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Sample Analysis at Mars

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Sample Analysis at Mars

Nona Cheeks

[FROM THE *Chief*

From the Chief

Over the years, many NASA missions have captured the public’s imagination. The most recent example is the Curiosity Mars rover, which touched down on the Red Planet in August, 2012. Curiosity continues to make science news on an almost daily basis, providing many historical firsts in the realm of planetary exploration and contributing numerous important findings and discoveries to further our understanding of the Martian environment.

Onboard Curiosity is the Sample Analysis at Mars (SAM) instrument suite, developed at NASA Goddard. SAM provides scientists and researchers with the tools to search for compounds of the element carbon that are associated with life. SAM’s instruments can also be used to explore ways in which these compounds are generated and destroyed in the Martian ecosphere.

SAM’s instruments incorporate many separate NASA Goddard technologies. These include innovations designed for chemical analysis, optics, software, mechanics, and others. A number of these have been made available for commercialization and use outside NASA Goddard, and (either standalone or in various combinations) offer significant value to a broad array of potential applications. These technologies comprise yet another compelling example of how NASA Goddard inventions, developed originally with space science in mind, can offer practical utility and benefit here on Earth.

In this issue of NASA Goddard *Tech Transfer News*, we review some examples of SAM technologies that could be adapted to terrestrial uses. We also speak with Dan Harpold of the Planetary Studies group about the many ways in which various forms of collaboration helped develop some of the core technologies for SAM. In addition, we interview Cynthia Firman, SBIR/STTR Technology Infusion Manager for the Innovative Partnerships Program (IPP) Office, and take a look at examples of how NASA Goddard’s SBIR/STTR program helped develop technologies for SAM. And our legal experts Bryan Geurts (Chief Patent Counsel for NASA Goddard’s Office of Patent Counsel) and Erika Arner (Partner for the law firm Finnegan, Henderson, Farabow, Garrett & Dunner) provide their views on how recent changes to U.S. patent law could affect patentability and disclosure.

Nona Cheeks
Chief, Innovative Partnerships Program Office (Code 504)
NASA Goddard

Sample Analysis at Mars

[INTERVIEW WITH *Dr. Dan Harpold*

Interview

Throughout NASA's history, collaboration has been key to mission success. And in today's environment of limited budgets and ambitious agendas, collaboration is more important than ever. The Sample Analysis at Mars (SAM) mission on Curiosity provides an excellent example of this philosophy. NASA Goddard has taken advantage of several forms of collaboration to ensure that many key components were developed, delivered, and available to be incorporated into SAM.

To learn more about how collaboration played an essential role in the development of SAM, we spoke with Dan Harpold of the Planetary Environments Laboratory (Code 699) who was the element lead on mass spectrometer and many of the gas processing system components

Q. *How was it determined which technologies were needed for SAM?*

Around 2003, NASA was considering what its next Mars mission might be. In response, Paul Mahaffy [*Chief, Planetary Environments Laboratory, Code 699*] began looking into what NASA Goddard would need in order to put together a proposal for this potential Mars mission. This involved reviewing existing capabilities we had developed for previous missions such as Galileo and Cassini. Some of the instruments and components we created for these missions might be adapted for the needs of a Mars mission.

As an example, planetary missions generally incorporate some way to measure and analyze gases, either as components of an atmosphere or from gases evolved from heated solid samples. A primary way to do this is through mass spectrometry. This is a technology that has been used for decades to measure the composition of gases in a variety of applications. One example is in the field of forensic science where law enforcement laboratories often will use a combination of a mass spectrometer and a gas chromatograph to help analyze the evidence. This combination of these instruments is often seen in TV series such as CSI.

During our review we also identified some technologies and components that, at that time, we didn't have in-house. These represented collaboration opportunities.

Q. *How important has collaboration been to the SAM development effort?*

It's been essential. To understand why, all we need to do is look at the three main instruments on SAM: the mass spectrometer, tunable laser spectrometer, and the gas chromatograph. In each case, the instrument is the result of collaboration between NASA Goddard and at least one other outside entity.

For example, consider the mass spectrometer I mentioned earlier. Back in the 1960's NASA began working with a company called Consolidated Systems Corporation – which later became part of Perkin-Elmer – to produce mass spectrometers we needed for our research into the Earth's upper atmosphere. We bought the instruments, then tested and calibrated them in-house to meet our requirements. In addition, we needed electronics to support these devices. This work required frequent tweaking and modifications from one launch to another, and cost a great deal in terms of time and money. So by the 1970's, we developed the capability to build mass spectrometers in-house. We also started collaborating with the University of Michigan to produce the support electronics. This collaboration relationship is still in place today as flight mass spectrometry is now considered one of NASA Goddard's bread-and-butter capabilities.

For SAM, the science required mass spectrometers with much more precision and sensitivity than those we were producing in-house, especially for gases such as methane -- which typically in mass spectrometers will have high background levels that makes measurements at low concentration levels difficult. To acquire this capability, we looked at an instrument called a tunable laser spectrometer, developed by Chris Webster at NASA Jet Propulsion Laboratory, which can detect methane concentrations at the parts per billion level. Dr. Webster agreed to become part of the SAM team.

The third instrument on SAM is the gas chromatograph (GC). We had worked with CNES, the French space agency, on a similar instrument for the Cassini/ Huygens mission. Gas chromatography provides a high level of sensitivity in terms of detecting certain gases in a sample. Gas chromatographs are used in industries around the world. Based on our Huygens collaboration with the French GC team, they accepted our invitation to become part of the SAM suite as well.

So to review, the three SAM instruments clearly illustrate a few ways NASA Goddard collaborates to develop needed technologies. The mass spectrometer is the result of collaboration, initially with private enterprise and more recently with academia. The tunable laser spectrometer was developed in collaboration with another NASA Center, and the gas chromatograph is the product of collaboration with another space agency. So it's easy to see just how essential collaboration has been to the whole SAM development program.

Q. ***Are there other examples of collaborations with private companies during the development of SAM?***

Absolutely. In addition to the three main SAM instruments, there are a lot of sub-components. If the technology exists and is commercially available, we'll always try to adapt it to our requirements; we don't want to re-invent something that's already available.

For instance, a device known as pressure regulator is used in many labs around the world. It reduces a higher pressure gas down to a pressure level that is required for a particular end use. On the Huygens mission in the late 1990's, we worked with a company called AutoFlow to develop a miniaturized pressure regulator that could withstand temperatures up to 250 C and survive the normal environmental conditions typically seen on space flight missions.

AutoFlow Pressure Regulator.

—PHOTO BY NASA

In the early development for SAM we approached them again, and asked whether or not they'd be interested in developing a version to meet the more demanding requirements of SAM. Autoflow was a very small company and did not have an internal source of money to redesign the Huygens regulator, so we provided AutoFlow with an R&D contract of around $100K to help defray the cost of this development. This was followed by a contract to produce prototype regulators, which went through the necessary qualification testing, and finally a contract for flight regulators. The regulators are working quite well in our SAM suite on the surface of Mars.

Q. *We've discussed several instances in which NASA Goddard collaborated to bring in technology. Can you provide an example of a NASA technology being transferred to the private sector?*

A good example of that is our microvalve technology. These are magnetic latching solenoid valves with low leak rates that can operate at high temperatures. These valves were initially designed for a proposed Venus probe mission in the mid 1970s and later developed for our Galileo Jupiter Probe mass spectrometer. Initially we had a single supplier for these valves. Over the years we ordered perhaps 100 or so from this supplier.

The microvalves quickly became a critical part of our planetary missions, because without them, we didn't have an experiment. However, during our development of our Huygens gas chromatograph mass spectrometer, we encountered some difficulty obtaining microvalves that met our specifications in a timely manner from the original vendor. If the same situation occurred with SAM, this would present a serious challenge as our schedule requirements were even more demanding. Shortly after the Huygens mission was completed, we decided to look for an alternative source for the microvalves to ensure these devices didn't impact the development schedule of future missions. We approached several large companies but they didn't have a great deal of interest as they didn't see a huge commercial market for this product. We also used the Small Business Innovative Research (SBIR) program to address this need. Although this generated some interest, it didn't result in a completed microvalve we could use.

Early in the development of SAM, the need for microvalves became so acute that we decided to try to develop this technology in-house with Internal Research and Development (IRAD) funding. This proved to be a difficult task, but with a talented engineering team behind the effort it proved successful. In fact, a patent was awarded to the lead engineer who developed the valves.

Once the microvalves were qualified and were in use in the SAM suite, we began working with NASA Goddard's Technology Transfer office to license the valve patent to a commercial company. This would ensure a continued source of microvalves for future flight gas chromatograph mass spectrometer

Mindrum Precision Microvalve.

—PHOTO BY NASA

instruments. In 2010, Mindrum Precision was granted a license to manufacture these microvalves. Obtaining a license agreement at that time became quite fortuitous, as our original supplier stopped producing microvalves. A few of their units are on SAM, but most are the in-house developed valves. Mindrum Precision is now our supplier for this technology and they also have the rights to sell this product to other customers.

This is an example where technology transfer really came through for us. Future planetary missions that need to measure the composition of atmospheres and planetary surfaces will always have a need for microvalves. With our collaboration with Mindrum that led to establishing a source for microvalves, whoever is selected to provide instruments for these future missions will be assured of having a reliable source for this valuable component.

Q. *NASA appears to collaborate frequently with smaller companies.*

In many instances smaller companies are better suited to be collaboration partners than larger ones. A big company may not be interested in developing technology that requires years to complete and for which NASA may only buy a limited number of units, with the next order not occurring until the next flight mission -- which may be only once every several years. We've often run into this. Even though the company's engineers find our work very interesting and would love to work on it, once the marketing and production people get involved, the company typically is not interested in pursuing the work. In addition, large companies usually want to be sure up front there's a large commercial market for the technology outside NASA.

For a smaller company with little overhead, a technology suited for NASA and a potential niche market might represent an attractive and viable business opportunity. And they are excited about working with NASA, often mentioning it on their company web site, at trade shows, and so on.

Q. *Has the development of SAM benefitted private enterprise in other ways?*

The NASA Goddard Materials Engineering Branch [*Code 541*] can perform testing and analysis that can be very valuable to commercial companies. An example is the vacuum seals used on SAM. These have always performed satisfactory in other applications. But under the more demanding requirements of SAM where we needed to store high pressures (2000 psia) of helium, the seals started developing leaks during testing, and the vendor had no idea why.

So the Materials Engineering Branch looked at the seals under high magnification, and discovered that the gold plating on these units appeared rough. This prompted the company to examine their plating process and they discovered that the problem was that the plating was being done too quickly. So they fine-tuned the plating steps and sent new units to us for testing. Sure enough, this fixed the leak problem. The vendor was very thankful because we helped them improve the performance of their product, which opened up new markets for them.

This is only a single example as the Materials Engineering Branch has similarly benefitted a number of other programs and companies.

Q. *What's next for your group?*

Currently, we are working on a new type of mass spectrometer which we will supply to the European ExoMars Rover mission to be launched in 2018. The mass spectrometer will be integrated into the MOMA (Mars Organic Molecular Analyzer) suite. The MOMA suite consists of a gas chromatograph which will once again be provided by the same French team; a laser system provided by the Max Planck Institute in Germany and the MOMA-Mass Spectrometer provided by our group. So once again we see the importance of collaboration between, in this case, governments.

In the near future, there will be a lot of focus on a proposed new Mars mission in 2020. We should learn more about this mission later this year. We'll review the science and other requirements, and if appropriate we'll begin the steps to prepare a proposal for this work. At the same time, it's likely we'll need to acquire new capabilities and technologies to suit the specific requirements of the mission. Once these are identified, we'll again be exploring every appropriate venue to identify collaboration opportunities to fulfill these needs. Combining our experience with these new collaborations hopefully will lead to a competitive proposal.

Dr. Dan Harpold

PLANETARY ENVIRONMENT LABORATORY

Code: 699, Goddard Space Flight Center

Years with NASA:
48

Education:

BS in Physics and Math, North George College

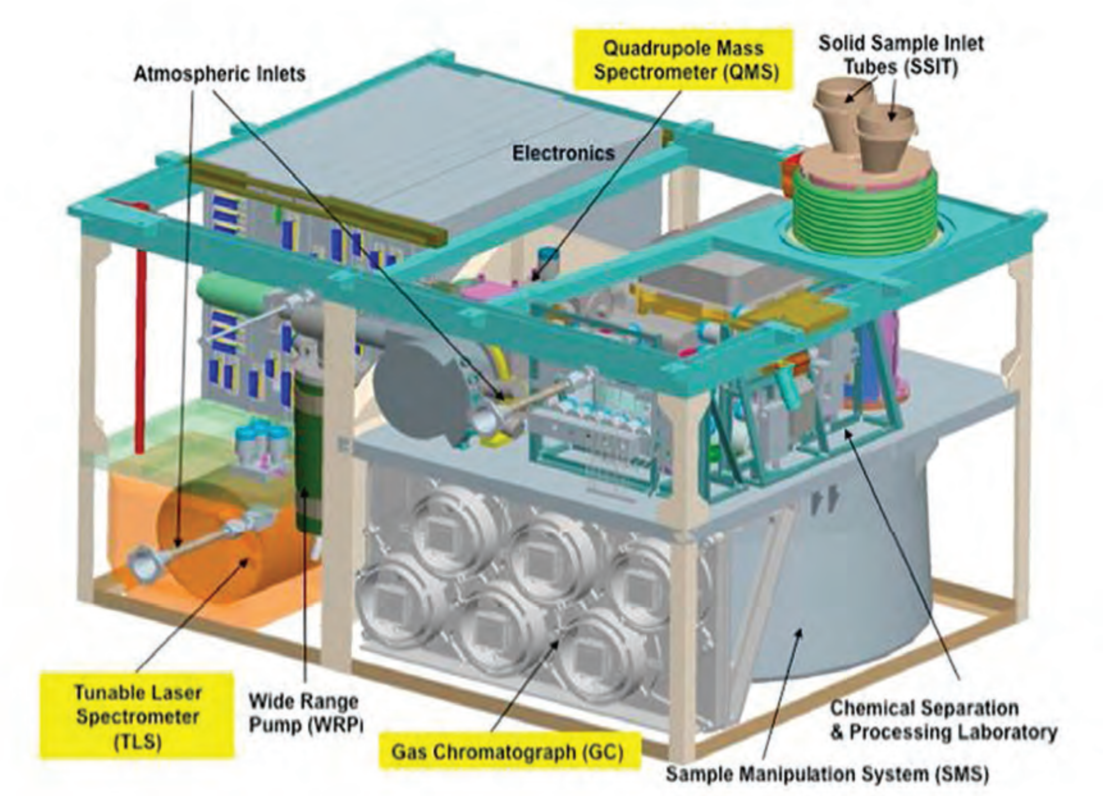
[SAMPLE ANALYSIS AT MARS *Technologies*

(SAM) Technologies

One of the primary instrument packages aboard the currently active Curiosity Martian rover is the Sample Analysis at Mars (SAM). This suite of instruments was developed by NASA Goddard to search for organic molecules on the Martian surface.

SAM's primary science instruments are a spectrometer that separates elements and compounds by mass for identification and measurement; a gas chromatograph that separates molecules of close molecular weight, measures and analyses the gases by mass, and routes gases to the mass spectrometer for further analysis; and a laser spectrometer that measures the abundance of various isotopes of carbon, hydrogen, and oxygen in atmospheric gases such as methane, water vapor, and carbon dioxide.

These three instruments are supported by a sample manipulation system (SMS) and a Chemical Separation and Processing Laboratory (CSPL). The latter incorporates a number of separate technologies, including microvalves, gas manifolds, chemical and mechanical pumps, carrier gas reservoirs and regulators, and others. CSPL samples the atmosphere on Mars by introducing a small amount of gas through an inlet tube to the SAM instruments. SAM analyzes solid

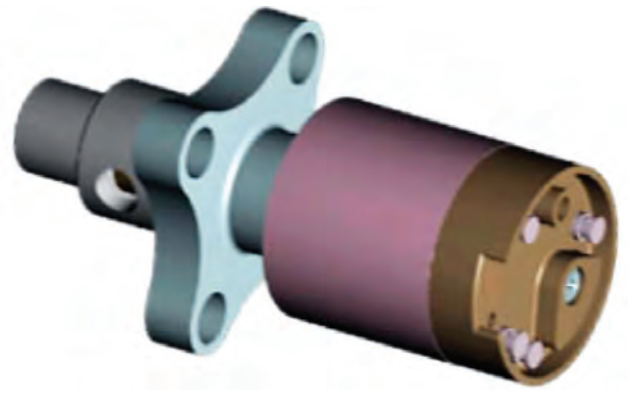


▶ *Sample Analysis at Mars Components*

—PHOTO BY NASA

phase materials by transporting finely sieved soils to one of the SMS sample cups; the cup with the sample then enters a SAM pyrolysis oven to release volatiles.

These and other technologies developed to support the SAM mission offer potential utility for a number of commercial and industrial applications. "These technologies could be applied to any situation where a sample needs to be analyzed in the field, but cannot be collected and returned to the laboratory – for example, in environments where it would be dangerous for people to enter, or for analyzing highly toxic substances" states David Martin, Technical Authority & Systems Lead for the SAM and Mars Organic Molecule Analyzer (MOMA) instruments.



▶ *Microvalve*

—PHOTO BY NASA

Mass Spectrometry

As noted by Dr. Dan Harpold of the Planetary Environment Laboratory [*see "Interview with Dan Harpold" in this issue of NASA Goddard* Tech Transfer News] NASA planetary missions frequently require the measurement and analysis of gases. Many missions employ a technique called mass spectrometry to do this. Mass spectrometry has a long history of use as a way to measure the composition of gases in a variety of applications, both space and terrestrial.

As shown in the preceding illustration, mass spectrometry is a critical capability of SAM. This technology could be potentially adapted to a number of commercial applications that require high levels of sensitivity and accuracy. In addition, associated technologies such as "scrubbers" and "traps" could also be leveraged to improve the performance of commercial mass spectrometry.

Microvalve GSC-15906-1

SAM instruments incorporate 52 miniaturized double-latching valves designed for gas sampling systems. These devices, commonly known as microvalves, were developed by NASA Goddard and are currently manufactured by Mindrum Precision. [*See also "Interview with Dr. Dan Harpold."*] The microvalve provides many advantages over other high-end high-performance valve technologies. For example, it has fewer parts than existing valves, and offers both reduced complexity and less stringent manufacturing tolerance requirements. Compared to other valves, the microvalve is more reliable, weighs less, and is easier and less expensive to fabricate.

Key innovations of the microvalve include a floating pintletip that allows for relaxed manufacturing tolerances; a removable solenoid that can be easily replaced if there is a failure in any coil, and shimming capability that determines the amount of compression achieved in the Belleville washer stack and allows for looser tolerances for the individual parts.

In addition to SAM, many upcoming and proposed NASA missions could have a need for microvalve technology. For example, Southwest Research Institute (SwRI) is preparing proposals for two NASA Discovery Missions that would each employ up to 10 microvalves. The Europa Jupiter System Mission could require a similar number of microvalves. Kennedy Space Center's Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction (RESOLVE) mission is another prime candidate for microvalves, this mission could require approximately 30 units.

In the commercial sector, the microvalve could be adapted for several applications and markets, such as gas regulation for the semiconductor industry, hand-held instruments for homeland security, and high temperature valves for use in the petroleum industry, among others. As Mr. Martin explains, "Microvalves could be of value to any instrumentation that requires high reliability and small size and mass."

Sample Analysis at Mars Instrument Simulator (SAMSIM) GSC-16566-1

Another SAM related invention is the Sample Analysis at Mars Instrument Simulator (SAMSIM). This is a high-fidelity numerical tool dedicated to plan-and-validate operations of the SAM instrument on the surface of Mars. SAMSIM consists of the following interacting modules:

• Software Module simulates the instrument Command and Data Handling System (C&DH). This module can execute and validate command scripts that are identical to those executed by SAM.

• Mechanical Module simulates the actions of a number of mechanical subsystems of the SAM instrument, including valves, pumps, and SMS.

• Thermal Module simulates the action of each of SAM's many heaters, and their thermal impact.

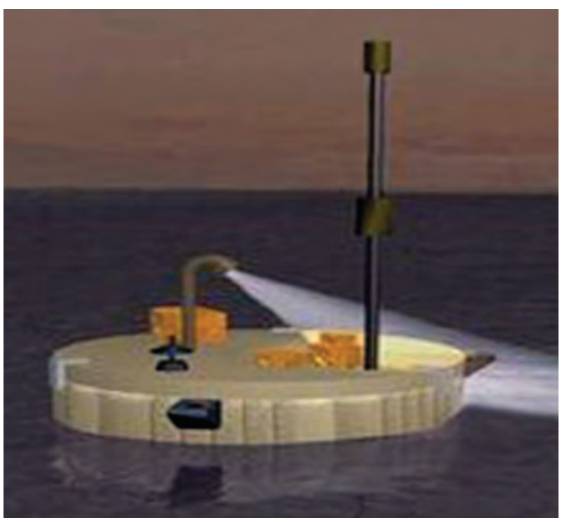
• Flow Module simulates the gas dynamics in the gas processing system of SAM.

• Electrical Module captures the electrical behavior of motor control boards and all elements that contribute to the instrument power profile.

SAMSIM can be adapted to model other systems for space or industrial applications. The simulator can be readily modified to model a commercial gas chromatograph mass spectrometer (GCMS). And the SAMSIM gas flow library is a standalone entity that can be utilized to build models for complex gas flow of vacuum systems.

Lab-on-a-Chip GSC-15970-1

As part of the ongoing effort to improve the ability to analyze planetary samples, NASA Goddard is currently developing the In Situ Wet Chemistry Laboratory. This is a lab-on-a-chip device designed for detecting and analyzing biological molecules in a sample. This combines multiple NASA Goddard technologies into a compact, lightweight unit designed for exobiology analysis on Mars, Titan, Europa, or any New Frontiers or Discovery Program missions that focus on the search for biologically relevant organic materials.



Artist's Concept of Proposed Mission to Titan

—PHOTO BY NASA

In addition to detecting whether or not a sample is biological, the lab could also be eventually developed to identify whether or not certain DNA is present. This immediately raises a broad spectrum of possible health and medical related applications. For example, this capability could theoretically be used to analyze a sample of drinking water, to detect a variety of dangerous microbes or pathogens. And the fact that this unit is potentially portable means it could be used in the field, for example in remote locations where consuming contaminated drinking water is often the most common means for contracting disease.

These are a sampling of potential uses for technologies developed for the SAM mission. For more information about these and all other NASA Goddard technologies, contact the Innovative Partnerships Program Office.

David K. Martin

AEROSPACE FLIGHT SYSTEMS

Code: 699

Years with NASA: 25

Education:

Masters in Electrical Engineering, Johns Hopkins University

[INTERVIEW WITH *Cynthia Firman*

As part of the ongoing effort to increase commercialization of innovations derived from public funding and to meet U.S. government research and development needs, NASA Centers maintain active Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

Heading NASA Goddard's SBIR/STTR efforts is Cynthia Firman, SBIR/STTR Program Manager and Technology Infusion Manager (Code 504). We recently spoke with Cynthia about how the SBIR/STTR program works at NASA Goddard, the benefits it provides to both NASA and its partners, and related topics.

Q. ***What's your personal experience with SBIR/STTR programs?***

I originally joined NASA after college, but left to start a family. I eventually returned to NASA in 2002. During the time I was away, I worked for a small business concern, initially as an employee and later as a subcontractor. At one point I applied for and won an SBIR grant from the National Science Foundation, to develop the first technology that allowed scientists in the Antarctic to send email via the internet. Today, of course, this can be done through satellite communications. But at the time, there was no way for scientists working in such remote locations to do this; our technology was the first. So I have experience with the SBIR program as both an awardee and, more recently, as Program Manager.

In my current position, I'm still in the process of learning how NASA does things. I attend agency conferences, and while there I meet with companies and their decision-makers. It provides the benefit of a broad mix of one-on-one conversations.

Q. ***How does NASA determine what technology needs might be filled through SBIR/STTR?***

The process begins with selecting solicitations – basically, what does NASA want? To decide this, we review mission directorates, for example science and human exploration. This helps determine what technologies NASA will need to meet these goals. For example, suppose NASA is planning a mission to an asteroid. The first step would be to define which technologies would be needed for that mission. Then we review what capabilities we already have or can develop in-house, and which can be developed externally. This latter category forms the basis of SBIR/STTR solicitations; technologies that NASA wants to encourage others to develop rather than develop ourselves.

NASA realizes that there's only so much the agency can do. Say a mission needs sensor technology. A review of what's already out there indicates that the technology is not yet available on the commercial market. We can write an SBIR/STTR solicitation for our requirement and have companies propose how they might satisfy it.

Q. ***What level of funding do SBIRs and STTRs provide?***

Traditionally, a Phase I award runs for six months, and provide the awardee with $125,000 in funding. Phase II awards generally run for 24 months, with $750,000 in funding.

Starting in 2013, there will be a new SBIR category called "Select." The time periods for these awards will be the same as the Phase I and Phase II awards, but the funding will be doubled. Six-month awards will be $200,000, with 24-month awards offering $1.5 million.

For my SBIR-funded project, the award was critical to our success. It paid the bills, it paid for my salary. It also paid for our equipment and even a trip to Antarctica. Of course, we had to budget carefully, allocating expenses in detail.

Q. *Beyond the monetary grant, what other benefits does the SBIR/STTR program provide?*

Proposals that fall into certain SBIR/STTR subtopics have NASA scientists assigned to evaluate them. If the proposal is successful, the awardee gets to meet directly with the assigned scientist and forms a relationship. In some cases, the awardee can request the use of government facilities, including access to office space, laboratories, and so on. This can be a major cost saving for the company in terms of reducing overhead.

In cases where the project produces IP, the awardee can request the patent or copyright. And some subtopics come with the designation TAV, also known as "Technology Available." In these cases, the awardee gets to use certain NASA-developed technologies for the duration of the project. This can be a good way to transfer publicly-funded technology and push it into the commercial space.

Phase I is an excellent way for smaller companies to jump on the NASA "train" and collaborate with us.

Q. *What is the expected deliverable at the end of a project?*

Typically, in Phase I the expectation is for the technology to be developed through the proof-of-concept stage. The inventor can then apply for a Phase II, and if NASA considers the technology promising, they'll receive the award. During Phase II the technology is expected to be developed into a full-blown proof or perhaps a test prototype. And if the IP can subsequently be used to form the basis of a commercial product, that's a real success story.

Q. *Did the SBIR/STTR program assist the development of Curiosity and/or the Sample Analysis at Mars instrumentation?*

The SBIR/STTR program played an important role in developing technologies for SAM. Six separate technologies on Curiosity came through the program; we've written a brochure listing them. [Editor's note: See http://osbp.nasa.gov/docs/MARS%20OSB_CS55_FINAL_LO=TAGGED.pdf.] Two companies that come to mind are Honeybee and Yardley, For example, Honeybee had two SBIRs with NASA Goddard.

Q. *How does the NASA SBIR/STTR program determine which Center owns which project?*

The review process determines which NASA Center gets assigned the project. Up to eight different NASA Centers might review a single proposal. So it's not uncommon for NASA Goddard to be involved in the review of a proposal that ultimately ends up in another Center.

For example, say the solicitation is for a detector than people throughout NASA want. If the appropriate person at NASA Goddard is too busy, we might ask JPL to administer the project. So which specific Center ends up with the project can sometimes involve a judgment call. Within NASA SBIR/STTR projects, the whole concept of ownership can sometimes be a little nebulous. It can also involve a little horse-trading between Centers.

Q. *What's the current state of the program at NASA?*

This past year we've had a bumper crop of Phase I proposals, more than expected. A lot of people are interested. We now have more proposals to choose from – as well as more to say no to!

Cynthia Firman

SBIR/STTR PROGRAM TECHNOLOGY INFUSION MANAGER

Code: 504

Years with NASA: 19

Education:

B.S. Major: Mathematics, Minor: Economics, 1982, University of Maryland

M.S. Electrical Engineering, 1990, Johns Hopkins University

SBIR/STTR Success Story

As mentioned in our interview with Dr. Dan Harpold, the Sample Analysis at Mars (SAM) instrument package comprises many technologies developed through various forms of collaboration. This includes six technologies that were developed with funding through NASA's SBIR/STTR program. Two of these were developed in collaboration with NASA Goddard. These include a space-qualified vacuum pump developed by Creare, and a dust removal tool developed by Honeybee Robotics.

Creare: Extremely Miniaturized, Turbomolecular Pump-Based Vacuum System

Over the past several years NASA has developed very small mass spectrometer sensors. These sensors are usually supported by vacuum systems, which historically have been large and heavy and require significant electrical power to operate.

▶ *Creare's miniaturized vacuum pump, shown next to a common battery for size comparison.*

—PHOTO BY NASA

To address this issue, NASA awarded an SBIR grant to Creare, an engineering company located in New Hampshire, to develop an extremely miniaturized vacuum system based on a very small turbomolecular pump (TMP). Creare subsequently partnered with NASA Goddard to develop a space-qualified version of the TMP for use on board SAM.

As shown in the preceding illustration, the TMP is smaller in size than a D-cell battery. However, it still provides the high performance necessary to meet the requirements of miniature analytical instruments. The TMP is part of a complete vacuum system optimized to support analytical instruments in terrestrial applications and on spacecraft and planetary landers.

Creare's support of the SAM mission includes the fabrication and delivery of three engineering model pumps, two life test pumps, four flight model pumps, one flight spare pump, and testing and evaluation of the pumps.

Honeybee Robotics: Dust Removal Tool (DRT)

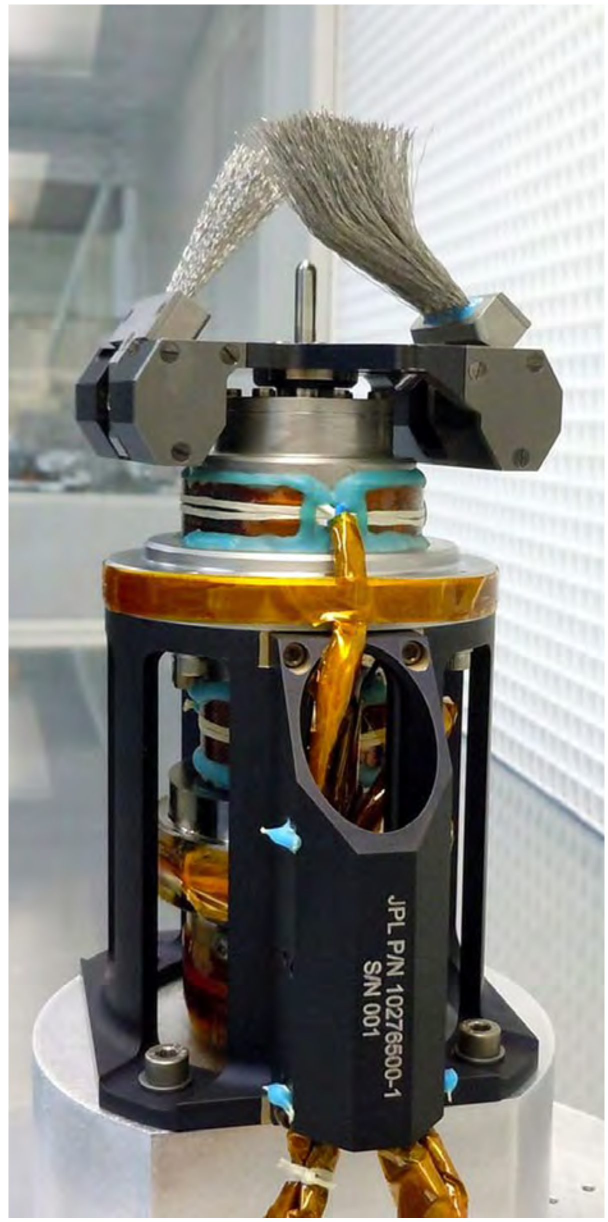
The surface of Mars is an extremely dusty place – indeed, the ubiquitous presence of this rust-colored dust has helped give Mars its nickname "The Red Planet." This dust needs to be removed from rock samples of interest before SAM can select and analyze them. In addition, Curiosity's observation tray must be kept free of dust.

Honeybee Robotics' Dust Removal Tool (DRT), developed in part through a NASA SBIR grant, is designed to expose the natural surfaces of Martian rocks obscured by layers of deposited dust. Using a single brushless DC motor, the DRT removes dust from an area 45 mm in diameter.

The DRT features a high reduction single-stage planetary gear box and a hinged brush block, both of which incorporate lessons learned from previous Mars missions. During the dust removal process, a set of brushes articulate to maintain surface contact as they rotate at high speed. The wide range of rock surface characteristics along with severe resource constraints makes the DRT well-adapted to the needs of the SAM mission.

Honeybee Robotics' support of the Curiosity mission also includes designing and developing the sample manipulation system for SAM.

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.



Honeybee Robotics' Dust Removal Tool (DRT).

—PHOTO BY NASA

Sample Analysis at Mars

[DISCLOSURE AND *Patentability*

Patenting Perspectives

High-profile missions such as the Curiosity rover on Mars often gather a great deal of popular press. Some of these articles may include technical details about technologies such as the Sample Analysis at Mars (SAM) instrument suite. In the past, the patentability impact of technology disclosure could be somewhat mitigated by the "first to invent" philosophy underlying much of U.S. patent law. With the advent the America Invents Act (AIA), and its new focus on "first to file," disclosure may now raise a number of patentability issues that have historically been of lesser concern to inventors.

This installment of Patenting Perspective reviews disclosure and how it may affect patentability under the changes mandated by the America Invents Act. Here to provide their perspectives on this topic are attorneys Bryan Geurts (Chief Patent Counsel for NASA Goddard's Office of Patent Counsel) and Erika Arner (Partner for the law firm Finnegan, Henderson, Farabow, Garrett & Dunner).

Q. *In general, how does public disclosure of an invention affect its ability to be protected under patent?*


Erika Arner

Erika: It's always better for the inventor to file for the patent before disclosing the invention, of course. But if for some reason this isn't possible, under previous rules the inventor has one year during which to file for a patent, as long as they can prove they were the first to invent. This provides a certain level of "comfort" for disclosing, at least in the U.S. The rules for this will change when the final provisions of AIA go into effect. When an invention is disclosed publically, how it's disclosed can affect its patentability.

The rules will change in March 2013. Under the new regime, you are no longer protected under "first to invent." Instead, priority will be given to "first to file." This is a very important point for inventors, and it's critical to get the word out about this.


Bryan Geurts

Bryan: Let's look at a possible scenario. At an aerospace technical conference a NASA scientist gives a presentation on the difficulties associated with designing demisable components for satellites re-entering Earth's atmosphere. A scientist from another organization, who has been working on demisable components as well, is present. After the presentation, this scientist discusses the presentation with the NASA scientist, who mentions that a paper covering his invention will be published in two weeks. The non-NASA scientist calls his company's patent attorney and has her file a patent application on all his work to date on demisable components. She files the patent application one week after the NASA scientist's presentation, and one week after that the NASA scientist's paper is published. Subsequent to publication the NASA scientist files a patent application covering his work. Under the AIA, the NASA scientist's publication will not be used as prior art against his patent application. However, the non-NASA scientist's patent application will, to NASA's detriment. This result causes a major shift in thinking about protecting inventions.

Q. *Do you see this impacting an inventor's willingness to publish an article about a new invention?*

Bryan: I do. Instead of just filing a simple, generic provisional application, it will be more advantageous to go to the trouble of filing a full application with claims before disclosure. This really changes the strategy and tactics around disclosure and patenting.

Q. *What steps should organizations be taking to ensure their innovators understand this change?*

Erika: Many of our clients are spending considerable time on this, often taking a two-pronged approach. One step is to evaluate the organization's internal procedures, and make changes as necessary. The other step is education – brown bag lunches, newsletters, and other trainings to get the word out that changes are coming.

Inventors have come to rely on the grace period; so for them the changes taking effect in March will be a major shift. Many companies are educating their people well in advance.

Bryan: At NASA, this is a particular challenge. We've already spent a lot of effort educating people about patenting over many years. With this significant change on the way, it'll be even more critical that our innovators pay attention. This may be difficult among scientists who feel they've already been educated about patenting and disclosure; they now need to be re-educated about this.

Q. *How are NASA Centers approaching this challenge?*

Bryan: Each NASA Center has its own approach. At NASA Goddard, our scientists have historically been very focused on publishing articles, and not always giving equal priority to patenting. We're taking all steps possible – lunchtime talks, forums, newsletters -- to ensure our innovators understand how these changes will affect them. We want to be sure we're in front of this issue.

Q. *Curiosity and SAM have been the subjects of a great deal of popular press. Does this affect the patentability of the technologies developed for them?*

Bryan: That's an interesting question. It's not settled patent law, but typically we consider flying on a spacecraft to be a public disclosure. So before liftoff, we want to have all patents filed for any IP that will be carried aboard the mission. This is what we did with SAM. Most of the time we have the luxury of significant development lead time, perhaps five or ten years before the mission flies. Therefore the technology on board SAM has been around for at least five years, a sufficiently long enough period for us to file applications for inventions as appropriate.

Erika: For any type of large-scale project, IP protection considerations should be factored very early into the development process. This should be a core part of the schedule, well in advance of launch.

Bryan: Ideally, patent counsel is a hands-on part of each development project from the beginning, advising inventors to ensure all their IP is protected. For example, for the Next Generation Geodysey mission we're working on location systems, similar to terrestrial GPS but based on the Earth's position relative to the sun, moon, stars, and other celestial objects. We're already proactively considering how we should approach patenting of this new technology.

Q. *How can inventors balance the desire to publish with the need for IP protection?*

Bryan: This is a very fine line to walk. One way is to evaluate the technology early and select an overall strategy. For instance, is it a one-off, or can it be leveraged into applications beyond the one for which it was originally developed? The devil is in the details, and each case must be considered independently in light of the organization's over-arching goals.

Bear in mind, some technologies are candidates for patenting and licensing, and some are better suited to be made freely available for public use, such as Open Source software. It really depends on how the technology can be used; it's not always solely about the bottom line.

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

Networking and Outreach

63rd International Astronautical Congress

(OCTOBER 1 THROUGH 5, NAPLES, ITALY)

Representatives from several NASA Centers attended the 63rd annual meeting of the International Astronautical Congress (IAC), held in October in Naples, Italy. The IAC is organized by the International Astronautical Federation, the world's leading space advocacy body with more than 200 members on six continents.

Among the sessions at this year's conference was "Moon, Mars and Beyond: Analogues, Habitation and Spin-Offs," co-chaired by Nona Cheeks, Chief for NASA Goddard's Innovative Partnerships Program Office. The purpose of this session was to explore the design of habitats and habitable structures for analogue environments and extra-terrestrial planetary surfaces, including spin-offs for terrestrial applications. The session included two presentations delivered by the IPP:

- "Optimize Use of Space Research and Technology for Medical Devices" (IAC-12,E5,2,8,x16096) presented by Ms. Cheeks reviewed the many ways the IPP Office facilitates technology transfer at NASA Goddard. It then presented numerous examples of how NASA Goddard innovations have been adapted for use within the medical community.

- "Using Real Options to See the Effect on Social Needs of Space Visualization Tools" (IAC-12,E5,2,9,x15843) presented by Dr. Phyl Speser of IPP's commercialization partner Foresight Science & Technology. According to Dr. Speser, the contribution of space technology to the economy is seriously underestimated because we only look at one dimension of a technology's value: its ability to generate revenues. In the commercial sector, patents and other IP is more than just a right to make a specific technology. As an asset, it has other uses – both as an enabler of future products and as a trading chip to protect potentially totally unrelated products. These uses affect the future value of the company, which is captured in its stock price. Just as real options help us better estimate the net discounted value of the revenues, stock options let us calculate contribution to the on-going concern value of the company. This value is, of course, less liquid because you have to sell stock or stock options to obtain it, but it is something you can take to the bank. By targeting potential licensees whose stock value is likely to be greater if they obtain the technology, we increase the likelihood of licensing.

Ms. Cheeks also co-chaired the session "Space Technologies - Earth Applications." This session presented examples of technologies developed to support space programs that have (or offer the potential to) transform and shape future society. This session also featured presentations from Ms. Cheeks and Dr. Speser:

• "Vetting Space Based Technology Societal Impacts" (IAC-12, E5,1,12,x15639) presented by Ms. Cheeks reviewed the technology transfer process implemented at NASA Goddard. This includes identifying the new innovation, evaluating possible applications for it, and promoting awareness of it throughout industry and the public. The presentation also highlighted the many ways in which NASA technologies can provide important benefits to society.

• "Lessons from the Technology Transfer in the Academic Sector" (IAC-12,E5,1,1,x15641) presented by Dr. Speser. This presentation explained how technology transfer is like "the nucleus in the atom of commercialization in the molecule of knowledge dissemination." Therefore doing technology transfer is much more than merely licensing, an awareness NASA Goddard has been acting on for years. Dr. Speser explored how offices like the IPP can be more entrepreneurial. An example is NASA Goddard's role in catalyzing a multinational space agency initiative in space technology applied to telemedicine.

4th Annual Donna Edwards College and Career Fair

(OCTOBER 13, 2013, LANDOVER, MD)

NASA Goddard IPP Office staff members hosted a display at the 4th Annual Donna Edwards College and Career Fair at the Prince George's Sports Complex in Landover, Maryland. The career fair allows middle- and high-school students to plan and gather information for their educational and professional future. Representatives from colleges, universities, training centers, and various government agencies were on hand offering resources in financial aid and education opportunities. The IPP demonstrated NASA'S Home and City website, which informs the public of technologies that were originally developed for NASA space science missions and are now being used in homes and businesses for other purposes. The IPP also spoke with attendees about Spinoff technologies and the NASA OPTIMUS PRIME Spinoff Video Contest. This video contest is open to students in grades 3 through 12; winners receive a scholarship donated from the American Society of Mechanical Engineers as well as the

Innovative Partnerships Program Office Senior Technology Manager, Ted Mecum, talks with a visitor about NASA technologies that are used in our everyday lives.

—PHOTO BY NASA

opportunity to meet NASA astronauts and Peter Cullen, the voice of OPTIMUS PRIME. IPP staff also distributed Spinoff Brochures, NASA Home and City Cards, NASA Home and City Posters, and the IPP *2011 Accomplishments Report.*

2012 USPTO National Trademark Expo

(OCTOBER 19-20, 2012, ALEXANDRIA, VA)

IPP Office staff member Trina Cox talks with attendees at the 2012 USPTO National Trademark Expo..

—PHOTO BY NASA

The IPP Office participated in 2012 United States Patent and Trademark Organization (USPTO) National Trademark Expo in Alexandria, VA. This two-day event helps educate the public about trademarks and their importance in the global marketplace by showcasing federally registered trademarks through educational exhibits and themed displays. IPP staff members were on hand to talk with attendees and promote the NASA OPTIMUS PRIME Spinoff Contest for students.

Phil Auerswald, Professor of Entrepreneurship and Innovation at George Mason University, interviews Lorry Lokey at the 20th Annual New Technology Reporting Program

—PHOTO BY NASA

Innovation 2 Commercialization: Making Tech Transfer Count

(NOVEMBER 2, ROCKVILLE, MD)

The IPP Office participated in the Innovation 2 Commercialization: Making Tech Transfer Count conference held at the Universities at Shady Grove and hosted by the Montgomery County Department of Economic Development. The conference featured exhibits from federal and academic tech transfer offices, business resources, educational programs, and funding resources; and offered panels on Innovation, Commercialization, and Financing. The IPP Office spoke with attendees about partnerships, licensing opportunities, and technology transfer.

20th Annual New Technology Reporting Program

(NOVEMBER 8, 2012, NATIONAL AGRICULTURAL LIBRARY, BELTSVILLE, MD)

The IPP Office held its 20th Annual New Technology Reporting Program on November 8, 2012 at the National Agricultural Library, located in Beltsville, MD. This annual program recognizes leadership in technology development and the support of outreach to industry for commercial applications of NASA Goddard technology.

This year's program featured guest speaker Lorry Lokey, founder of the global press release company Business Wire. Mr. Lokey spoke on innovation and best business practices for managing science and technology.

NASA Goddard management was on hand to present patent awards to innovators. The 2012 James Kerley Award was presented to Dr. Bruce Dean, Dr. Matthew Bolcar, Dr. Ron Shiri, Dr. Timo Saha, J. Scott Smith, Dr. David Aronstein, and Rick Lyon for their work in Wavefront Sensing. The James Kerley Award recognizes the individual(s) who best exemplify leadership in technology transfer activities over the past year.

Wavefront Sensing team receives the 2012 James Kerley Award. Left to right: Bill Oegerle, Christyl Johnson, David Aronstein, Matt Bolcar, Ron Shiri, Rick Lyon, and Juan Roman.

—PHOTO BY NASA

NASA Technology Days Showcase

(NOVEMBER 28-30, 2012, CLEVELAND, OH)

IPP Office staff members Darryl Mitchell, Enidia Santiago-Arce, and Brady Spenrath attended the 2012 NASA Technology Days Showcase held in Cleveland, OH. This three-day event connects industry representatives from the aerospace, automotive, innovative manufacturing, advanced energy, and human health fields with NASA centers from across the country.

Bert Pasquale talks with an attendee at the 2012 NASA Technology Days Showcase held November 28th – 30th in Cleveland, Ohio.

—PHOTO BY NASA

Noche de Ciencias at USPTO

(DECEMBER 13, 2012, USPTO, ALEXANDRIA, VA)

On December 13 the Society of Hispanic Professional Engineers (SHPE) hosted Noche de Ciencias (Science Night) at the US Patent and Trademark Office in Alexandria, VA. The event was targeted towards all local students interested in college studies or a career in science, engineering, or technology. Several engineering firms and local universities, the Department of Energy, and the IPP Office hosted booths at the event. Students talked about college experiences and gathered information on pursuing careers in science or technology fields. IPP Technology Manager Enidia Santiago-Arce met with several students for in-depth discussions. Other staff members promoted the NASA OPTIMUS PRIME Spinoff Contest for students.

David Martin poses with a model of Curiosity.

—PHOTO BY NASA

In the News

Freshly drilled hole in 'John Klein' rock on Mars.

—PHOTO BY NASA

The following is a brief review of a few recent news stories prominently featuring NASA Goddard accomplishments and technologies.

Curiosity and the Sample Analysis at Mars (SAM) continues to make discoveries

As this issue of *Tech Transfer News* goes to press, the Curiosity lander on Mars continues to be the dominant story in science and technology. For example, Curiosity recently used a drill carried at the end of its robotic arm to bore into a Martian rock named "John Klein" to collect a sample from its interior – the first time any robot has drilled into a rock to collect a sample on Mars.

The hole was drilled into a patch of fine-grained sedimentary bedrock believed to hold evidence about long-gone wetter Martian environments. Curiosity will use its SAM suite of instruments to analyze the rock powder collected by the drill.

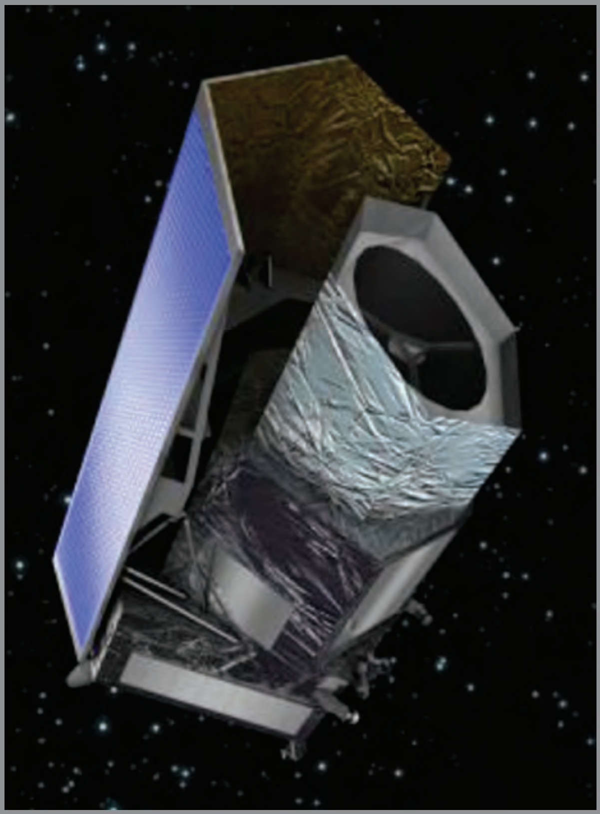
For all the latest news involving Curiosity and SAM, see http://www.nasa.gov/mission_pages/msl/index.htm.

NASA Goddard selected for Euclid dark energy mission

A team from NASA Goddard has been chosen to participate in the European Space Agency's Euclid mission. Euclid, currently scheduled to launch in 2020, is a space telescope designed to explore the universe for signs of dark energy and dark matter.

Alexander Kashlinsky, an astrophysicist with Science Systems and Applications, Inc., will lead the NASA Goddard group. The team will use Euclid imaging data to explore the cosmic infrared background (CIB), the collective light emitted throughout cosmic history by all sources, including those that cannot be detected directly.

Read the complete article here: http://phys.org/news/2013-02-nasa-goddard-team-dark-energy.html.



Artist's Rendition of Euclid Telescope.

—PHOTO BY NASA

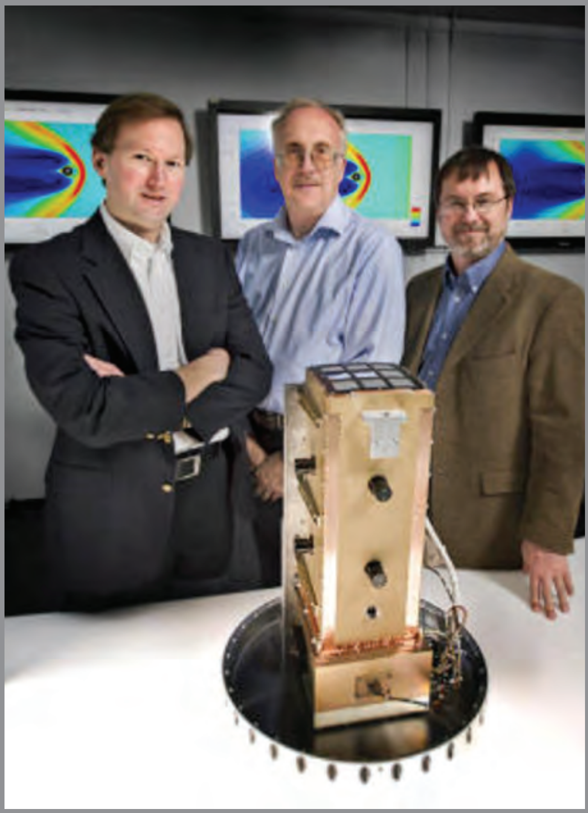
NASA Goddard builds first-ever wide-field X-ray imager

NASA Goddard scientists have developed the first wide-field-of-view soft X-ray camera for studying the phenomenon of "charge exchange," which occurs when solar wind collides with Earth's exosphere and neutral gas in interplanetary space. This camera is the result of collaboration between NASA Goddard's Heliophysics, Astrophysics, and Planetary Science divisions. The instrument incorporates a novel X-ray focusing technology called "lobster-eye optics."

The wide-field-of-view camera has imaged processes near Earth's magnetosphere, which until now has not been possible. These processes could be important in determining space weather in and around Earth, and may also affect other planetary bodies.

This project represents "a wonderful example of cooperation across divisions to better understand a process that is of interest to us all, but for different reasons," says Michael Collier, a planetary scientist who collaborated with astrophysicist Scott Porter and heliophysicist David Sibeck. "Charge exchange is one of the few phenomena that brings together scientists from three of the science divisions at Goddard," adds Dr. Porter.

For more information, see http://www.sciencedaily.com/releases/2013/02/130207131715.htm.



NASA Goddard scientists Michael Collier, David Sibeck, and Scott Porter with the wide-field X-ray camera.

—PHOTO BY NASA

Technology Disclosures

Disclosures

- **ADVANCED SPACECRAFT INTEGRATION & SYSTEM TEST SOFTWARE (ASIST) VERSION 20.0**

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

- **SPACECRAFT PARAMETER DATABASE TOOL**

  Lawrence Alexander

- **IMPROVED SYMBOL TIMING ESTIMATION DESIGN FOR A DISTORTED POISSON COMMUNICATIONS CHANNEL**

  Wai Fong, Wing-Tsz Lee

- **USING PARAFFIN WITH -10C TO 10C MELTING POINT FOR PAYLOAD THERMAL ENERGY STORAGE IN SPACEX DRAGON TRUNK**

  Michael Choi

- **USING BLACK POLYIMIDE/KEVLAR AS METERING STRUCTURE MLI INNER COVER FOR MINIMIZING STRAYLIGHT AND PROVIDING MICROMETEOROID PROTECTION**

  Michael Choi

- **SOFTWARE PACKAGE VERSION 1.3 FOR THE CAMERAS FOR ALL-SKY METEOR SURVEILLANCE (CAMS)**

  Peter Gural, Petrus Jenniskens

- **ARC:A LOW COST AND SCALEABLE ARCHIVE STORAGE MANAGEMENT SYSTEM**

  Robert Mason

- **ATMS ANTENNA BEAM ANALYSIS SOFTWARE**

  Kenneth Hersey

- **FITNESS (FREQUENCY INITIATED TECHNIQUE FOR A NOVEL EXERCISE STABILITY SYSTEM)**

  Steven Curtis

- **SYMMETRIC ABSORBER-COUPLED MICROWAVE KINETIC INDUCTANCE DETECTOR DESIGN - 12 IRAD**

  Kongpop U-yen, Edward Wollack, Ari Brown, Thomas Stevenson, Amil Patel

- **RIDGE WAVEGUIDE STRUCTURES IN MAGNESIUM-DOPED LITHIUM NIOBATE - STTR PHASE II**

  Justin Hawthorne, Gregg Switzer, Philip Battle, Phil Himmer

- **STACKED CAPACITOR SPECIAL LEAD ADAPTER**

  Stuart Kai

- **METHOD OF CONTROLLING A LARGE NUMBER OF THERMOELECTRIC COOLERS THAT MINIMIZE HEAT REJECTION SYSTEM SIZE FOR COOLING DETECTORS**

  Michael Choi

- **RAPID OPTICAL CHARACTERIZATION SUITE FOR IN SITU TARGET ANALYSIS OF ROCK SURFACES (ROCSTAR)**

  Pamela Conrad, Barbara Zukowski, Peter Morey

- **MISSION OPERATIONS CENTER - PRECIPITATION PROCESSING SYSTEM (MOC-PPS) INTERFACE SOFTWARE SYSTEM (MPISS) VERSION 3**

  Jeffrey Ferrara, William Calk, Tina Tsui

- **SSSHIFT - SYNTHETIC SKELETAL-MUSCULAR SYSTEM HIERARCHICALLY IMPLEMENTED FLEXIBLE TOPOLOGY**

  Steven Curtis

- **WALLOPS FLIGHT FACILITY 6U ADVANCED CUBESAT EJECTOR (ACE)**

  Luis Santos, John Hudeck

- **LEARNS (LOGIC EXPANSION FOR AUTONOMOUSLY RECONFIGURABLE NEURAL SYSTEMS)**

  Steven Curtis

- **SINAPSE (STRUCTURE OF INTERFACE FOR NEURAL ARCHITECTURES PSYCHOLOGICALLY STABLE EVOLUTION)**

  Steven Curtis

- **THE REMOVAL OF MID-SPATIAL FREQUENCY (MSF) ERRORS USING STRESS-POLISHING**

  Peter Hill

- **GEO-CORRECTION FOR AIRBORNE PLATFORMS (GCAP) 1.0**

  Vuong Ly, Timothy Creech, Joshua Bronston

- **AN INNOVATIVE DESIGN TO MINIMIZE SIZE OF HEAT REJECTION SYSTEMS THAT USE THERMOELECTRIC COOLERS TO COOL DETECTORS IN SPACE**

  Michael Choi

Patents Issued

- **MIRRORLET ARRAY FOR INTEGRAL FIELD SPECTROMETERS (IFS)**

  Qian Gong, Philip Chamberlin, David Content, Jeffrey Kruk

- **A NON-INTRUSIVE METHOD OF RESOLVE THE THERMAL-DOME-EFFECT OF PYRANOMETERS**

  Si-Chee Tsay, Qiang Ji

Provisional Patents Filed

- **SAMPLING THEOREM IN TERMS OF THE BANDWIDTH AND SAMPLING INTERVAL**

  Bruce Dean

- **EXPANDABLE RECONFIGURABLE INSTRUMENT NODE - WEB SENSOR STRAND DEMONSTRATION**

  Lawrence Hilliard, Manohar Deshpande

Patent Applications Filed

- **FINE CONTROL AND MAINTENANCE ALGORITHM FOR VISIBLE NULLING CORONAGRAPHY**

  Richard Lyon, Matthew Bolcar, Mark Clampin

The 'Sky Crane' lowers Curiosity towards the Martian surface.

—PHOTO BY NASA

▶ *Curiosity on Mars.* —PHOTO BY NASA

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

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