addition to real-time observational data, NASA Goddard also manages specialized collections of data produced by climate models. According to Dr. John Schnase, Senior Computer Scientist in NASA Goddard's Office of Computational and Information Science and Technology, this represents hundreds of terabytes of data that can be manipulated many ways – including for the development of commercial products. "Traditionally, the outputs from climate simulations have served scientists doing climate research," states Dr. Schnase.

"Recently, there has been more interest from other research communities and the private sector, for example insurance companies attempting to predict and assess risk. We are considering how to serve these new customers."

One of the ways NASA Goddard ensures this data is readily usable to potential consumers is by developing technologies to support climate data services. "We're fundamentally rethinking how we fulfill our mission to manage large collections of climate data," says Dr. Schnase. "Historically, scientists have used large files systems and archives to store their data. More recently, we've decided that the ability to perform analytical computations has to reside with the data. So now we're looking at developing server-side analytical capabilities. This allows for computations to be performed on our high-performance storage cluster computers, to create data products that can be more relevant to specific users than raw data files served from a file system."

Such tools could form the foundation upon which new types of predictive models are based. As Dr. Schnase states, "There are already many potential applications for climate data in the models used by the observational community, for researchers studying water and biological resources, for example. Many want to understand not just what's happening now, but also what might be happening 20 years from now. We're trying to build the data management and analysis technologies that can deliver readily usable climate data products for these applications."

Climate change modeling and prediction could be of high interest to commerce. States Dr. Schnase, "The private sector, such as the insurance industry, wants to understand the future risks of wildfires, floods, and so on. This is an area we would like to support better, so we're working with the Innovative Partnerships Program Office to find ways to make this technology available outside NASA Goddard, for example through APIs (application programming interfaces) that allow customers to avail themselves of our data and the tools we've developed for it. We're learning a lot from the IPP Office about how to distribute our APIs while still retaining control over the underlying code. We're trying to think through the technical and organizational approaches that are necessary for making data services a new part of our mission. People are beginning to realize there's a new world opening up."

Conclusion

NASA Goddard Earth Science data, both real-time and archived, serve important scientific interests and research. At the same time, they offer important tangible terrestrial benefits that can be of enormous importance to many communities, local, regional, and global. Further exploitation of this valuable resource will lead to new life-saving applications – as well as a number of potentially attractive commercial opportunities.

For a complete listing of available climate databases, see "Atmosphere and Climate Data Websites" on the NASA Goddard web site (http://globalchange.nasa.gov/Resources/pointers/meteo.html). For more information about IPOPP, see the NASA Goddard Direct Readout Laboratory web site (http://directreadout.sci.gsfc.nasa.gov/index.cfm?section=technology&page=IPOPP). And for additional details about Sensor Web, see the "Sensor Web – Testbed Initiatives" web site (http://eo1.gsfc.nasa.gov/new/extended/sensorweb/sensorWeb.html).

Takeaways

NASA Goddard Earth Science data can be used in multiple ways. Real time data can be developed into detection and monitoring systems, through programmatic interfaces such as the International Polar Orbiter Processing Package (IPOPP) and Sensor Web 2.0. Applications for these include fire and flood detection, weather monitoring, tsunami detection and warning, and many others. NASA Goddard Earth Science climate data is also being made accessible to new customers in new ways. In addition to the data itself, NASA Goddard is developing tools that allow consumers to build tailored data products from this data, making it more useful to a wide range of applications.

Sharing Earth Science Data

Interview

[INTERVIEW WITH *Dr. Horace Mitchell*

Dr. Horace Mitchell presents a wall-sized visualization of Earth's orbiting satellites on the NCCS visualization wall.

—PHOTO BY NASA/PAT IZZO

In this issue of the Tech Transfer News, we speak with Horace Mitchell (Code 606.4), Lead for NASA Goddard's Scientific Visualization Studio (SVS) Group. This group "facilitates scientific inquiry and outreach within NASA programs through visualization, such as videos and animation. The SVS collaborates with scientists to create visualization products, systems, and processes to promote a greater understanding of Earth and Space Science research activities at Goddard Space Flight Center and within the NASA research community." For more information, see the Scientific Visualization Studio Group web site at http://svs.gsfc.nasa.gov.

Dr. Mitchell is the 2011 winner of NASA Goddard's Excellence in Information Science and Technology (IS&T) award. In this interview, he talks about the evolution of the Scientific Visualization Studio, the purpose of the visualizations his group produces, and some examples of animations that have gained public popularity.

Q. *How has the Scientific Visualization Studio evolved over the years?*

Originally, visualizations were created as a way for NASA Goddard scientists to make animations from their Earth Science data, to be viewed by themselves and possibly other scientists. For the most part, it was a NASA Goddard internal effort.

It has now evolved into a public outreach effort. The animations we produce today serve as a way to get scientific and technical ideas out to the public. One of the biggest changes in the science community over the last 20 years has been that scientists now need better ways to explain things to the public, ways that not only describe how something works, but actually show it in action. This allows scientists to say, "We've collected information and data; now watch this video to see how the world works."

We currently have a staff of around 13 people, creating animations in areas such as Earth Science, planetary phenomena and heliophysics. We've even dabbled in virtual reality. We've also built a virtual "Google Earth" using Silicon Graphics software. Note that our group doesn't develop modeling or simulation tools. Instead, we use products and technologies that are already available on the market. Our creativity is in how we use these tools to render data and conceptual ideas into visualizations, not in the tools themselves. We're not tied to the technology; we're tied to the visuals.

We've also helped to develop ways to display these animations, such as the Hyperwall, to take full advantage of their visual impact.

Q. *Hyperwall?*

A Hyperwall is a display system developed in collaboration with NASA Ames. It provides a sophisticated, high resolution platform for viewing our visualizations. It can run up to 9 or 15 separate visualizations simultaneously. In some respects it's similar to a high-end "white board" that allows us to project anything we want. At the drop of a hat, we can display virtually any material in a way that attracts a lot of attention.

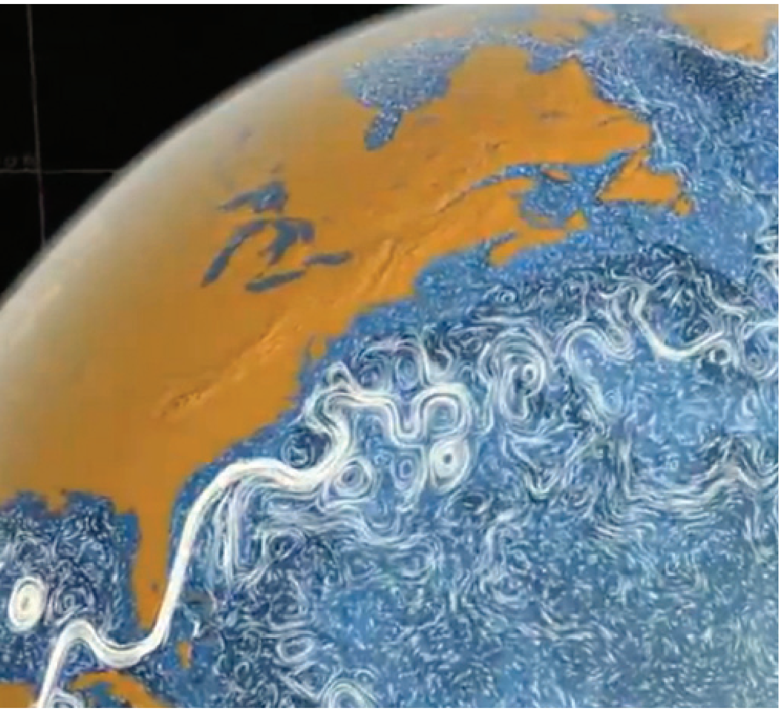
Hyperwall has become quite popular outside NASA. Our group goes around the world, supporting Hyperwall shows in places such as Australia and the UK. Winnie Humberson *[Task Lead for the Earth Observing System Project Science Office]* supports NASA presentations at conventions. I've worked with her to ensure Hyperwall has a presence at shows.

Q. *Do you make visualizations freely available to the public?*

Yes. We have posted literally thousands of animations on our web site [see http://svs.gsfc.nasa.gov/Gallery/index.html]. Basically, we said "Why don't we take the best visualizations we've done, and make them available in a way that people can enjoy?" We've even developed an iPad app for displaying these visualizations, a technology for which we've submitted an NTR [New Technology Report].

The NASA Visualization app offers a window into the world of NASA research with high quality graphics, simulations and content. http://svs.gsfc.nasa.gov/nasaviz/index.html

—PHOTO BY NASA



'Perpetual Ocean' Visualization.

—PHOTO BY NASA

Q. *What are some of your more popular visualizations?*

One visualization we created, called "Perpetual Ocean," animates the Earth's ocean currents. This video has quickly gone viral, with literally millions of views since we made it available to the public.

We also prepared animations for the recent transit of the planet Venus. Another visualization animates the famous "Earthrise" photograph taken on Apollo 8. William Anders, the astronaut who originally took this photograph, actually came to the Scientific Visualization Studio and paid us a visit.

Q. *How do visualizations get made?*

The process is similar to making a movie – the director requests special effects, and the special effects department makes them. Some groups who approach us have real data, for example data collected from Earth Science satellites, they'd like us to visualize. Others may just have a concept in mind. We can create animations based solely on existing data, or from pure conceptualization.

An example of a visualization made from Earth Science data is the "Perpetual Ocean" animation I mentioned earlier. This took some innovation on our part, as we figured out how to take data from ocean current flow and put it together in a compelling and easy to understand way. The results are now being used to produce visualizations of models of ocean currents.

Q. *Can these visualizations be used for education?*

The Scientific Visualization Studio isn't an educational effort per se. But the visualizations on the site could conceivably be assembled in different ways, to form content for specific courses. Teachers have informed us they need better ways to present science content in the classroom. We would love to sit down with educators to determine how our visualizations could align with science guidelines for schools, and to match our visualizations to the appropriate grade levels.

We're also currently involved in a pilot program for our NASA Visualization Explorer iPad app that allows schools to view our scientific visualizations.

One of the most gratifying things for us is when we hear about how prevalent our visualizations have become, and how often people use them. But we believe the Scientific Visualization Studio is still an underpublicized part of NASA. We're working with the results of NASA Earth Science research, and we're helping people understand what this data really means.

Dr. Horace Mitchell

LEAD, SCIENTIFIC VISUALIZATION STUDIO GROUP

Code: 606.4

Years with NASA:
21

Education:

Rice University (BA, MA, PhD),
Princeton University (MA)

[HYPERWALL AND *Science-on-a-Sphere*

Hyperwall

NASA Goddard Earth Science missions have produced vast volumes of data over the years, in diverse areas such as weather, vegetation, ice mass, cloud cover, and many others. This data is of vital interest to the scientific community for applications such as climate change, modeling, and simulation.

In addition, NASA Goddard makes much of this data freely available to the public. Consumers can access this data in several different ways, depending on how they plan to use it. Programmers can use the International Polar Orbiter Processing Package (IPOPP), Land Information System (LIS) and Sensor Web coding standards to create data products from Earth Science data, both for commercial purposes and for governmental monitoring systems such as flood monitoring and warning. Scientists, researchers, and educators can use NASA Goddard tools to access this data and derive meaningful information from it.

One way to present Earth Science data to the general public is through visualizations. These include animations and images that "visualize" data in a graphical, easy-to-understand way. In many cases these visualizations can be distributed through sites such as YouTube and viewed on a computer screen. However, very sophisticated visualizations may require more advanced display methods in order to be seen to full advantage. NASA Goddard has helped develop two such display technologies, Hyperwall and Science On a Sphere.

In this article we briefly review Hyperwall and Science On a Sphere, and how each can be used to present Earth Science data to the public in compelling and entertaining ways.

▶ *'Dr. Phil Webster demonstrates the NASA Goddard Hyperwall.*

—PHOTO BY NASA

Hyperwall

Hyperwall is a highly advanced and sophisticated system for visualizing large sets of data. Hyperwall (also called the video wall or visualization wall) can simultaneously display multiple images and animations through an array of high definition screens. There are several hyperwall installations, including a "travelling" version that can be set up (for example, at remote sites and meetings) to display NASA Goddard visualizations.

The largest NASA Goddard Hyperwall is in the Computational and Information Sciences and Technology Office (CISTO, Code 606). As CISTO Chief, Dr. Phil Webster led the transformation of NASA Goddard's supercomputing center into the NASA Center for Climate Simulation (NCCS) to enhance agency capabilities in climate and weather simulation. He also guided the effort to integrate Hyperwall into his group's data visualization and analysis capabilities.

Hyperwall visualizations cover a variety of Earth Science topics, based on data collected from many previous and ongoing NASA missions. Some visualizations are designed to illustrate change, such as climatological changes over the past several decades. Others show large-scale static images accompanied by descriptive text captions. NASA Goddard continually develops new hyperwall visualizations and associated content and makes these available to the public, in an ongoing effort to promote scientific literacy.

According to Dr. Webster, enhanced capabilities are being explored for future Hyperwall content. "We would like to develop Hyperwall to be a monitor for our supercomputer," he explains. "This would allow us to run incredibly high-level visualizations of, for instance, global weather patterns."

In addition, there are efforts underway to allow Hyperwall to be more interactive. "Currently, our models can't see in real time—basically we're limited to 'playback mode,'" states Dr. Webster. "We're preliminarily looking at ways to allow scientists to change things 'on the fly.' Suppose we were running an Earth model, for example, to help determine where precisely a hurricane starts. As we're watching, a scientist may want to know, 'what's happening with this other variable I just thought about?' If she could change that variable in real-time, and immediately see the results on the screen, this could be a very powerful tool."

Science on a Sphere

Another sophisticated display system through which NASA Goddard Earth Science data can be visualized is Science On a Sphere. This system uses computers and video projectors to display animated data onto the outside of a sphere. When installed in a room, the sphere is generally suspended from above and surrounded at the corners of the room by four video projectors.

As described by Maurice Henderson, Project Director for Science On a Sphere at NASA Goddard, this visualization system "shows datasets in the exact form – Earth, planetary, solar – as they exist in nature. It's a very popular application."

According to Mr. Henderson, NASA Goddard is a major supplier of content for Science On a Sphere. "It is a very important outreach tool for mission data at NASA Goddard. It helps capture the essence of a mission, which is visualized in a way that makes it very easy to be understood by the public, especially children. An example is climate change. We have a series of clips that incorporate data about precipitation, ice mass, vegetation, and other factors that are then displayed in an organized way like a presentation."

NASA scientist Thorsten Markus speaks with students in the a live performance of " Bella Gaia" by Kenji William, a Science on a Sphere program.

—PHOTO BY NASA

Visiting Students are treated to a upclose view of Science on a Sphere.

—PHOTO BY NASA / BILL HRYBYK

One of the first full-feature movies developed for Science On a Sphere is "Footprints," produced by NASA Goddard. This movie depicts satellite data and other visual effects, including visualizations about the biosphere, planetary views of city lights at night, and hurricane formation. "In 'Footprints,' we tried to capture each science theme at NASA Goddard," explains Dr. Webster. In addition, other entities have used NASA Goddard Earth Science data to create Science On a Sphere visualizations. "It is common to see NASA Goddard fingerprints in other visualizations," notes Dr. Webster.

Bringing NASA Goddard Earth Science to the public

We live in a time when a good working knowledge of Earth Science concepts is essential for the public to make well-informed and effective decisions that could shape society for generations. One way to help promote public awareness and understanding of these concepts is by making NASA Goddard Earth Science data accessible to everyone. Hyperwall and Science On a Sphere represent two important tools in this effort, presenting large datasets – that in some forms might appear arcane or difficult for the layperson to easily digest – in ways that people find highly understandable, compelling, and entertaining.

Takeaways

NASA Goddard makes Earth Science data, compiled through its various missions, accessible to the public. Hyperwall and Science On a Sphere are two sophisticated display systems for showing graphical representations of this data to the public. These systems can also be further developed for potential use in real time modeling and simulation applications.

Climate Data

► *High-performance storage cluster computers like "Discover" supercomputer have a total of nearly 15,000 processors and manage the vast amounts of data generated by NASA Missions.*
—PHOTO BY NASA

As we've noted elsewhere in this issue of NASA Goddard Tech Transfer News, NASA Goddard has compiled a vast store of Earth observational data, on phenomena such as precipitation, temperature, vegetation, ice mass, and others. This data archive represents the accumulated results of a number of important NASA Earth Science missions. In addition, the research activities of NASA climate scientists are producing vast amounts of data from climate models that are becoming increasingly important to an expanding array of new customers, including private sector partners who are using this data to generate commercial products.

To help ensure this data is readily accessible to these user communities, NASA Goddard is developing several technologies that provide easier data management and manipulation. These technologies allow NASA scientists as well as non-NASA entities to maximize the value of NASA resources when developing applications and products based on NASA Goddard's climate data.

In this article, we look at several new data services technologies that NASA Goddard is developing for easier management of NASA Goddard Earth climate data sets.

Virtual Climate Data Server

A growing challenge for the Earth Science and climate modeling communities is how to manage expanding volumes of data, literally hundreds of terabytes and constantly growing. Handling data of this magnitude creates a need for data management capabilities that meet the following requirements:

- Simple, inexpensive, and easy to deploy for non-NASA users
- Extensible to accommodate future needs
- Flexible, with the ability to use, optimize, and change deployment configurations in response to changing resource needs
- Allows new data collections to be integrated into a data center's growing collection of data collections

To address these requirements, NASA Goddard has developed the Virtual Climate Data Server (vCDS, NTR number GSC-16444-1). The vCDS is a cloud-oriented software appliance designed specifically for the data management needs of data-centric climate applications. It provides policy-based control over collection-building, managing, querying, accessing, and preserving large scientific data sets. vCDS includes enhancements to the integrated Rule-Oriented Data System (iRODS) that enable the system to manage collections of NetCDF, HDF, GeoTIFF, and similar data products. vCDS benefits NASA's aerospace and aeronautical mission by extending the effectiveness of NASA's remote sensing and climate modeling capabilities.

Potential users and applications for vCDS include:

- Data-intensive climate research activities.
- Tailored collections of climate data products.
- Other NASA, NOAA, governmental, and non-governmental scientific data centers.

The following chart illustrates vCDS and its major components.

Scripts are used to automatically build vCDS images on local host computers, local Virtual Machine environments, NASA's Nebula Cloud Services, and Amazon's Elastic Compute Cloud.

As part of vCDS's development and testing, NASA Goddard registered MODIS Atmosphere data products in a vCDS that contains 54 million registered files, 630 terabytes of data, and over 300 million metadata values. NASA Goddard is now assembling IPCC AR5 data into a production vCDS that will provide the platform upon which NASA's Earth System Grid (ESG) node publishes to the extended science community.

The vCDS includes several associated technologies that are also being made available to users outside NASA Goddard. These include:

- Administrative Extensions
- NetCDF Module
- Repetitive Provisioning

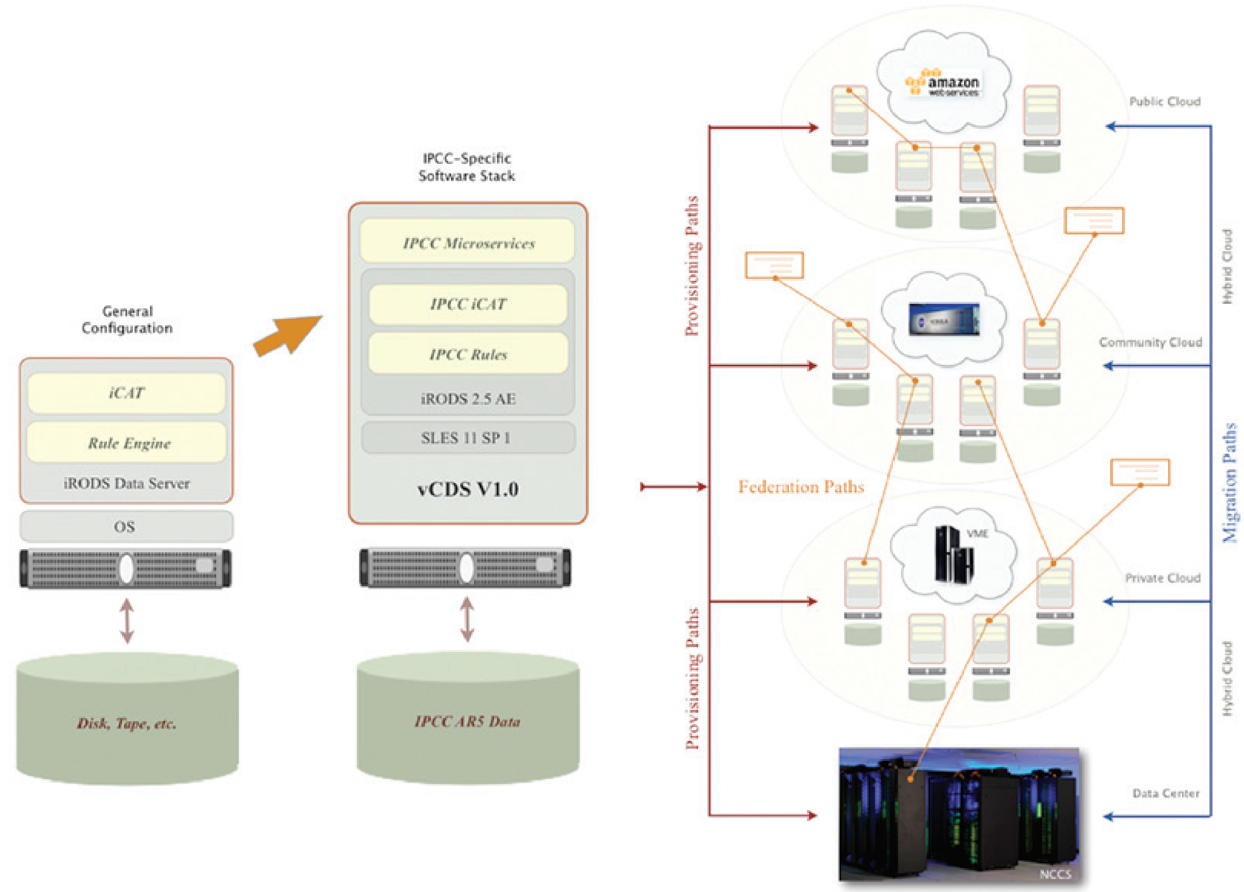
These technologies are described in the following sections.

Administrative Extensions

The **Virtual Climate Data Server Administrative Extensions** (GSC-16446-1) provide the Open Archive Information System (OAIS) database extensions, OAIS metadata views, and collection action logging required to:

- Manage system-level object provenance
- Provide views and QA over OAIS metadata compliance
- Support administrative monitoring and control over vCDS-managed collections of scientific data

When provisioned with Administrative Extensions, a vCDS can deliver policy-based control over collection-building, managing, querying, accessing, and preserving scientific data sets.



The vCDS architecture showing the internal organization of the software appliance and how vCDS virtual images can be deployed into various computing environments, such as local computing facilities and public clouds.

—PHOTO BY NASA

Administrative Extensions provide the core system capabilities for administrative control over vCDS managed collections. In addition, encapsulating system-level collections management operations as a module greatly simplifies the construction of tailored system administrator interfaces to the vCDS.

NetCDF Module

The **vCDS NetCDF Module** (GSC-16445-1) is an iRODS kit that encapsulates the microservice code, supporting utilities, rules, and configuration files required to implement the canonical create, read, update, and delete operations of an OAIS-compliant NetCDF collections-management kernel. When provisioned into vCDS, the resulting image becomes a software appliance tailored to the data management needs of a scientific collection of NetCDF data.

The vCDS NetCDF Module is the only currently available iRODS kit created especially for managing NetCDF files. Encapsulating OAIS-compliant collections-management operations as a module greatly simplifies the sharing and use of these capabilities by others.

Repetitive Provisioning

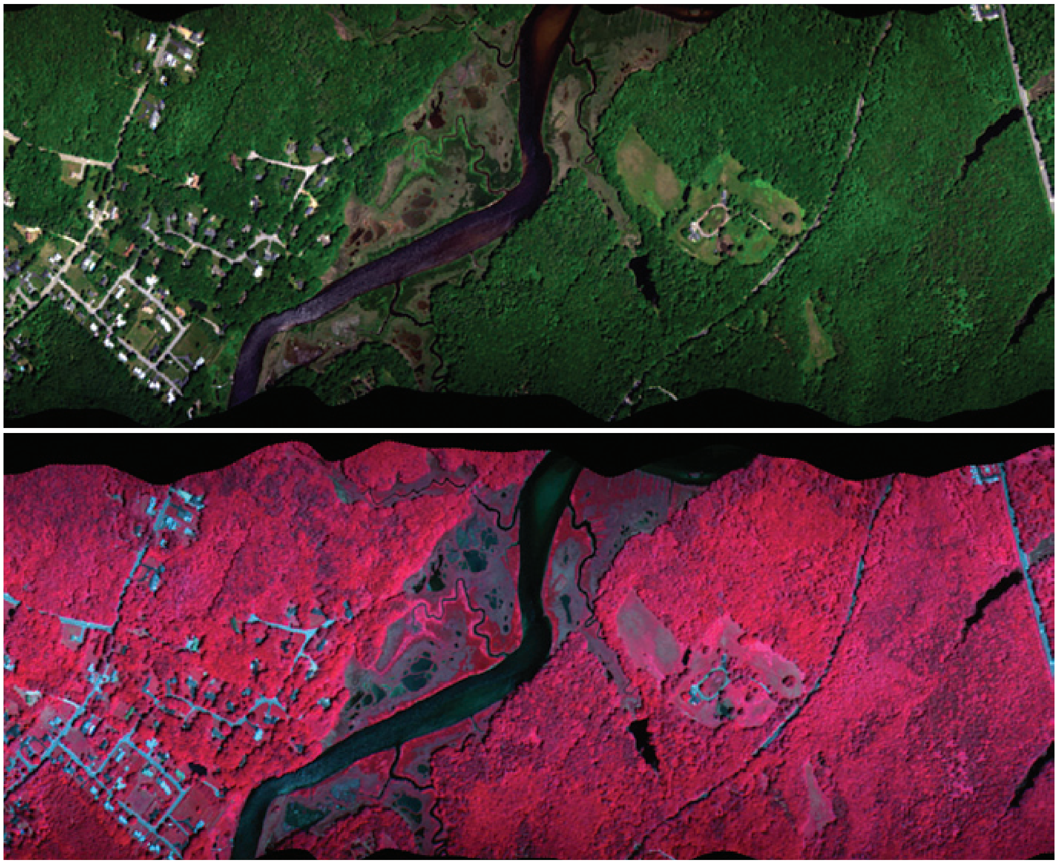
This feature (GSC-16447-1) provides an automated capability for building vCDS software stacks in various computing environments. vCDS itself is a software appliance that provides policy-based control over scientific data collections. Repetitive provisioning, along with the vCDS images produced by the provisioning process and the overall vCDS architecture, enable Virtualization-as-a-Service and various modes of deployment and distribution in cloud computing environments, including Platform-as-a-Service and Software-as-a-Service.

Repetitive provisioning allows vCDS technology to be conveniently deployed into a tiered array of storage and compute resources, thereby providing operational flexibility to data centers that use vCDS technology.

Sharing Earth Science Data

[SBIR/STTR *Success Story*

SBIR/STTR Success Story



Hyperspectral Image.

—PHOTO BY NASA

Under an SBIR contract originally awarded in 2006, Flight Landata of Andover, MA developed a gimbal-stabilized compact hyperspectral imaging system. This system provides measurement calibration and validation observations for Earth observing mid-altitude missions.

The technology

Flight Landata's system represents a breakthrough for advanced mapping, remote sensing, and persistent surveillance applications. The instrument fully integrates a three-axis eGimbalTM with a large format Earth observing imaging system into a portable airborne package. The device offers repeated pushbroom hyperspectral imagery and multispectral stereo imagery over non-linear corridors and block areas, with inch-level resolution for change detection applications. The gimbal system (eGimbalTM) is directly driven by electromagnetic force without using any mechanical transmission. Two patents have been applied for the gimbal technology innovation.

Flight Landata has leveraged this innovation into a commercial product. The company has a contract with the Canadian Defense Agency, Defense Research and Development Canada (DRDC) for a multiple instrument platform based on this technology. To date, commercial sales for the gimbals and cameras exceed $1 million in revenues.

The company

Flight Landata designs, integrates, and deploys airborne sensor systems, platforms, and collection services for the ISR (Intelligence, Surveillance, and Reconnaissance) and defense markets. In August 2011, Flight Landata was acquired by KEYW Corporation of Hanover, MD. KEYW provides rapid response engineering services to the Intelligence, Surveillance, and Special Military communities. Their solutions serve the following fields (among others):

- Cybersecurity
- Cloud Computing
- Systems Engineering & Integration
- Software Engineering & Integration
- QRC & Custom Engineering
- Professional Services

Details about the Flight Landata/KEYW merger can be found in the press release (http://investors.keywcorp.com/releasedetail.cfm?ReleaseID=597902). For more information about Flight Landata, see their web page (http://www.flightlandata.com/). And for further information about KEYW and its services, consult the company's web site (http://www.keywcorp.com/home.html).

The market

Hyperspectral imaging is being applied to a wide variety of markets and applications. In addition to space research, these applications include:

- Military and Defense (border protection, reconnaissance/surveillance, spectral tagging, targeting)
- Mining Exploration and Mineral Processing (airborne exploration, drill core analysis, mineral mapping, quarry and excavation analysis)
- Remote Sensing (civil and environmental engineering, environmental monitoring, pollution detection, forestry management, precision agriculture)
- Medical Sciences (microscopy, non-invasive diagnostic imaging, optical biopsy, therapeutic analysis)

…and many others. Collectively these comprise a global market in which new hyperspectral technologies may be of interest.

For more information about NASA's SBIR/STTR program, including how to submit a proposal in response to a solicitation, see http://sbir.gsfc.nasa.gov/SBIR/SBIR.html.

This mock-up of the Landsat Data Continuity Mission is essentially a full scale model of the actual satellite, which is scheduled for launch in 2012. The mock-up enables engineers to check that all components seat and connect correctly.

—PHOTO BY NASA

Sharing Earth Science Data

[TECHNOLOGY AVAILABLE (TAV) *and the SBIR/STTR Program*

Technology Available

NASA SBIR/STTR programs can help drive technology transfer of NASA Goddard inventions into the public sector. Conversely, technology transfer can promote interest in the SBIR/STTR programs.

TAV designations

NASA SBIR/STTR solicitations may include information about relevant technologies designated as "Technology Available" (TAV). These are technology innovations that NASA has identified as potentially useful for a specific SBIR/STTR project proposal.

NASA technologies classified under the TAV designation can be:

- Protected by NASA-owned patents
- Non-patented NASA-owned or controlled software
- Other technologies available for use by the public

A non-exclusive, royalty-free research license is required to use any TAV technology protected by a NASA patent for the duration of the SBIR/STTR performance period. Similarly, a Software Usage Agreement is required for non-exclusive, royalty-free usage of NASA controlled software during the SBIR/STTR. In some cases, the SBIR/STTR awardee may be able to continue to use the TAV-designated technology after the SBIR/STTR project is completed; in other cases a license or similar agreement may be required. If there is no IP protection for the TAV, the technology is freely available for use without a license or any other restrictions.

Through TAV, the SBIR/STTR process can provide access to NASA Goddard technologies for outside entities. The successful SBIR/STTR applicant can use the TAV technology, generally without payment, during the project. And upon completion of the project, the applicant may be able to continue to use the TAV technology, either via licensing or for free.

Technology transfer drives SBIR/STTR

The TAV designation can also help identify potential SBIR/STTR collaboration partners for NASA, even if these partners may not initially be familiar with these programs.

For example, a small company may be interested in an available NASA Goddard technology, but may not be able to pay the licensing fees for it. If the technology is designated as a TAV associated with an SBIR/STTR solicitation; the company can submit a proposal against a specific subtopic. If successful, they will be able to use the technology without charge during the project period. The company will then retain rights to any new technology they have created during this project. In this way, the company will be able to use NASA Goddard technology to which they might not otherwise have access. And in some cases, the company may also retain the right to use the technology itself, beyond the project period.

Conclusion

The TAV designation offers several benefits, both for NASA and its potential SBIR/STTR partners. For NASA Goddard, it provides another mechanism for fulfilling the U.S. governmental mandate to make all technology developed through public funding available for transfer to the private sector. It also attracts potential applicants for SBIR/STTR projects. For NASA Goddard's partners, TAV allows the SBIR/STTR process to provide free access to NASA Goddard technologies, for the duration of the project and possibly beyond.

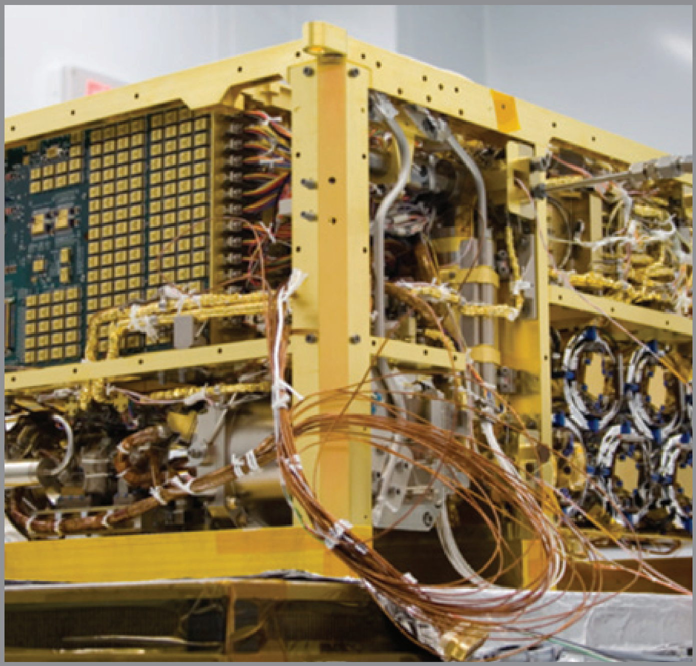
In the News

Starting with this issue of NASA Goddard Tech Transfer News, we briefly review a few recent news stories prominently featuring NASA Goddard accomplishments and technologies.

Curiosity and the Sample Analysis at Mars (SAM)

Dominating the science headlines these past few months has been the successful landing, deployment, and ongoing discoveries made by the Curiosity lander on Mars. A critical component of Curiosity's onboard tool set is the Sample Analysis at Mars (SAM) system developed at NASA Goddard. SAM is a suite of three instruments that collectively investigate the chemistry of the Martian surface and atmosphere. These measurements will help scientists better understand environmental conditions over time and potentially help determine whether or not Mars could support and preserve evidence of microbial life, now or at some earlier point in its planetary history.

Note that in addition to its science and measurement capabilities, SAM also represents a significant technological accomplishment in terms of miniaturization. SAM's instruments would likely fill a laboratory here on Earth; for Curiosity they have been miniaturized to the approximate size of a microwave oven.



SAM at NASA Goddard, before installation onboard Curiosity

—PHOTO BY NASA

For more information on SAM and its role onboard Curiosity, see the SAM home page at http://ssed.gsfc.nasa.gov/sam/index.html.

Hurricane and Severe Storm Sentinel (HS3) Investigates Hurricane Leslie

To advance the understanding of hurricane science, in September a specially equipped Global Hawk drone airplane spent 10 hours collecting data from around and within Hurricane Leslie as it churned its way over the North Atlantic. This ground-controlled aircraft is part of the Hurricane and Severe

NASA's Global Hawk lifts off the runway at NASA's Wallops Flight Facility, Wallops Island, Va. on Sept. 19, 2012.

—PHOTO BY NASA

Storm Sentinel (HS3) project, designed to help scientists decipher the relative roles of the large-scale environment and internal storm processes that shape hurricane systems.

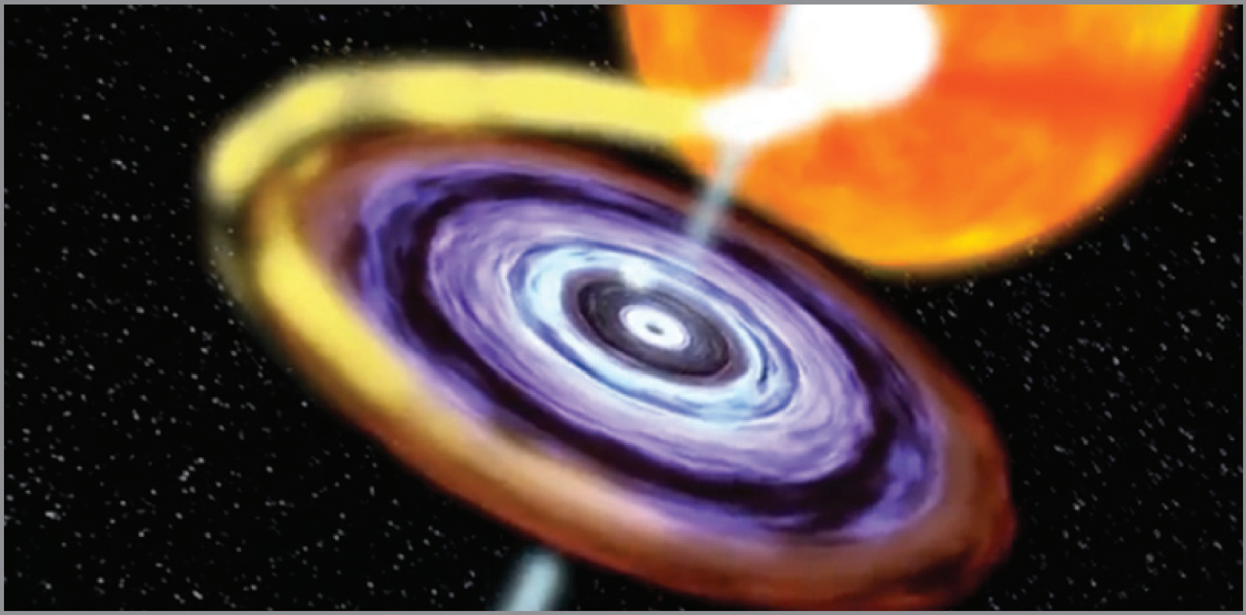
According to Scott Braun, HS3 mission principal investigator and research meteorologist at NASA Goddard, the primary objective of this research is to gather data about the interaction "between tropical disturbances and cyclones with the hot, dry and dusty air that moves westward off the Saharan desert and appears to affect the ability of storms to form and intensify." For more information, see the article "NASA Drones Analyze Hurricanes" at http://www.worldandi.com/subscribers/feature_detail.asp?num=28845.

Swift Discovers New Black Hole at the Milky Way Center

In October, NASA Goddard scientists announced that a newly discovered black hole has been discovered at the center of the Milky Way galaxy. This object was initially detected by NASA Goddard's Swift gamma-ray burst satellite as a rising tide of high-energy X-rays. This burst is the result of an extremely rare X-ray nova, which have been termed "once-a-mission events."

The nova, named Swift J1745-26, resides an estimated 20,000 to 30,000 light-years away from Earth in the direction of the constellation Sagittarius.

For more information about the Swift mission, see its home page at http://heasarc.gsfc.nasa.gov/docs/swift/swiftsc.html.



Swift J1745-26.

—PHOTO BY NASA

[SHARING *Earth Science Data*

Patenting Perspectives

NASA Goddard's sharing of Earth Science data raises several issues involving risk, liability, and ownership. This is especially true when this data is processed and packaged by a third party into products eventually sold to consumers.

This installment of Patenting Perspectives examines the potential legal issues associated with sharing Earth Science data. Offering his perspective on this topic is attorney Bryan Geurts, Chief Patent Counsel for NASA Goddard's Office of Patent Counsel.

Q. ***What are some of the major challenges involving NASA Goddard's sharing of Earth Science data?***

Bryan: The nature of the data is one challenge.

Bryan Geurts

The data coming from the Earth Science satellites really isn't useful to anyone in its raw form. So NASA Goddard typically manipulates this data until it makes sense. This involves subjecting it to a series of programs that sifts through the transmissions from the satellites, and then making the results available to the public free of charge.

Third party entities are entitled to use this data to solve a particular need. This means that at some point, data that has not traditionally been copyrightable in the United States ends up in the hands of someone making a proprietary product. This raises an important legal issue: At what stage does a copyright vest? And how can we ensure that the Earth Science data used in these products remains openly accessible to everyone, free of charge? These are important questions to answer.

Q. ***Are other NASA Centers dealing with these issues?***

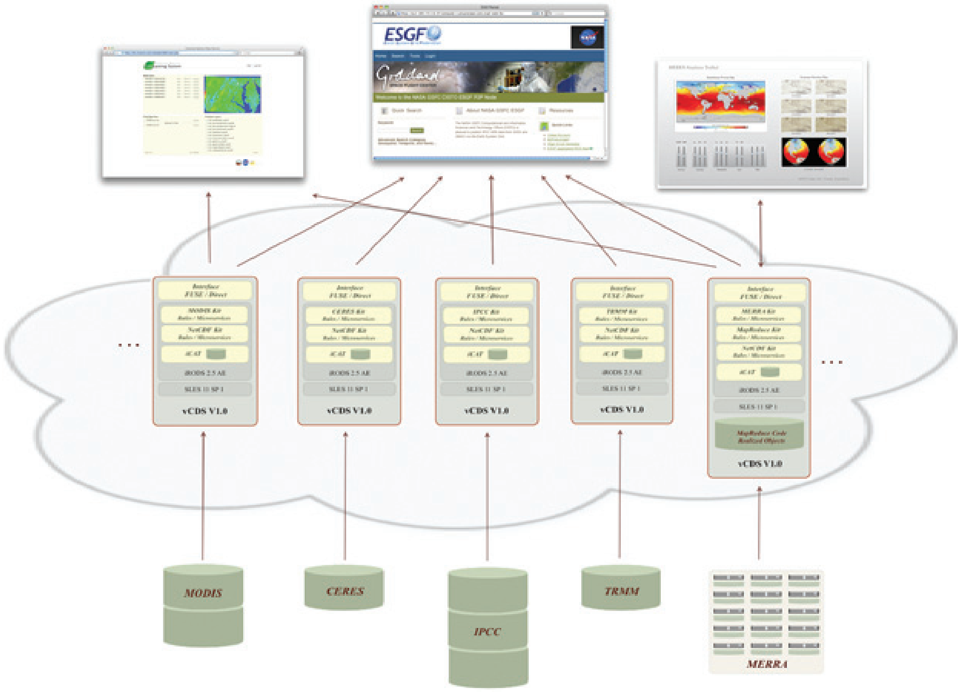
Bryan: To my knowledge, none of the other Centers is dealing with an analogous situation. No one else is producing Earth Science data free to the public that is also being exploited commercially.

Q. ***Does this commercial exploitation present any potential risks to NASA Goddard?***

Bryan: There are some risks, but they aren't insurmountable.

For example, suppose that the Earth Science data we put out is not representative of reality in some way. Science is what it is; and we can't always be sure that data is 100% accurate all the time. If for example someone makes an investment decision based on data that turns out to be faulty, and the investment ends up losing money, that person may raise the issue of legal liability, either on NASA's part or on the part of the developer of the product that uses NASA data.

Another issue is the appearance of endorsement. Someone may juggle the data and come to controversial conclusions they advertise as "based on NASA research." This can lead others to think we're endorsing the conclusions themselves. To minimize this risk, we need to be careful how we release the data. We also have to carefully monitor the use of the NASA name and "meatball" logo. There are on occasion unauthorized non-NASA web sites out there that use both the NASA name and logo, which may confuse readers into thinking it's a NASA site, or that we at least endorse the content. This is usually not the case and we take steps to shut down such unauthorized sites.



The NASA Center for Climate Simulation is using cloud computing technologies to deliver specialized collections of climate data to a growing community of public and private-sector research and applications customers.

—PHOTO BY NASA

Q. *What recourse does NASA Goddard have when its data has been misused?*

Bryan: Actually, the best recourse may be none at all. For example, consider the issue of climate change. There will always be proponents and detractors, using NASA Earth Science data to support their various positions. We generally don't take any action, unless someone claims their opinion represents NASA's "official position." If that happens, we will come down on them hard!

Q. *Does NASA Goddard place any restrictions on how its Earth Science data is used?*

Bryan: We take the same approach as science everywhere. Data needs to be out there and accessible to everyone, for people to process and use to come to their own conclusions. That's the beauty of science; it's an iterative process that repeats until the scientific community eventually comes to a consensus about what the data means.

Q. *Are there any issues involved in when, where, and by whom the Earth Science data is manipulated and stored?*

Bryan: We haven't had any such issues arise yet. We haven't had anyone come forward and say "we want this data in rawer form." And no one else has the capacity to store this data; it's a huge effort to do so. So whenever our Earth Science data is commercialized, it will probably continue to be after NASA Goddard has filtered it.

Q. *Are the tools NASA Goddard uses to manipulate this data also freely available to consumers?*

Bryan: We haven't faced this issue yet, but likely will eventually. When a NASA scientist or engineer creates a tool for processing Earth Science data, they're not thinking about how much money it might make on the commercial market. Any sharing of the tool will probably be with other members of the scientific community; NASA Goddard is good at this type of sharing. But as Earth Science data is further commercialized, it's possible that the software tools associated with it will also be commercialized.

We have had inquiries from private groups asking us to make more powerful data manipulation tools available with the Earth Science data. However, this would require a fairly significant money investment for NASA Goddard, and thus far no one else has stepped up to do this for us due to the expenses involved. So this remains a hot topic at the moment, one that over the next decade or so is only likely to grow bigger.

Bryan Geurts

CHIEF PATENT COUNSEL

Code: 140.1

Years with NASA: 11

Education:

B.S. - Civil Engineering, B.A. German from University of Utah

Juris Doctor Degree from Brigham Young University

International Thriller Writers' ThrillerFest VII

(JULY 13-14, 2012, NEW YORK CITY, NY)

Innovative Partnerships Program (IPP) Office Chief, Nona Cheeks, spoke at this year's ThrillerFest VII conference which took place in New York City on July 13 - 14, 2012. ThrillerFest is a celebration of thriller books, the authors who write them and the fans who read them. This conference offers an environment in which readers can meet authors and gain the tools and make the contacts they need to get published. Ms. Cheeks was on hand to speak with a group of science fiction and mystery thriller writers about how NASA technologies can be transformed to be used beyond their original intent in fields such as forensics science.

Federal Lab Consortium (FLC) Mid-Atlantic and Northeast Regional Meeting

(AUGUST 28-30, 2012, CAMBRIDGE, MARYLAND)

Innovative Partnerships Program (IPP) Office Senior Technology Manager, Enidia Santiago-Arce, presented at the FLC Regional meeting held in Cambridge, Maryland on August 28 - 30, 2012. Ms. Santiago-Arce's presentation showcased specific examples of how technology development and technology transfer have made a positive impact on people's lives. Collaborative efforts between federal agencies and outside parties that have resulted in tangible benefits to the public were presented to highlight the ultimate goal of NASA GSFC's technology transfer activities.

Juxtopia® Urban Innovation and Cooperative Entrepreneurship (JUICE) Conference

(SEPTEMBER 19, 2012, BALTIMORE, MD)

Innovative Partnerships Program (IPP) Office Senior Technology Manager, Enidia Santiago-Arce, presented to a group of microenterprises (MEs), small businesses, inventors, students and high tech investors at the Juxtopia(r) Urban Innovation and Cooperative Entrepreneurship (JUICE) Conference taking place on September 19, 2012 in Baltimore, Maryland. Ms. Santiago-Arce's presentation dealt with partnering and collaborating with NASA by taking advantage of NASA Goddard's reach portfolio of technologies that are available for licensing.

26th Annual AIAA/USU Conference on Small Satellites Utah State University

(AUGUST 13 - 16, 2012, LOGAN, UT)

The Innovative Partnerships Program (IPP) Office attended the 26th Annual Small Satellite Conference held this year from August 13 – 16, 2012, at Utah State University in Logan Utah. This year's conference theme was entitled "Enhancing Global Awareness through Small Satellites" and was hosted by the American Institute of Aeronautics and Astronautics (AIAA). IPP staff members Ted Mecum and Adil Anis attended many of the networking sessions to promote partnership opportunities available at NASA Goddard.

NTRs and Patents

NTRs

- **PARTIALLY TRANSPARENT PETALED MASK/OCCULTER FOR VISIBLE RANGE SPECTRUM**
  Shahram Shiri, Wasyl Wasylkiwskyj
- **PHOTONIC WAVEGUIDE CHOKE JOINT WITH ABSORPTIVE LOADING**
  Edward Wollack, David Chuss, Kongpop U-Yen
- **DEVELOPMENT OF A 1,920 X 2,048 (2K X 2K) GAAS QWIP ARRAY**
  Murzban Jhabvala, Christine Jhabvala, Kwong Kit Choi
- **PHASE II FOR FIBER COUPLED PULSE SHAPER FOR SUB-NANOSECOND PULSE LIDAR**
  Tony Roberts, Gregg Switzer, Philip Battle
- **DRIVER COMMUNICATION DISRUPTOR**
  Eleanya Onuma
- **MERRA ANALYTIC SERVICES (MERRA/AS) CONCEPT, DESIGN, ARCHITECTURE, AND OPERATION**
  John Schnase, Daniel Duffy
- **PHASE II FOR DOMAIN ENGINEERED MAGNESIUM OXIDE DOPED LITHIUM NIOBATE FOR LIDAR-BASED REMOTE SENSING**
  Philip Battle, Martin Fejer, Carsten Lang
- **FLEXIBLE MULTILAYER OXYGEN AND WATER BARRIER FILM FOR FOOD PACKAGING AND RELATED APPLICATIONS**
  Stuart Cogan, Michael Gilbert
- **UV-TO-SWIR PHOTODIODE**
  Abhay Joshi, Shubhashish Datta
- **FLASHPOSE: RANGE AND INTENSITY IMAGE-BASED TERRAIN AND VEHICLE RELATIVE POSE ESTIMATION ALGORITHM**
  Nathaniel Gill, John Van Eepoel, Joseph Galante
- **SYNTHETIC IMAGING MANEUVER OPTIMIZATION (SIMO) SBIR PHASE 2**
  Alvar Saenz-Otero, John Merk
- **DUPLICATE OF MODIFIED COLLINS CRYOCOOLER FOR CRYO-PROPELLANT THERMAL MANAGEMENT**
  Chuck Hannon, Jake Hogan, Martin Segado, John Brisson
- **COMPOSITE ROLLED MAGNETOMETER BOOM, CROMAG BOOM**
  Robert Taylor, Dana Turse, Mark Reavis
- **BROADBAND PHOTON-COUNTING MICROWAVE KINETIC INDUCTANCE DETECTOR**
  Samual Moseley, Kongpop U-yen, Ari Brown, Thomas Stevenson, Wen-Ting Hsieh, Edward Wollack, Negar Ehsan
- **GEO SERVICING SATELLITE MISSION ARCITECTURE**
  Bo Naasz, Benjamin Reed, Joseph Pellegrino
- **WAVELENGTH DRIFT CORRECTOR FOR WIND LIDAR RECEIVERS (T4.01-9860)**
  J. Sirota
- **RIDGE WAVEGUIDE STRUCTURES IN MAGNESIUM-DOPED LITHIUM NIOBATE**
  Justin Hawthorne, Gregg Switzer, Philip Battle, Phil Himmer
- **AN OMNIDIRECTIONAL, CIRCULARLY POLARIZED, BROADBAND, S-BAND ANTENNA FOR SPACECRAFT COMMUNICATIONS**
  Ali Mahnad, Devid Green
- **FORTRAN TESTING AND REFACTORING INFRASTRUCTURE**
  David Alexander
- **PARTICLE FILTER SIMULATION AND ANALYSIS ENABLING NON-TRADITIONAL NAVIGATION**
  John Gaebler, Alinda Mashiku, Russell Carpenter
- **CARBON FOAM WICK STRUCTURES FOR LOOP HEAT PIPE AND HEAT PIPE APPLICATIONS**
  Eric Silk, David Myre, Brandon Stanley, Matthew Stanley

- **OPTICAL DEVICE FOR CONVERTING A LASER BEAM INTO TWO COALIGNED BUT OPPOSITELY DIRECTED BEAMS**

  Donald Jennings

- **A SIMPLE ESD TEST APPARATUS FOR SOLDERING IRONS**

  Jose Sancho, Robert Esser

- **SPACE OPERATIONS LEARNING CENTER (SOLC) IPHONE/IPAD APPLICATION**

  Scott Hull, Daniel Binebrink, Heng Kuok

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS DAY/NIGHT BAND (DNB) LOOK UP TABLES (LUT) (GVVSSE & GVVSLE) GENERATION (VIIRS 001)**

  Calvin Liang

- **ALGORITHM SUPPORT FUNCTIONS (ASF) GEOLOCATION LOOK-UP TABLE (LUT) TOOL**

  Lushalan Liao

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS DNB ZERO OFFSET VS. RESPONSE LOOK-UP TABLES (LUT) (VIIRS 047)**

  Stephanie Weiss

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS DUAL GAIN ANOMALY TRACKING**

  Shu-Hsiang Lou

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS H-SCALE FACTOR LOOK-UP TABLE (LUT) (VIIRS 100)**

  Tohru Ohnuki

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS ICE SURFACE TEMPERATURE (IST) REGRESSION COEFFICIENT GENERATION TOOL (VIIRS 016**

  Robert Mahoney

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS LAND SURFACE TEMPERATURE (LST) REGRESSION COEFFICIENT GENERATION TOOL (VIIRS 014)**

  Robert Mahoney

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS QUARTERLY SURFACE TYPE (QST) LAND WATER MASK (LWM) OVERLAY TOOL (VIIRS 200)**

  Robert Mahoney, Don Searcy

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS SEA SURFACE TEMPERATURE (SST) REGRESSION COEFFICIENT GENERATION TOOL (VIIRS 004)**

  Robert Mahoney

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS SEA SURFACE TEMPERATURE (SST) MATCHUP GENERATION TOOL (VIIRS 004A)**

  Albert Danial

- **ALGORITHM SUPPORT FUNCTIONS (ASF) VIIRS SURFACE TEMPERATURE (ST) IP REGRESSION COEFFICIENT GENERATION TOOL (VIIRS 028)**

  Robert Mahoney

- **ATMS RDR EXTRACTOR CALIBRATION/VALIDATION TOOL**

  Alex Foo

- **CRIS NONLINEARITY CORRECTION COEFFICIENTS ANALYSIS CALIBRATION/VALIDATION TOOL**

  Chunming Wang

- **CRIS ON-ORBIT SPECTRAL CALIBRATION/VALIDATION TOOL**

  Denise Hagan

- **CRLS RADIOSONDE OBSERVATION (RAOB) MATCHUP CALIBRATION/VALIDATION TOOL**

  Alex Foo

- **CRLS RDR DATA READER CALIBRATION/VALIDATION**

  Chunming Wang

- **CRLS SDR QUALITY FLAG (QF) TRENDING PGE CALIBRATION/VALIDATION TOOL**

  Denise Hagan

- **OMPS CALIBRATION SDR CHECK AND OMPS STATISTICS EARTH SDR CALIBRATION/VALIDATION TOOL [OMPS SDR GLOBAL DISPLAY TOOL]**

  Wen-Hao Li, Bhaswar Sen

- **OMPS READER FOR OPERATIONAL BINARY TABLES CALIBRATION/VALIDATION TOOL**

  Bhaswar Sen

- **OMPS TOTAL COLUMN AND NADIR PROFILE READER, MAPPER AND ANALYSIS CALIBRATION/VALIDATION TOOLS**

  Megan Novicki, Wen-Hao Li

- **VALIDATING CRLS GEOLOCATION SDR USING VIIRS CALIBRATION/VALIDATION TOOL**

  Denise Hagan

- **VIIRS AEROSOL OPTICAL THICKNESS (AOT)/ AEROSOL PARTICLE SIZE PARAMETER (APSP) CALIBRATION/VALIDATION TOOL**

  Sid Jackson

- **VIIRS BAND-TO-BAND REGISTRATION, MTF, HSR AND LSF CALIBRATION/VALIDATION TOOL**

  Lushalan Liao

- **VIIRS CALIBRATOR VIEW VISUALIZATION AND ANALYSIS CALIBRATION/VALIDATION TOOL**

  Frank Sun

- **VIIRS CLOUD MASK (VCM) TOOL AND COEFFICIENT GENERATION DOCUMENT CALIBRATION/ VALIDATION**

  Barbara Lisager, Keith Hutchinson

- **VIIRS CLOUDS {CLOUD OPTICAL THICKNESS (COT), CLOUD TOP PARAMETERS (CTP) & CLOUD BASE HEIGHT (CBH)} CALIBRATION/ VALIDATION TOOL**

  Eric Wong, Li Wen-Hao

- **VIIRS COMMON MATCHUP CUTOUT CALIBRATION/VALIDATION TOOL, V2.9**

  Albert Danial

- **VIIRS CO-REGISTERED IMAGE VISUALIZATION CALIBRATION/ VALIDATION TOOL**

  Lushalan Liao

- **VIIRS EARTH RDR VISUALIZATION & ANALYSIS CALIBRATION/ VALIDATION TOOL**

  Steven Mills, Frank Sun

- **VIIRS ENCODER ANALYSIS CALIBRATION/VALIDATION TOOL**

  John Shepanski

- **VIIRS GAIN MAP GENERATION CALIBRATION/VALIDATION TOOL**

  Shu-Hsiang Lou

- **VIIRS ICE SURFACE TEMPERATURE (IST) CALIBRATION/VALIDATION TOOL**

  Justin Ip

- **VIIRS LAND SURFACE TEMPERATURE (LST) CALIBRATION/ VALIDATION TOOL**

  Justin Ip

- **VIIRS OCEAN COLOR PHASE I CALIBRATION/VALIDATION [OVERLAP MATCHUP (OMT) CAL/ VAL TOOL]**

  Patty Pratt

- **VIIRS OCEAN COLOR (OC) POLARIZATION VERIFICATION TOOL (PVT) PHASE II CALIBRATION/ VALIDATION TOOL**

  Patty Pratt

- **VIIRS OVERPASS RADIOMETRIC COMPARISON CALIBRATION/ VALIDATION TOOL**

  Ziping Sun

- **VIIRS QUARTERLY SURFACE TYPE (QST) LOGIC TREE UPDATES ALGORITHM SUPPORT FUNCTIONS (ASF) TOOL**

  Alain Sei

- **VIIRS QUARTERLY SURFACE TYPE (QST) UPDATES ALGORITHM SUPPORT FUNCTION (ASF) TOOL**

  Alain Sei

- **VIIRS RDR EXTRACTOR CALIBRATION/VALIDATION TOOL**

  Michael Plonski

- **VIIRS SEA SURFACE TEMPERATURE (SST) CALIBRATION/VALIDATION TOOL**

  Sid Jackson

- **VIIRS SURFACE REFLECTANCE AND VEGETATION INDEX CALIBRATION AND VALIDATION TOOL**

  Alain Sei

- **VIIRS SUSPENDED MATTER CALIBRATION/VALIDATION TOOL**

  Sid Jackson

- **VIIRS TELEMETRY PROBES - ON DEMAND CALIBRATION/VALIDATION TOOL**

  Michael Plonski

- **DEVELOPMENT OF TRANSITION-EDGE HOT-ELECTRON MICROBOLOMETERS (THM) FOR MILLIMETER AND SUBMILLIMETER ASTROPHYSICS**

  Wen-Ting Hsieh, Emily Barrentine, Thomas Stevenson, Kongpop U-yen, Edward Wollack

- **MEASURING FOREST CANOPY HEIGHT USING ICESAT-2 SIMULATED DATA**

  Ross Nelson, Ricardo Topham

- **ACCELEROMETER FOR SPACE APPLICATIONS BASED ON LIGHT-PULSE ATOM INTERFEROMETRY**

  Adam Black, Frank Roller, Thang Tran

- **ADVANCED EXOPLANET STAR TRACKER FOR ORBIT SELF DETERMINATION**

  George Hindman

- **DUAL-LASER OPTICAL MODULE INTEGRATED WITH MICROCHIP CAPILLARY ELECTROPHORESIS AND AUTOMATED ON-CHIP IMMUNOASSAY**

  Hong Jiao

- **ELECTRONICALLY-TUNED HARMONIC MATCHING NETWORKS FOR HIGH EFFICIENCY RF POWER AMPLIFIER**

  Salvador Mendez, Timothy Wurth, Jeffrey Wells

- **HIGH PRESSURE "PUMP-ON-A-CHIP" TECHNOLOGY**

  Hong Jiao

- **CARBON NANOTUBE-BASED SUPERCAPACITOR**

  Jun Ai, Fedor Dimov

- **HIGH PRECISION METAL THIN FILM LIFTOFF TECHNIQUE**

  Ari Brown, Amil Patel

- **TOOL FOR AUTOMATED RETRIEVAL OF GENERIC EVENT TRACKS (TARGET)**

  Shawn Freeman, Kwo-Sen Kuo, Thomas Clune, Carlos Cruz, Jules Kouatchou, Robert Burns

- **LASER BASED, TEMPERATURE INSENSITIVE, CARBON DIOXIDE ISOTOPE RATIO MEASUREMENTS**

  Steven Massick, Kristen Peterson, Anthony Gomez

- **LASER BASED, TEMPERATURE INSENSITIVE, CARBON DIOXIDE ISOTOPE RATIO MEASUREMENTS**

  Steven Massick, Kristen Peterson, Anthony Gomez

- **HIGH TEMPERATURE AND HIGH QE BROADBAND LONGWAVE INFRARED SLS FPA FOR LANDSAT**

  Mani Sundaram

- **THE NASA VIZ APPLICATION AIMS TO DEVELOP AN INTUITIVE AND HIGHLY INTERACTIVE APPLICATION FOR THE IPHONE TO SHOWCASE THE BEST MULTIMEDIA CONTENTPRODUCED BY THE NASA GSFC STORYTELLING TEAM. THIS APPLICATION IS AN EXTENSION OF THE NASAVIZ IPAD PROJECT, WHICH WAS RELEASED ON JULY 26, 2011.**

  Troy Ames, Carl Hostetter, Horace Mitchell, Joycelyn Jones, Wade Sisler, Katherine Lewis, Helen-Nicole Kostis, Kayvon Sharghi

- **GLOBAL PRECIPITATION MEASUREMENT (GPM) SPACECRAFT FLIGHT SOFTWARE (FSW) VERSION 4.2.3**

  David McComas, Maureen Armbruster, Maureen Bartholomew, David Hardison, Susanne Strege, Nicholas Yanchik, Ji-Wei Wu, Michael Lambertson, David Kobe, Stephen Judy, Robert McGraw, Scott Applebee, Anren Hu, William Keksz, Bruce Trout, James Dailey, Chien-Cheng Fu

- **SINGLE PHOTON COUNTING NANOWIRE SPECTROSCOPIC DETECTOR**

  John Hagopian

- **SLIM FOR AGILE MISSION LIFECYCLE MANAGEMENT**

  Manas Bajaj, Andrew Scott, Anh Phung

- **SPACECUBE V2.0 PROCESSOR CARD, ENGINEERING MODEL**

  David Petrick, Dennis Albaijes

- **INTERNATIONAL SPACE STATION (ISS) EXPERIMENT CONTROL CENTER**

  Jeffrey Hosler, Daniel Espinosa, David Petrick

- **ATMS SDR READER CALIBRATION/VALIDATION TOOL**

  Alex Foo

- **GODDARD MISSION SERVICES EVOLUTION CENTER (GMSEC) WEB SERVICE 1.1**

  Vuong Ly, Robert Wiegand, LaMont Ruley

- **GEMS 1.2**

  Timothy Esposito, Danford Smith

- **CUBESAT POWER SYSTEM WITH AUTOMATIC HIGH-POWERED PAYLOAD CYCLING**

  Thomas Flatley

- **JWST/ISIM IC&DH INSTRUMENT FLIGHT SOFTWARE (IC12.5)**

  Bruce Savadkin, Gary Smith, Brett Mathews, Charles Rogers, Christos Xenophontos, Edgar Greville

- **ADVANCED SPACECRAFT INTEGRATION & SYSTEM TEST SOFTWARE (ASIST) VERSION 9.7.N**

  Ryan Detter, Edwin Fung, James Dowling, Larry Alexander, Jeffrey Condron, Daniel Grogan, Thomas Green, Peter Gorog, George Wofford

- **AN IPHONE/IPAD MOBILE APPLICATION FOR THE WALLOPS RESEARCH RANGE: WHATS UP AT WALLOPS**

  Pamela Pittman, Nathan Riolo

- **AN ANDROID MOBILE APPLICATION FOR THE WALLOPS RESEARCH RANGE: WHATS UP AT WALLOPS**

  Pamela Pittman, Nathan Riolo

- **SWITCHABLE VOLTAGE REGULATOR CIRCUIT WITH OVER CURRENT DETECTION**

  David Petrick

- **ADVANCED MISSION GRAPHICS (AMG) HEALTH AND STATUS MONITOR**

  Sandra Kleckner, Sarah Daugherty, Earl Taylor, Benjamin Cervantes, Nathan Riolo, Jeffrey Dorman, Deborah Stanley, Michael Matthews, Debra Parks

- **AMMONIA LEAK DETECTION THROUGH X-RAY FLUORESCENCE**

  Jordan Camp, Scott Barthelmy, Gerry Skinner

- **LIGHTWEIGHT LIQUID HELIUM DEWAR FOR HIGH-ALTITUDE BALLOON PAYLOADS**

  Alan Kogut, Bryan James, Dale Fixsen

- **COMMON SENSE CLIMATE INDEX**

  James Hansen

- **ASSERT-BASED UNIT TEST TOOLS**

  David McComas, Steven Slegel

- **ADVANCED MISSION GRAPHICS (AMG) DISPLAY BUILDER**

  Debra Parks, Sandra Kleckner, Sarah Daugherty, Earl Taylor, Benjamin Cervantes, Nathan Riolo, Jeffrey Dorman, Deborah Stanley, Michael Matthews

- **ADVANCED MISSION GRAPHICS (AMG) MISSION CONFIGURATION SERVER**

  Debra Parks, Sandra Kleckner, Sarah Daugherty, Earl Taylor, Benjamin Cervantes, Nathan Riolo, Jeffrey Dorman, Deborah Stanley, Michael Matthews

- **RANGE SAFETY FLIGHT ELEVATION LIMIT CALCULATION SOFTWARE**

  Raymond Lanzi

- **DUPLICATE OF MULTIPASS SPECTROSCOPY CELL WITH INTEGRATED INPUT OUTPUT FIBER DELIVERY**

  Philippe Bado, Tom Haddock

- **OPEN SOURCE PLATFORM-NEUTRAL BLAS LIBRARY**
  Kyle Spagnoli

- **VERY LOW-COST, RUGGED, VACUUM SYSTEM PHASE II**
  Paul Sorensen, Christian Passow, Steve Bilski, Robert Kline-Schoder

- **EXPLORATION PORTABLE ELECTROSTATIC DETECTOR**
  Telana Jackson, William Farrell

- **SPHERICAL EMPIRICAL MODE DECOMPOSITION**
  Nicolas Gagarin

- **JAMES WEBB SPACE TELESCOPE INTEGRATED SCIENCE INSTRUMENT MODULE (ISIM) ALIGNMENT OPTIMIZATION TOOL**
  Brent Bos

- **ORBIT DETERMINATION TOOLBOX 2012A (V5.0)**
  Kenneth Getzandanner, Russell Carpenter, Kevin Berry, John Gaebler

- **SPACECUBE V2.0 FLIGHT PROCESSOR CARD**
  David Petrick, Thomas Flatley, Alessandro Geist

- **DATA ENCODING AND PARALLELIZATION PORTING TECHNIQUES TO TRANSFORM DATA-INTENSIVE APPLICATIONS PROCESSING BINARY DATA FORMATS TO HADOOP/MAPREDUCE**
  Qiming He

- **VIRTUAL TELESCOPE DEMONSTRATION MISSION**
  Neerav Shah

- **NEAR-EARTH ASTEROID HYPER-RESOLUTION IMAGER (NEAHRI) DEVELOPMENT**
  Brent Bos, Patrick Thompson, James Rice

- **COMPACT FOCAL PLANE ASSEMBLY FOR PLANETARY SCIENCE**
  Ari Brown, Shahid Aslam, Wei-chung Huang, Rosalind Steptoe-Jackson

- **PROPELLANT LOADING VISUALIZATION SOFTWARE**
  Bryan Friia, Graham Webster

- **DEVELOPMENT OF TECHNOLOGY FOR A COMET SAMPLE RETURN MISSION**
  Joseph Nuth, Donald Wegel, Lloyd Purves, Edward Amatucci

- **METER CLASS SINGLE CRYSTAL SILICON (SCSI) MIRROR FABRICATION**
  Peter Hill, Vincent Bly

- **CONFORMAL CARBON NANOTUBES FOR STRAY LIGHT SUPPRESSION, NEAR-IDEAL CALIBRATORS, DETECTORS AND OTHER APPLICATIONS**
  John Hagopian, Vivek Dwivedi

- **NANO-ANTENNA DESIGN FOR ENERGY HARVESTING AND LIGHT DETECTION**
  John Hagopian, Edward Wollack, Shahram Shiri, Patrick Roman

- **NANO-ANTENNA DESIGN FOR EXTENDING THE BAND GAP OF SILICON DETECTORS**
  John Hagopian, Patrick Roman, Shahram Shiri

- **(HYPER)GAUSSIAN LIQUID CRYSTAL IRIS FOR DIFFRACTION SUPPRESSION IN OPTICAL SYSTEMS**
  John Hagopian, Shahram Shiri

- **HYDROLYSIS USING NANOSCALE ANTENNAS**
  John Hagopian, Shahram Shiri

- **HYDROLYSIS USING PLATINUM OR OTHER METALLIC NANO-PARTICLES**
  John Hagopian

- **IN SITU AIRBORNE FORMALDEHYDE INSTRUMENT**
  Andrew Swanson, Thomas Hanisco, Steven Bailey

- **PHOTONICS WAVEGUIDE CIRCUIT BASED FOURIER TRANSFORM SPECTROMETER ON A CHIP FOR INFRARED REMOTE SENSING APPLICATIONS REQUIRING LOW-MASS, LOW-POWER SYSTEMS**
  Shahid Aslam, Tilak Hewagama, Patrick Roman, George Shaw, John Annen, Hollis Jones, John Allen, Theodor Kostiuk, Donald Jennings

- **THE GLOBAL MICROSCOPE: INTEGRATING NASA DATA INTO LEARNING AND TEACHING**
  Sarah Baker

- **FABRICATION METHOD FOR LOBSTER-EYE OPTICS IN <110> SILICON**
  James Chervenak, Michael Collier, Jennette Mateo

- **FLEXIBLE MICROSTRIP CIRCUITS FOR SUPERCONDUCTING ELECTRONICS**
  James Chervenak, Jennette Mateo

- **LASER-BASED TRACTOR BEAMS FOR REMOTE SENSING AND SAMPLE COLLECTION APPLICATIONS**
  Paul Stysley, Demetrios Poulios, Richard Kay, Donald Coyle

- **42: A COMPREHENSIVE GENERAL-PURPOSE SIMULATION OF ATTITUDE AND TRAJECTORY DYNAMICS AND CONTROL OF MULTIPLE SPACECRAFT COMPOSED OF MULTIPLE RIGID OR FLEXIBLE BODIES**
  Eric Stoneking, Brayden Holus

- **EXPENDABLE COMPOSITE CANARIES FOR RADOME HEALTH MANAGEMENT**
  John Evans

- **TASS-ENHANCED NEAR EARTH NAVIGATION EXPERIMENT**
  Kenn Gold, Michael Mathews, Peter MacDoran, Michael Davies, Monther Hasouneh

- **A NOVEL HYBRID COLOR MAPPING APPROACH TO GENERATING HIGH RESOLUTION HYPERSPECTRAL IMAGES**
  Chiman Kwan, Jin Zhou

- **PRECISION MINIATURE ATTITUDE DETERMINATION AND CONTROL SYSTEM**

  Steve Fujikawa

- **ADVANCED CMOS RADIATION HARDENED MICRO PROCESSOR BASED STRUCTURED ASIC AND DESIGN FLOW**

  Kelly DeGregorio, Dale Wilson, Douglas Hackler, Scott Dahl

- **COVARIANCE ANALYSIS OF ASTROMETRIC ALIGNMENT ESTIMATION ARCHITECTURES FOR PRECISION DUAL SPACECRAFT FORMATION FLYING**

  Neerav Shah, Philip Calhoun

- **ELECTROMAGNETIC SCATTERING AND ABSORPTION PROPERTIES OF MULTIPLE SPHERE CLUSTERS VIA PARALLELIZED T-MATRIX FORTRAN CODE**

  Michael Mishchenko, Daniel Mackowski

- **SINGLE-FREQUENCY NARROW LINEWIDTH 1.5UM SEMICONDUCTOR LASER SUITABLE FOR SPACEFLIGHT OPERATION**

  Lew Stolpner, Georgious Margaritas

- **LOW-POWER RADIATION-HARDENED DELAY-INSENSITIVE ASYNCHRONOUS MICROCONTROLLER TECHNOLOGY CAPABLE OF OPERATING IN EXTREME TEMPERATURE ENVIRONMENTS**

  Marcelo Sschupbach

- **INDEPENDENT TEST CAPABILITY (ITC) SYNCHRONOUS BUS (ITCSB)**

  Steven Saeger, Daniel Nawrocki, Scott Zemerick, Justin McCarty, Jeffrey Joltes, Brandon Bailey, Gary Carvell, Mark Pitts, Justin Morris

- **CRYOGENIC AND VACUUM COMPATIBLE METROLOGY SYSTEMS**

  Gregory Scharfstein

- **PASSIVATION OF FLEXIBLE YBCO SUPERCONDUCTING CURRENT LEAD WITH AMORPHOUS SILICON DIOXIDE LAYER**

  Daniel Yohannes, Robert Webber

- **METHOD FOR THE SYNTHESIS OF BULK AMORPHOUS FERROMAGNETIC MATERIALS**

  David Gray, Alex Aning

- **THE FIRST MONOLITHIC SILICON CARBIDE ACTIVE PIXEL SENSOR ARRAY FOR SOLAR BLIND UV DETECTION**

  Leonid Fursin

- **LOW ER-DOPED YTTRIUM GALLIUM GARNET (YGG) AS ACTIVE MEDIA FOR SOLID STATE LASERS (SSLS) AT 1651 NM**

  Igor Kudryashov

- **LOW-NOISE ANALOG APDS WITH IMPACT IONIZATION ENGINEERING AND NEGATIVE FEEDBACK**

  Xudong Jiang, Mark Itzler

- **ADVANCED SPACECRAFT NAVIGATION AND TIMING USING CELESTIAL GAMMA-RAY SOURCES (GLINT)**

  Suneel Sheikh, Chuck Hisamoto, Zaven Arzoumanian

- **POROUS SILICON ON SILICON-ON-INSULATOR SUBSTRATES**

  Amil Patel

- **JWST IV&V SIMULATION AND TEST (JIST) CORE**

  Justin Morris, Daniel Nawrocki, Scott Zemerick, Steven Seeger, Justin McCarty, Jeffrey Joltes, Brandon Bailey, Mark Pitts

- **JWST IV&V SIMULATION AND TEST (JIST) RT LOGIC T501 EMULATOR**

  Daniel Nawrocki

- **JWST IV&V SIMULATION AND TEST (JIST) SOLID STATE RECORDER (SSR) SIMULATOR**

  Scott Zemerick

- **SOFTWARE FOR PLANNING AND IMPLEMENTING OPTICAL TESTING**

  Scott Antonille, Randal Telfer, Cherie Miskey, Don Lindler, Eliot Malumuth, Derek Sabatke, Wayne Landsman

- **DIGITALLY STEERED ANTENNA ARRAY FOR NAVIGATOR GPS RECEIVER**

  Monther Hasouneh, Heitor Pinto, Luke Winternitz, Jennifer Valdez

- **HADS ANALYSIS SOFTWARE FOR ASSEMBLY AND ALIGNMENT OF X-RAY MIRRORS**

  Timo Saha, Scott Rohrbach, William Zhang

- **CART - CHALLENGE ACTION RESULT TRACKING TOOL**

  Wesley Powell, Kenneth Li, Sharon Cooper, Lixa Rodriguez-Ramon, Malinda Thomas, Robert Lebair, Arletta Love

- **SOLAR DYNAMICS OBSERVATORY COMMAND AND DATA HANDLING ELECTRONICS**

  Kenneth Li, Harry Culver, Ronald Barasch, Kevin Ballou, Kevin Hawkins, Lars Hovmand, Michael Osman, John Pope, John Folk, Wesley Powell

- **GENTRE, VERSION 2**

  Brent Newhall, Luther Lighty

- **CONTROLLED THERMAL EXPANSION ALLOYS**

  Timothy Stephenson

- **TRMM PRECIPITATION CALCULATOR WITH DATE AND SHAPEFILE INPUTS**

  Gerasimos Michalitsianos

- **SELF-CALIBRATING VECTOR HELIUM MAGNETOMETER (SVHM)**

  Robert Slocum, Andy Brown

- **COOLSPICE: SPICE SIMULATOR FOR CRYOGENIC ELECTRONICS**

  Akin Akturk, Neil Goldsman, Siddharth Pothare

- **LASER FEMTOTESLA MAGNETIC GRADIOMETER**

  Robert Slocum

- **TOXOGRAPHY: MAPPING AND FORECASTING TOXINS AND ALLERGENS AS THEY MOVE ABOUT THE ENVIRONMENT**

  James Perry

- **WIDEBAND, DUAL POLARIZED L-BAND ANTENNA ELEMENT FOR MICROWAVE REMOTE SENSING**

  Manohar Deshpande

- **WFF LDE WEB DATABASE**

  Prasad Hanagud, Angela Walker, Brandon Wright, Michelle Leimbach, Julie Hurst, Cheryl Maguire

- **THERMALLY AND SPECTRALLY CONTROLLED NIST-TRACEABLE AMBIENT RADIOMETRIC CALIBRATIONS IN THE REFLECTED SOLAR WAVELENGTH REGION**

  James Butler, Si-Chee Tsay, Leibo Ding, Qjang Ji

- **NONLINEAR ADAPTIVE FILTER FOR MEMS GYRO THERMAL BIAS CANCELLATION**

  Joseph Galante

- **COMPACT KA BAND ANTENNA FEED WITH DOUBLE CIRCULARLY POLARIZED CAPABILITY FOR NASA'S KA BAND COMMUNICATION APPLICATIONS**

  Cornells Du Toit, Kenneth Hersey

- **HIGH COEFFICIENT OF PERFORMANCE HGCDTE AND METALLIC SUPERLATTICE-BASED THERMOELECTRIC COOLERS**

  Silviu Velicu, Cynthia Deters

- **MULTI FREQUENCY RADIO SIGNAL GENERATOR (MRSIG)**

  Kenn Gold, Michael Davies

- **NEW ACTION ITEMS SYSTEM**

  Christopher Martino, David Kuok

- **WEEKLY TOOL**

  Christopher Martino, David Kuok

- **APPARATUS FOR HIGH RESOLUTION MEASUREMENTS OF TOTAL HEMISPHERIC EMISSIVITY AT CRYOGENIC TEMPERATURES**

  James Tuttle, Edgar Canavan, Michael DiPirro

- **SATURN AND URANUS PROBE APPROACHES**

  Amato Michael

- **CONCEPT STUDY OF SPACE BORN MM-WAVE RADAR FOR SPACE AWARENESS**

  Manohar Deshpande, John Gaebler

- **DUAL POLARIZED WIDEBAND P-BAND ANTENNA FOR NASA GSFCS ECOSAR CAMPAIGN**

  Manohar Deshpande, Quenton Bonds, Rafael Rincon

- **ULTRA WIDE BAND DUAL POLARIZED BEAM STEERING P-BAND ARRAY ANTENNA**

  Cornelis Du Toit

Patents Issued

- **PASSIVELY Q-SWITCHED SIDE PUMPED MONOLITHIC RING LASER**

  Steven Li

Patent Applications Filed

- **A HIGH EVENT RATE, ZERO DEAD TIME, MULTI-STOP TIME-TO-DIGITAL CONVERTER APPLICATION SPECIFIC INTEGRATED CIRCUIT**

  George Suarez, Jeffrey DuMonthier

- **A HIGH EVENT RATE, ZERO DEAD TIME, MULTI-STOP TIME-TO-DIGITAL CONVERTER APPLICATION SPECIFIC INTEGRATED CIRCUIT**

  Roy Sterritt, Michael Hinchey

- **AUTONOMIC AUTOPOIESIS**

  Roy Sterritt, Michael Hinchey

- **ENHANCED ADHESION MULTIWALLED CARBON NANOTUBES ON TITANIUM SUBSTRATES FOR STRAY LIGHT CONTROL**

  John Hagopian, Stephanie Getty, Manuel Quijada

- **MINIATURIZED HIGH SPEED MODULATED X-RAY SOURCE**

  Keith Gendreau, Zaven Arzoumanian, Steve Kenyon, Nick Spartana

- **MINIATURIZED LASER HETERODYNE RADIOMETER FOR CARBON DIOXIDE (CO_2), METHANE (CH_4), AND CARBON MONOXIDE (CO) MEASUREMENTS IN THE ATMOSPHERIC COLUMN**

  Emily Steel, Matthew McLinden

- **PHASE CONTROLLED MAGNETIC MIRROR FOR WAVEFRONT CORRECTION**

  John Hagopian, Edward Wollack

- **POWER PROVISION BASED ON SELF-SACRIFICING SPACECRAFT**

  Michael Hinchey, Emil Vassev

- **RESOLUTION ENHANCED PSEUDO RANDOM CODE TECHNIQUE**

  Steven Li

- **SPACECUBE MINI**

  Michael Lin, David Petrick, Alessandro Geist, Thomas Flatley

- **TIRS SINGLE CRYSTAL SILICONSCENE SELECT MIRROR ENVIRONMENTAL QUALIFICATION REPORT**

  John Hagopian, Scott Rohrbach, Vince Bly, Armando Morell, Jason Budinoff

- **V-ASSEMBLY DUAL HEAD EFFICIENCY RESONATOR (VADER) LASER TRANSMITTER**

  Barry Coyle, Paul Stysley, Demetrios Poulios

- **VECTORIZED REBINNING ALGORITHM FOR FAST DATA DOWN-SAMPLING**

  Jeffrey Smith, David Aronstein, Bruce Dean

- **WAFER LEVEL MICROCHANNEL FABRICATION PROCESS FOR LAP-ON-A-CHIP DEVICES**

  Yun Zheng, Edward Wassell, Manuel Balvin, Stephanie Getty

ICB Awards

Software Awards: 7

- **GLOBAL PRECIPITATION MEASUREMENT (GPM) OPERATIONAL SIMULATOR (GO-SIM) INSTRUMENT SIMULATIONS**

  Dan Nawrocki, Jeffery Joltes, Justin Morris, Steven Seeger

- **ITC SYNCHRONOUS COMMUNICATIONS BUS - 1553 (ITCSB_1553) / GPM OPERATIONAL SIMULATOR (GO-SIM) 1553 API**

  Jeffery Joltes, Justin McCarty, Justin Morris, Steven Seeger

- **GLOBAL PRECIPITATION MEASUREMENT (GPM) OPERATIONAL SIMULATOR (GO-SIM) CORE**

  Arturo Ferrer, Brandon Bailey, Charles Rogers, Dan Nawrocki, Jeffery Joltes, Justin Morris, Steven Seeger

- **LUNAR RECONNAISANCE ORBITER (LRO) SPACECRAFT FLIGHT SOFTWARE**

  Michael Blau, Lonnie Walling, Bruce Trout, Thomas Clement, Michael Yang, Glenn Cammarata, Larry Shackelford, Joel Chiralo, Ji-Wei Wu, Susanne Strege

- **INTEGRATED SPACE WEATHER ANALYSIS SYSTEM (ISWA)**

  David Berrios, Lutrz Rastaetter, Marlo Maddox, Michael Hesse, Peyush Jain, Richard Mullinix

- **GODDARD SATELLITE DATA SIMULATION UNIT**

  Toshihisa Matsui

- **SPACE WEATHER ANDROID APP; A STANDALONE ANDROID APPLICATION WHICH DISPLAYS SPACE WEATHER INFORMATION TO USERS**

  David Berrios, Michael Hesse, Richard Mullinix, Marlo Maddox

Board: Board Action (SAA): 1

- **FURTHER REFINEMENT OF THE COMPUTATIONALLY EFFICIENT HSEG ALGORITHM**

  James Tilton

Board: BA (SAA) - IOY NOM: 2

- **PIVOT 2.0: RADIATION HARDENED, FAST ACQUISITION/WEAK SIGNAL TRACKING GPS RECEIVER**

  Gregory Boegner, Luke Winternitz, Steve Sirotzky

- **MULTIMODAL PRESSURE FLOW ALGORITHM**

  Norden Huang, William Gloersen, Liming Salvino

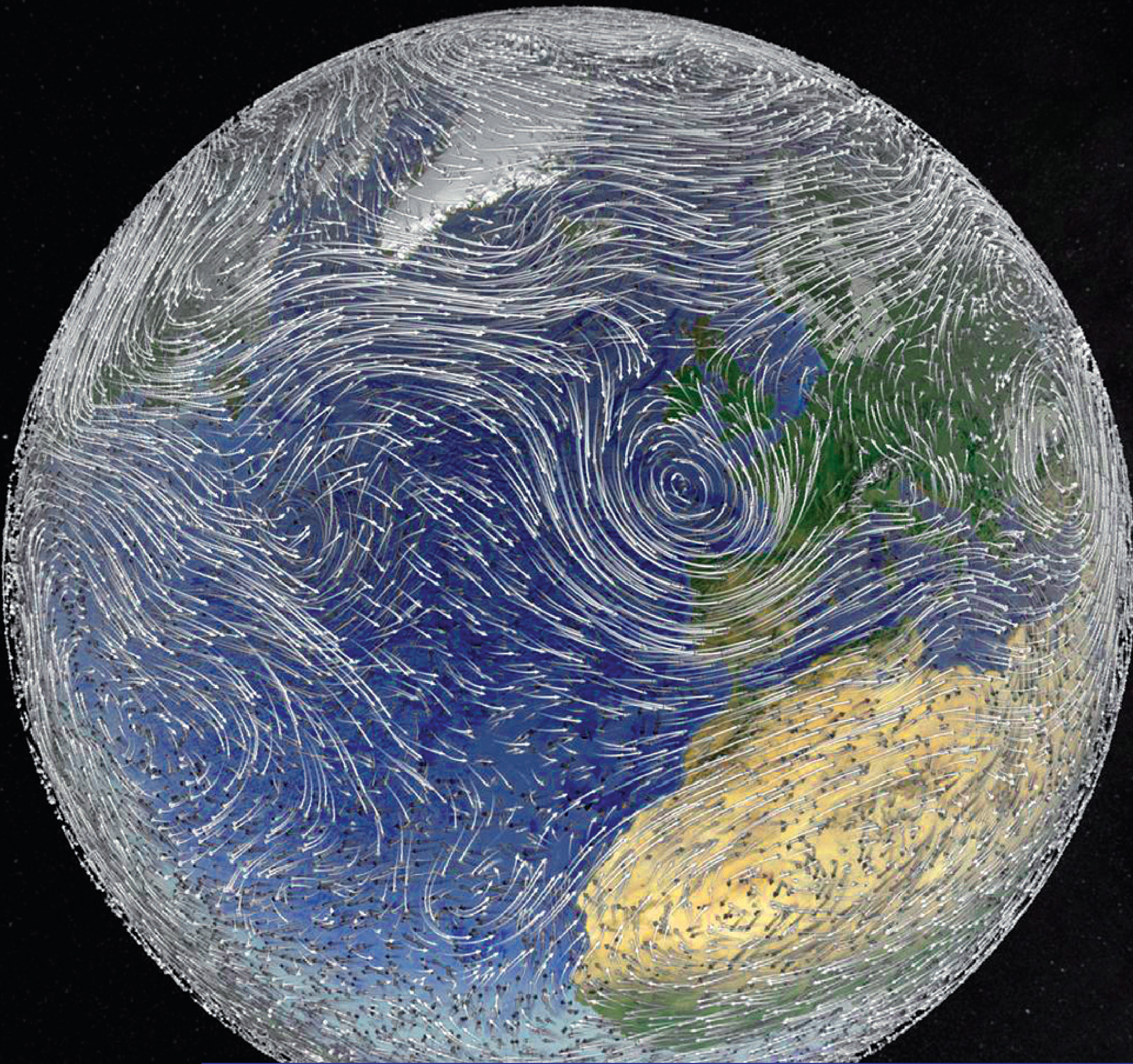
Board: BA (SAA) - SOY NOM: 2

- **GO-SIM SUITE**

  Steven Seeger, Arturo Ferrer, Justin McCarty, Justin Morris, Charles Rogers, Dan Nawrocki, Brandon Bailey, Jeffery Joltes

- **INTEGRATED SPACE WEATHER ANALYSIS SYSTEM (ISWA)**

  David Berrios, Lutrz Rastaetter, Marlo Maddox, Michael Hesse, Peyush Jain, Richard Mullinix



Winds whip around the world in this NASA-created image, a still capture from a 4-minute excerpt of "Dynamic Earth: Exploring Earth's Climate Engine"

—PHOTO BY NASA

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

Goddard *Tech Transfer News* is the quarterly magazine of the Innovative Partnerships Program Office (Code 504) at NASA's Goddard Space Flight Center. Also available online at: http://ipp.gsfc.nasa.gov. Send suggestions to Robert.S.Leonardi@nasa.gov.

www.nasa.gov

NP-2012-11-354-GSFC