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Taking Hubble to its Scientific Pinnacle with SM4

The Great Day Arrives

On May 10, one day before the planned launch of Space Shuttle *Atlantis* and the start of the long-awaited Servicing Mission 4 (SM4), I gave the GSFC Hubble Program pitch to the Wide-Field Camera 3 (WFC3) Science Oversight Committee (SOC), gathered in Florida as many of us were for the historic event. I recall telling the SOC that "I was certain" the launch would occur with no more slips, and hence that in only four days' time we would have a brand new state-of-the-art camera—WFC3—on the telescope, its functional test successfully completed. The happy prediction was that WFC3 would soon be embarking on its voyage of discovery, taking us into new realms of the Universe not reachable even with the previous superb cameras on HST. Unless, I said jokingly, the EVA astronauts of Servicing Mission 1 (SM1, in

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Message from the Director Of

Greetings:

WOW! I think that best summarizes what has happened in FPD since my last Message in The Critical Path. The final visit to HST, the 4th Servicing Mission – a resounding success! The Lunar Reconnaissance Orbiter (LRO) launch – ditto! The GOES-O launch – ditto ditto! These successes will be hard to overcome before the next issue, but we will certainly try. The Directorate work force and all of our partners should be proud of their efforts in all these endeavors as well as countless others in the making.

Every last objective of the HST 4th Servicing Mission was accomplished by the crew of STS-125. Before the mission, some said it couldn't be done, that there were just too many tasks to possibly be accomplished in 5 EVAs. The success is a tribute to the hard work of the entire extended Hubble team. What a way to culminate 20 years of dedication. Following HST SM4, LRO was successfully launched, entered lunar orbit without a hitch, and the team has flawlessly executed the commissioning phase of the mission with nary an issue. Commissioning will conclude within the next month and the LRO orbit will be lowered to the science altitude. Congratulations to the entire LRO team. Likewise, GOES-O was successfully launched, reached GEO orbit exactly as planned, and is now GOES-14. The combined Boeing, NASA, and NOAA team completed early checkout and GOES-14 was handed over to NASA to complete commissioning. Congratulations to the entire GOES-O (14) team! With the launch of GOES-O, we had 6 successful launches within one year. Amazing!

More at the beginning of their journey to launch are the TDRS-K/L and MMS projects that were confirmed into Phase C since my last Message. Congratulations to those teams, also.

And newest of all, GSFC's Gravity and Extreme Magnetism Small Explorer (GEMS) proposal was selected by the Science Mission Directorate (SMD) under the Small Explorer (SMEX) Announcement of Opportunity (AO). Congratulations to GEMS PI Jean Swank (Code 662) and GEMS PM Sandra Cauffman (Code 400).

During this same time period, the Senate confirmed without objection the President's nominees for NASA Administrator and Deputy Administrator: Charles Bolden and Lori Garver. I wish both these former NASA individuals much good luck in the years ahead.

Further, FPD programs and projects supported and enjoyed another great Celebrate Goddard Day. These events serve to really help us appreciate the great organization that we work in and the wonderful people we work with. Our Diversity and appreciation of it, is unparalleled in government and industry. To that end, a new workshop series for supervisors and group leaders began in May, Power and Privilege – Race. I don't think I've experienced a more enlightening and meaningful training event than this. It came about as a result of the dedication of the GSFC Diversity Council.

The remainder of this calendar year will see the GPM project confirmed into Phase C and the SDO Project launched (currently scheduled for December 4, 2009). In addition, we just completed the FPD Peer Awards selections. The winners will be announced during the Peer Awards Ceremony at the Rec Center on September 24. Please remember to buy your tickets!

I hope everyone is having a wonderful summer and taking whatever opportunities available to rest, relax, and enjoy family and friends.

Until next time,

George

PERSONALITY TINTYPE

Jean Grady

Jean is the Project Manager for the International X-ray Observatory (IXO) in Code 445. IXO is a high throughput, facility-class X-ray observatory, which is in technology development and under study in collaboration between NASA, the European Space Agency (ESA), and the Japanese Aerospace Exploration Agency (JAXA).

Born: Washington, D.C

Education: BS Aerospace Engineering University of Maryland

Life at Goddard: Jean started working at GSFC as a co-op student in the Mechanical Engineering Branch in 1977. She has enjoyed many interesting and unique opportunities at GSFC, such as learning to weld while building a prototype for the COBE primary structure (when it was still slated for a shuttle launch) and scuba diving with the astronauts in preparation for the Solar Maximum Repair Mission. Jean managed the development of Space Telescope Imaging Spectrograph, which operated well over its design life and was repaired on the most recent HST servicing mission.

She managed the formulation and technology development efforts for Constellation-X (Con-X). Last year, Con-X merged with the ESA/JAXA mission XEUS to form a new mission, IXO. Jean notes,

(Grady Tintype Continued on page 29)

Howard Ottenstein

Howard is Editor of The Critical Path since its inception in 1993 and Facilitator of the PMDE program since its beginning in 1989.

Born: Brooklyn, NY

Education: BA Brooklyn College, MA New York University

Life Before Goddard: After receiving his degree (English/History) from Brooklyn College in 1951, Howard grew bored with working on a Master's Degree and served in the Marine Corps during the Korean War. That service probably helped him get a job as a copy boy on the (now defunct) New York Mirror which had a number of former marines on its editorial staff. He simultaneously completed most of his MA requirements and was awarded a graduate assistantship at the University of New Mexico, which he turned down to work for relatives in real estate in California. Fired 9 months later as being overly efficient, Howard went to work for the old Douglas Aircraft Company in Santa Monica, CA. which was beefing up to start their missile business (Nike, Thor). There followed stints at Lycoming (Connecticut), ITT International Electronics Corp (New Jersey), Martin Company (lost the Apollo program to North American), and RCA Astro-Electronics Division (whole division laid off after one year, concurrent with the birth of first child). Those were the days!

Life at Goddard: Howard then called Joe Dunst who had offered him a position before

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Goddard-Led GEMS Mission to Explore the Polarized Universe

An exciting new astrophysics mission led by Goddard will provide a revolutionary window into the universe. Named the Gravity and Extreme Magnetism Small Explorer (GEMS), the satellite will be the first to systematically measure the polarization of cosmic X-ray sources.

"To date, astronomers have measured X-ray polarization from only a single object outside the solar system -- the famous Crab Nebula, the luminous cloud that marks the site of an exploded star," said Jean Swank, a Goddard astrophysicist and the GEMS principal investigator. “We expect that GEMS will detect dozens of sources and really open up this new frontier."

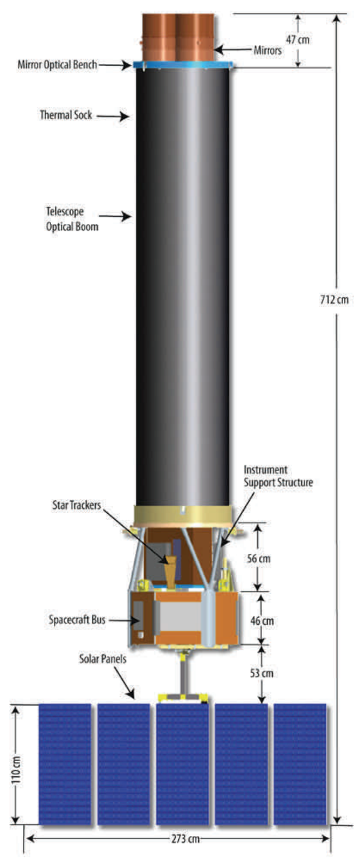
Goddard will provide the X-ray mirrors and polarimeter instrument for GEMS and oversee the mission's science operations center, science data processing and systems engineering.

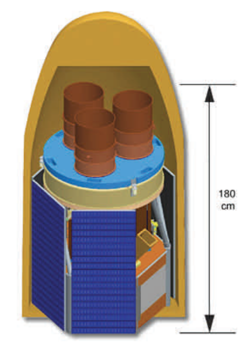
Electromagnetic radiation -- light, radio waves, X-rays -- contains a varying electric field. Polarization refers to this field's direction. An everyday example of putting polarization to use is as close as a pair of sunglasses. Reflected light contains an electric field with a specific orientation. Because polarized sunglasses block light vibrating in this direction, they can reduce the glare of reflected sunlight.

The extreme gravitational field near a spinning black hole not only bends the paths of X-rays, it also alters the directions of their electric fields. Polarization measurements can reveal the presence of a black hole and provide astronomers with information on its spin. Fast-moving electrons emit polarized X-rays as they spiral through intense magnetic fields, providing GEMS with the means to explore another aspect of extreme environments.

"Thanks to these effects, GEMS can probe spatial scales far smaller than any telescope can possibly image," Swank said. Polarized X-rays carry information about the structure of cosmic sources that isn't available in any other way.

GEMS
Gravity and Extreme Magnetism SMEX





GEMS, shown here in its stowed configuration, is designed to fit within a Pegasus XL class launch vehicle.

"GEMS will be about 100 times more sensitive to polarization than any previous X-ray observatory, so we're anticipating many new discoveries," said Sandra Cauffman, GEMS Project Manager and the Assistant Director for Flight Projects at Goddard.

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Some of the fundamental questions scientists hope GEMS will answer include: Where is the energy released near black holes? Where do the X-ray emissions from pulsars and neutron stars originate? What is the structure of the magnetic fields in supernova remnants?

What makes GEMS possible are innovative detectors that efficiently measure X-ray polarization. Using three telescopes, GEMS will detect X-rays with energies between 2,000 and 10,000 electron volts. (For comparison, visible light has energies between 2 and 3 electron volts.) The telescope optics will be based on thin-foil X-ray mirrors developed at Goddard and already proven in the joint Japan/U.S. Suzaku orbital observatory.

NASA announced June 19 that GEMS was selected for development as part of the agency's Small Explorer (SMEX) series of cost-efficient and highly productive space-science satellites. GEMS will launch no earlier than 2014 on a mission lasting up to two years. GEMS costs are capped at $105 million, excluding launch vehicle.

Corporate and academic partners are responsible for other aspects of the mission.

Orbital Sciences Corporation in Dulles, Virginia, will provide the spacecraft bus and mission operations. ATK Space in Goleta, California, will build a 4-meter deployable boom that will place the X-ray mirrors at the proper distance from the detectors once GEMS reaches orbit. NASA's Ames Research Center in Moffett Field, California, will partner in the science, provide science data processing software and assist in tracking the spacecraft's development.

The University of Iowa will assist with instrument calibration, and students there will develop an experiment that could become part of the mission. Other GEMS collaborators include the Massachusetts Institute of Technology, Cambridge, Massachusetts.; Johns Hopkins University, Baltimore, Maryland.; Cornell University, Ithaca, New York.; Rice University, Houston, Texas; North Carolina State University, Raleigh, North Carolina; Washington University, St. Louis, Missouri.; and the University of Oulu in Finland.

Francis Reddy (Code 660)
Science Writer

Big Change

For years various polls indicating citizen and college graduate interest in careers in the Federal service were consistently near the bottom of various lists of professions, business, and academic areas of work. However, a recent George Washington University poll showed that by an overwhelming margin, (would you believe?) 79 percent of Americans said that they would encourage “a young person who was considering going to work as a Federal civilian employee.” Barely 15% discouraged that career path. It shouldn’t take a recession to encourage Americans to seek a career in Federal service especially at NASA. Incidentally, NASA ranks third in an annual survey of Federal employees as the best organization to work for in the Federal service.

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December 1993) had welded the Wide-Field Planetary Camera 2 (WFPC2)—the instrument WFC3 was going to replace—into the telescope when no one was looking. Smiles and chuckles all around: everyone was looking forward to tomorrow.

There were no slips. The candles were lit at 2:01 p.m. EDT on May 11, and *Atlantis* with its brave and extraordinary crew of seven lifted into the sunny sky. What a moment that was, not only for the crew but for the legions of people who had worked tirelessly to build, test and deliver the new Hubble hardware to the launch pad; worked with the crew on the intricacies of the hardware and the extraordinary importance of efficient EVA task choreography; developed detailed mission timelines and mountains of contingency procedures (which we hoped we wouldn't need); gone through seemingly countless mission simulations with our JSC colleagues; and in the end done all they could to make this uniquely challenging mission and the next 5(+) years of Hubble science a resounding success.

Atlantis on May 10, the night before lift-off

Atlantis's two-day race to catch up with, then capture, Hubble was on.

The Run-up to SM4

The wait for SM4 had been a long one, and Hubble Space Telescope was certainly ready for servicing, on both the scientific and engineering sides of the ledger. The extraordinarily demanding SM3B had occurred in March of 2002, and the 7+ years that had elapsed since that last servicing call to HST was more than double the previous maximum interval between servicing missions. The original servicing plan for Hubble had not called for intervals this long, and it showed. Yes, HST was still doing peer-reviewed, world-class science not doable with any other facility, but it was accomplishing that solely on the back of one extraordinary instrument—one that, at fifteen and a half years of age, certainly owed us nothing. The instrument was WFPC2, the vintage machine from SM1 that had been responsible for so many of Hubble's iconic images. How had our set of scientific tools gotten so thin prior to SM4?

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Space Shuttle *Atlantis* lifts off and SM4 is underway!

It was really pretty simple: time is the enemy, and builders of science instruments and other space hardware know it. To increase longevity, specifically to meet the requirement for at least 5 years of science production (per instrument) and maintain a broad mix of scientific capabilities, Hubble instruments are designed and built to be electrically redundant. When "Side 1" fails, you go to "Side 2." But at some point an instrument may cease working and the alternatives—for Hubble at least—are: replace, leave alone, or attempt repair during the next SM.

SM4 was always going to replace WFPC2—whatever its state—with the immensely more powerful WFC3, and to replace that magical, but long unneeded box of corrector mirrors from SM1, "COSTAR," with the Cosmic Origins Spectrograph (COS), the most sensitive ultraviolet spectrograph to ever fly on Hubble (or indeed any other space platform). Two new scientific instruments flying up to Hubble in one servicing mission was something for astronomers to cheer themselves hoarse about, having been done only once before (SM2, 1997). But at 7+ years downstream from SM3B, and 12+ from SM2, the Advanced Camera for Surveys (ACS, installed on SM3B) and the Space Telescope Imaging Spectrograph (STIS, SM2) had both completed their journey down the Side 1/Side 2 failure path (in January 2007 and August 2004, respectively). Although a portion of ACS was still working, it was the part least in demand scientifically, and it was not incorrect to view HST as the "WFPC2 Observatory" in the months leading up to SM4. A post-SM4 "COS-WFC3 Observatory" would be capable of taking HST into uncharted waters of exploration and be enormously productive and exciting—fully worth the scientific price of admission—but it was clear that ACS and STIS still had much more to give …. if only they could be repaired.

On the engineering side, things were somewhat better, but not by much. Hubble's six nickel-hydrogen batteries were the original 1990-vintage articles. That they still held enough charge to enable HST to function and survey the skies during orbit night was considered an engineering miracle, but it was unthinkable to trust the scientific promise of WFC3 and COS over the next 5+ years to batteries 19 years old. They had to be replaced. Gyros: the heart of HST's matchless pointing control system, and again the number six comes up. Hubble has six gyros, and all were installed during SM3A in late-1999. Prior to SM4 the telescope was down to three functioning units, all of which were on the steep portion of their failure probability distributions. Although the GSFC HST Program and the Space Telescope Science Institute (STScI) had ingeniously devised two- and even one-gyro guiding modes, and although HST had actually been using the two-gyro mode

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for nearly four years prior to SM4 with no meaningful loss in scientific performance, at some point the gyros were going to hurt us. No question, we needed to replace them all.

The other major components of Hubble's pointing system are the three Fine Guidance Sensors (FGS). At any moment in time, a fourth FGS exists on the ground that can be refurbished and flown to replace the weakest on-orbit FGS during the next SM, and this had happened in SM2 and SM3A. The plan for SM4 was to fly the ground spare—fully refurbished and good as new—and replace the degrading FGS2 (installed during SM3A).

As a result of the slow, long-term degradation of thermal insulating blankets on Hubble's exterior, as well as the increased heat dissipation of some powered hardware, two of Hubble's equipment "bays" were projected to run hotter after SM4 than the telescope's operations could easily handle. Unless, that is, new blanketing material could be attached by astronauts to the exterior surfaces of the affected bays and thereby cool them. A third bay, while not in as severe a situation as the other two, would also benefit from new insulation if there were time to install it (the official EVA timeline said there was not). So in addition to new batteries, gyros, and an FGS, three New Outer Blanket Layers (NOBLs) were on the engineering side of the mission manifest.

Finally, but far from least, was the Science Instrument Command and Data Handling (SI C&DH) unit. SI C&DH was not in the mix until late-September 2008, when one of two Control Unit/Science Data Formatters (CU/SDF) inside SI C&DH failed two weeks prior to the (then) planned October 14, 2008 launch of SM4. This unit had worked for the entire 18.5 years Hubble had been on orbit. The Program successfully made the switch from CU/SDF-A to CU/SDF-B (electronic sides of instruments are numbered; with general spacecraft hardware, letter designations are used), but that left the telescope's science program zero-fault tolerant, a situation Administrator Mike Griffin considered unacceptable, as did the HST Program. SI C&DH routes commands and data to/from the science instruments, and without it the telescope is safe but there is no science program (a minor exception at the 1% level is provided by FGS astrometric science data, which are not routed from the SI C&DH). The problem—and a severe one it was—was that the on-orbit SI C&DH had to be replaced with a ground "spare" whose fourteen individual boxes and components were not all integrated onto the SI C&DH "tray." Moreover, although the spare had been delivered to the HST Project in 1992, due to lack of funds it had never been fully certified for flight. It was a very tall order indeed to assemble this hardware into a fully tested, flight-qualified unit in time for a May, 2009 launch.

It's all about the Science

To start: the new science instruments (SIs), COS and WFC3. To a new spectrograph (COS) add a new wide-field imager (WFC3), and you have a beautiful balance. Far from being clones of prior instruments, COS and WFC3 were designed to continue the tradition of previous new Hubble instruments by bringing either entirely new capabilities to the telescope,

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or very large improvements (defined as ≥ 10x) to critical existing ones. A hallmark of Hubble Space Telescope that people speak about with passion is that after each servicing mission, *it becomes in effect a new observatory*. SM4 was to be no different, and in fact we wanted and expected SM4 to be *the ultimate example* of a new, tremendously more powerful Hubble emerging from a servicing mission.

COS

By design, and by actual fact over the course of seven and a half years (1997-2004), STIS would be a brilliant spectrograph with unmatched wavelength coverage and overall versatility. It was hard to ask for anything more in a spectrograph, but that's exactly what COS Principal Investigator (PI) Jim Green of the University of Colorado/Boulder did in his team's response to the NASA/HST Announcement of Opportunity issued in November, 1996. One important area for which STIS was *not* optimally designed was absorption line spectroscopy of thin intergalactic gas in the unimaginably large spaces between galaxies both near and far. The importance of studying this gas (made up of baryons, the stuff of which we are made) is that it can tell us a great deal about the Dark Matter-dominated formation of structure in the universe—the so-called "cosmic web" of Dark Matter and baryons—and just as importantly, about galaxy formation and the feedback processes that exist between them and the intergalactic medium (IGM). Although STIS had made important initial strides by taking spectra along sightlines to distant quasars and looking for telltale intergalactic absorption by the different elements comprising the clumpy intervening gas, the number of quasars bright enough for STIS was really not enough to satisfy the more demanding requirements of IGM research.

Cosmic Origins Spectrograph (COS) being readied for flight after being shipped from GSFC to KSC.

What was needed was a more ultraviolet-sensitive spectrograph than STIS—for all its versatility—was designed to be. And the required improvement in sensitivity was not modest or incremental: it needed to be as large as possible, in the ≥ 10x category, particularly in the far-UV (FUV) spectral region.

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Jim Green and his COS team did not try to “have it all” by duplicating STIS’s unique capabilities and then somehow giving a boost to FUV sensitivity. Had they done so they certainly would have failed in their quest for scarce UV photons. Instead, they assumed that STIS would continue to operate and designed a relatively simple spectrograph that could reach the faint and distant quasars by minimizing UV light losses inside the instrument, and by incorporating state-of-the-art detectors, particularly in the FUV. Every time UV light bounces off an optical surface inside an instrument (e.g., a mirror), a non-negligible amount of light is lost. If you have three, four, or more bounces prior to the light hitting a diffraction “grating (which disperses the light into its component colors on the way to the detector), you’ve lost a lot of light and the instrument’s sensitivity suffers greatly.

SM4 approaches and the COS Team is happy; PI Jim Green and Instrument Manager Hsiao Smith third and fifth from left, respectively. “Cepi” on far left..

The COS design is beautifully simple in the primary FUV channel and solves this problem directly: the first optical surface the light hits is one of the three FUV gratings, and it not only disperses the light but makes the correction to the telescope’s spherical aberration. One extremely productive bounce and the light enters the FUV cross delay-line detector—can’t get better than that. When all is said and done, COS’s FUV channel will have about 70 times the speed of STIS when observing the faintest quasars, and for the first time the cosmic web will be observable in a statistically significant way. COS much more than fulfills the informal $\geq$ 10x requirement for a new instrument, and it is a real greyhound: it was built for speed.

With three mirror reflections COS’s near-UV (NUV) channel is a bit more conventional, but it is still “faster” than STIS’s near-UV channel by a factor of about four. The NUV detector is a Multi-Anode Microchannel Array (MAMA) that came off the original MAMA production line created for STIS.

Here’s the bottom line for COS: whereas for the most challenging types of IGM science STIS was only able to measure IGM gas along a relative handful of quasar sightlines, COS will easily be able to reach hundreds of them, thereby providing a statistical framework to the study of the structure and physical conditions of the cosmic web, as well as the formative and feedback relationship it has had with galaxies over cosmic time. Some of those quasar sightlines will, in addition to probing IGM gas, intersect the extended halos of galaxies at different redshifts, allowing studies of the chemical composition of the halo gas, particularly as a function of cosmic time as the enrichment of heavy elements takes place through successive waves of star formation and death. COS will be suitable for many other areas of astrophysics, including planetary atmospheres inside and outside the solar system, supernovae and their production of the heavy elements, and the interstellar

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LRO At The Moon!

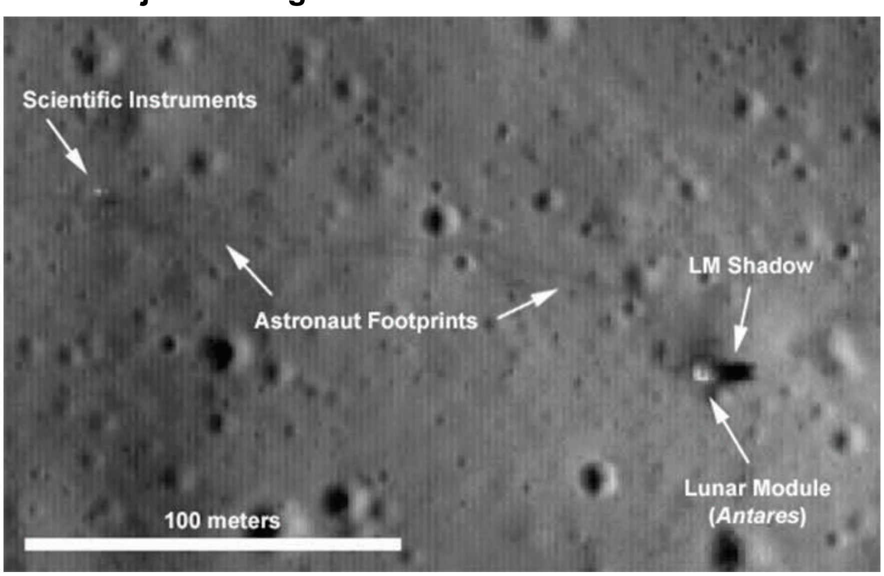
On June 18th, 2009 LRO rocketed into the Florida sky headed for lunar orbit. This was the culmination of over 4 years of hard work and perseverance by the LRO Team. With the launch of LRO, and her sister spacecraft LCROSS, the first flight mission of NASA's Exploration Program had begun. The Atlas V launch and subsequent trans-lunar injection were flawless as was LRO's own Lunar Orbit Insertion maneuver 5 days later. After a series of orbital maneuvers that established LRO's commissioning phase orbit the LRO Team began the 2 month commissioning phase of the mission.

Upon completion of commissioning at the end of August LRO will be maneuvered into the 50 km circular polar orbit from which the 1 year exploration mission will be conducted. Commissioning has unfolded on schedule and is now past the halfway point. In addition to the focus on calibrating the instruments during this period LRO is also performing observations to aid in the final impact target selections for the LCROSS mission. Along the way LRO's camera returned the first ever photographs of the Apollo landing sites in which the human artifacts are visible. The spacecraft (built here at Goddard), the seven instruments, and the Ground Systems are all performing nearly flawlessly and NASA is anticipating an extremely fruitful primary LRO mission followed by at least 2 years of an extended science mission after that.

Craig Tooley (Code 451)
LRO Project Manager

LRO (atop LCROSS) being encapsulated in the Atlas V fairing.

LRO launch on June 18, 2009



Apollo 14 site imaged by LRO

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Tracking and Data Relay Satellite (TDRS K/L) Project is OFF AND RUNNING

In July, the TDRS-K/L replenishment project (a.k.a. TDRS K/L Project) successfully completed Key Decision Point C (KDP-C) and now has approval from the Agency's Program Management Council to proceed with the implementation phase of their mission. The next major programmatic milestone is the system Critical Design Review (CDR), which is currently scheduled for late January 2010. Leading up to the system CDR, there are approximately 90 unit-level and subsystem-level CDRs that are occurring throughout the summer and fall of 2009. Needless to say, both the NASA and contractor teams are extremely busy during this non-recurring effort (NRE) phase of the project.

NASA's TDRS comprise the communication satellite component of the Tracking and Data Relay Satellite System (TDRSS) which provides tracking and data acquisition services between low Earth orbiting spacecraft and satellite control centers and data processing facilities. The system is capable of providing coverage to such user spacecraft for up to 100% of each orbit. The TDRSS space segment currently consists of nine TDRS located in geosynchronous orbits around the Earth. People around the world benefit from the environmental and science research data that moves through the TDRS satellites currently in orbit. In fact, there are a number of diverse customers (human space flight programs as well as science research missions) that use the TDRS satellites to enable mission success such as the Space Shuttle, International Space Station (ISS), Hubble Space Telescope (HST), Tropical Rain Measuring Mission (TRMM), X-ray Timing Explorer (XTE), Landsat, and Compton Gamma Ray Observatory (GRO), just to name several. Additionally, Expendable Launch Vehicles (ELVs) use TDRS support to help minimize the need for expensive airborne downrange tracking.

NASA GSFC has a long heritage of managing TDRS development efforts for well over two decades. The TDRS K/L development effort is managed by Code 454 which is part of the Exploration and Space Communication Projects Division, Code 450. The program office resides within the Space Communications and Navigation (SCaN) office at HQ. The overall effort managed by GSFC is a $1.4B project, including launch vehicles for K and L.

In December 2007, the TDRS K/L project awarded a prime contract to Boeing (El Segundo, California) to design, build, and integrate the TDRS K and L satellites (with options for two additional spacecraft – M&N), as well as provide ground asset updates at the NASA White Sands Complex (WSC) located near Las Cruces, New Mexico. It is at WSC where data is uplinked (forwarded) as well as downlinked (received) to/from the orbiting TDRS and then to/from the TDRS to various user spacecraft (i.e., HST, ISS, Shuttle, etc). Code 452, Space Networks (SN) Project is responsible for the day-to-day operations at the WSC. Both TDRS K and L will launch from Cape Canaveral Air Station, Florida aboard an Atlas V rocket. The TDRS K launch is scheduled for April 2012, and TDRS L is scheduled for February 2013.

Rich Ryan (Code 454)
DPM/R, TDRS Project

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medium, but it was designed primarily to attack the problem of the origin of large-scale structure and the nature of the cosmic web.

We can expect great things from COS, the fastest UV spectrograph Hubble has ever seen. COS was built at Ball Aerospace in Boulder, CO, and the very able GSFC Instrument Manager and Team leader was Hsiao Smith. Hsiao was also head of the HST Instrument Development Office. Nicely done!

WFC3

In 1997, as STIS was—or would be—to spectroscopy, so ACS would be to wide-field imaging. What more was possibly needed? ACS was to launch on SM3 in 1999, the next-to-last servicing mission. It was thought that manifesting COS on the final one, SM4, then scheduled for 2002, would provide the remaining science punch Hubble needed. Dave Leckrone—a career spectroscopist and HST's Senior Project Scientist—had another idea. Dave knew that diffraction-quality imaging over a wide-field was Hubble's signature product, and the data were there to back it up. The Eagle Nebula, the original Hubble Deep Field, the comet Shoemaker-Levy/9 impacts on Jupiter—these were WFPC2 imaging *tours de force* that had resonated deeply not only within the astronomical community, but with policymakers and the public. Moreover, on the long term the statistics of Hubble observing time had broken down into an approximate 2/3:1/3 relationship between imaging and spectroscopy. Imaging was dominant, and the number of important research papers coming out of WFPC2 was just phenomenal.

For all the wonders that everyone knew would come out of ACS and eclipse WFPC2, ACS needed, and the community would want, a back-up camera: the telescope simply could not be without wide-field imaging late in its life. How to achieve that? Leckrone knew that the original WF/PC (WFPC2's predecessor, returned to ground by SM1) had reusable parts of value, and that by utilizing them and going with the high-level "WFPC look," it would be possible to build a more modern version of WFPC2 on a fast track. If NASA Headquarters bought off on the idea of a wide-field "facility instrument," COS would have a scientific running mate on SM4 and HST would have an imaging insurance policy. As it turned out, an incredibly powerful one.

Long story short, after multiple reviews by independent panels, "WFC3" and the general concept that it derive from the WF/PC and WFPC2 architectures and replace WFPC2 during SM4, were approved. But what, exactly, would it be capable of?

It is the reality of new Hubble instruments that clones are not welcomed—they all must be capable of new and exciting things. As STIS was to the first-generation spectrographs GHRS and FOS (hugely more capable), ACS was to WFPC2, and COS was to STIS—at least in the area of UV sensitivity if not overall versatility. In the case of WFC3, given that time was tight and there was no PI or even a "pre-Phase A" design, executing a "build-to-print" WFPC2-like instrument but with better and fresh CCD detectors, could perhaps have been forgiven. After all, WFC3 was an insurance policy.

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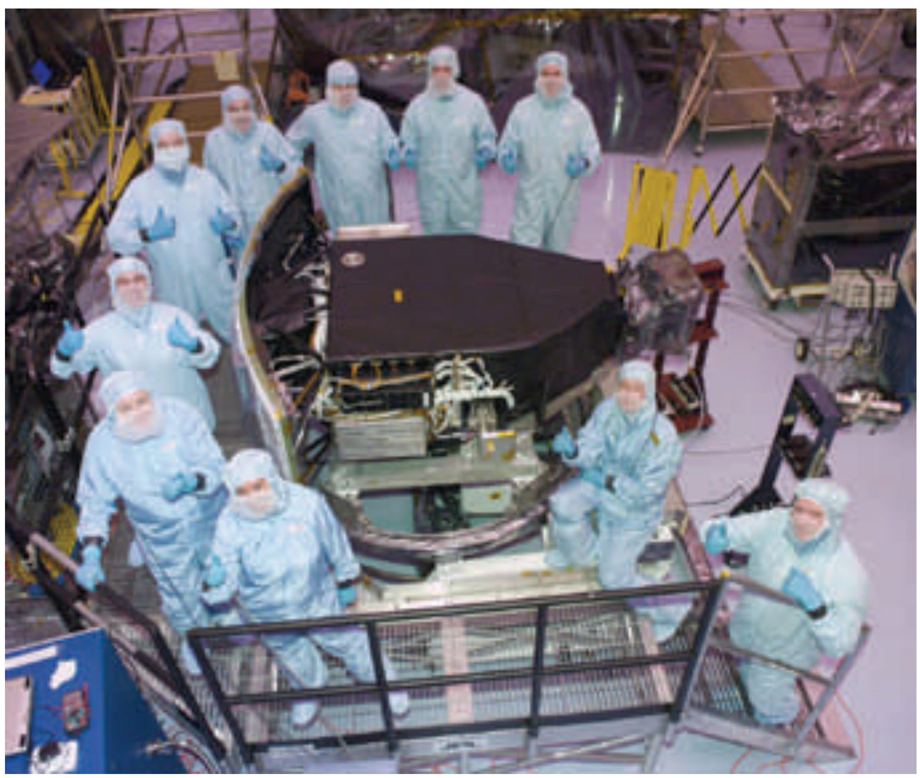
Not what happened. Vital as the visible-red region of the spectrum is—as perhaps best exemplified by the ACS's Hubble Ultra Deep Field of 2004, the wide-field ultraviolet (which ACS does not have) is also extremely important in many ways, such as enabling detailed measurements of the temperature, heavy-element composition ("metallicity"), and surface gravity of the individual stars in stellar systems close enough to be resolved and to require a wide field. The UV is also effective in probing advanced stellar evolution in these systems. In more distant galaxies where the light is not resolved but integrated, *the UV is the critical piece* in UV-Visible-Near-IR imaging for teasing out the history of star formation in the galaxy, offering vital clues to galaxy formation mechanisms. The UV and blue are also extremely valuable for observing the red-shifted extreme - and far-UV of distant galaxies and deriving their "photometric redshifts" at the epoch when universal star formation was peaking and galaxies were in their late stages of assembly.

To see galaxies in their earliest formative stages near the edge of the observable universe, i.e., *to go beyond the Hubble Ultra Deep Field*, is to observe them at longer wavelengths: in the near-IR and IR. As WFPC2 had earlier, ACS would and did give us unparalleled performance in the visible and deep red, but there was no near-IR coverage in ACS. Although NICMOS from SM2 did provide medium- and narrow-field near-IR imaging, to move forward and push deeper back in cosmic time with good statistics on the most remote galaxies, Hubble would need true wide-field coverage in the near-IR, and with substantially greater sensitivity than NICMOS possessed. It was important to continue to go fainter and farther with Hubble, both on the individual merits and to build a bridge to the James Webb Space Telescope.

Summed up, there were real needs in the wide-field UV and near-IR that had not been met on Hubble, and it was important that the "insurance policy" fill these gaps.

WFC3 evolved into a two-channel instrument that has continuous wavelength coverage from 2000A to 1.7 microns. It was the first time Hubble would have such wide-field "panchromatic" imaging, and it was under the roof of one camera. Covering the UV-Visible range would be a blue-optimized CCD, and a Mercury-



Jubilant Wide-Field Camera 3 (WFC3) Team with their instrument at KSC and SM4 beckoning; Instrument Manager Jackie Townsend in extreme left foreground

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Cadmium-Telluride detector would be the heart of the IR channel. Both would have to be superb detectors. Unique performance, especially in the UV and near-IR, and excellent (though not the equal of ACS) performance in the visible-red, would serve both purposes of bringing critical new capabilities to HST while backing up ACS in the area in which it was supreme.

As a facility instrument, there was no PI for WFC3. Its construction, largely by Ball Aerospace, was superbly led by GSFC's Jackie Townsend (Instrument Manager) and Randy Kimble (Instrument Scientist), and STScI's John MacKenty (Deputy Instrument Scientist). The already mentioned WFC3 SOC, which was assembled through a competitive process, provided a science conscience and advisory function not dissimilar to that of Jim Green's COS Instrument Definition Team. Kudos go to Ball for their fine work on WFC3—it was a long haul. From my perspective, special praise goes to the GSFC WFC3 Team led by Jackie and Randy, a team that included the staff of GSFC's superb Detector Characterization Laboratory (DCL); and to John's WFC3 Integrated Product Team (IPT) at STScI. All those folks worked tirelessly, and in the end, as built and as launched, WFC3 is a marvel. It brings "discovery efficiency" (field of view times sensitivity) gains over previous imagers of ~ 30x (on average) in the UV and ~ 25x in the near-IR. Stay tuned: the future should be fun with WFC3.

STIS Repair

The prospect for performing on-orbit surgery on a Hubble instrument and bringing it back to life occurred to a number of people soon after STIS failed on Side 2 in August, 2004. A Failure Review Board (FRB) analyzed the failure signature and was able to pinpoint the location of the fault with a high degree of certainty. Low Voltage Power Supply board #2 (LVPS2) contains a 5-volt power converter whose purpose is to drive STIS's mechanisms—the corrector mirrors, mode select mechanism, slit wheel, etc.—and because these were non-operational it was logical that this converter had failed. If astronauts could somehow get inside STIS and replace the entire LVPS2 board with a fresh one, the instrument would come back to life, at least on Side 2. The earlier Side 1 failure in 2001 was not as easily diagnosed and pinpointed, and repair of that electronic chain was not considered feasible.

There was just one little problem with Side 2 repair: access to LVPS2 was via a cover panel held down by 111 fasteners, and non-captive ones at that. How would astronauts deal with that situation? With EVA time so precious, would they have the time to remove, handle, and stash so many small fasteners with gloved hands even before the board removal and replacement was attempted? Everyone involved with the effort knew that this approach was not feasible.

In the end there might be a way, but was STIS even worth repairing in the first place? We had COS coming on board the telescope in SM4, and it was a spectrograph that we said was more powerful than STIS, at least in gobbling up UV photons. But what even a cursory inspection of COS and STIS showed is that the instruments complement each other beautifully. COS—lean, dedicated to the UV and designed for speed to enable programs STIS cannot accomplish, does

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not have a great many observing modes, whereas STIS has a wide variety of them spanning a much greater wavelength range (FUV through about 1.1 microns) and diffraction-limited long-slit spectroscopy in the bargain. It was a no-brainer to want to have them both available—the "full set" of spectroscopic tools. After all, STIS was the consummate hunter of supermassive black holes in the centers of galaxies, and the first measurer of exoplanetary atmospheres, to name just two of its notable achievements—its work was far from done.

Mike Massimino practicing on the
STIS Fastener Capture Plate (FCP) trainer

There was some early thinking that the "little problem" of dealing with the 111 cover fasteners might be addressable with an autonomous, robotic machine that astronauts would clamp down over the cover. The "robot" consisted of a power tool—a screwdriver basically—on a translating stage that would move to the known positions of the fastener heads. Actual fastener removal could take place when no astronauts were in the cargo bay on an EVA. The beauty of the GSFC Applied Engineering and Technology Division (AETD) version of the robot was that something called a "fastener capture plate" was on the bottom of the box—directly positioned over the access cover—and it solved the problem of removed, drifting fasteners in a clever way. The "FCP" created a capture chamber above every fastener by virtue of a clear cover on the top of the honeycombed (or pocketed) plate, with holes precisely registered above every fastener. The powered tool on the translation stage would go to the FCP entrance hole for each fastener, the screwdriver bit would be lowered into the hole, and the eventually backed-out fastener—whose head was smaller than the overhead FCP hole—would be captured in the FCP. Drifting fastener problem gone.

The machine was a very elegant, gee-whiz solution for STIS repair, but it was not needed. The FCP component *was needed*, but that did not need to be part of a robotic operation. I recommended to the Program that astronaut installation of just the FCP over the access panel was enough—once that was done astronauts could do the job of fastener removal manually with their hand-held mini-power tool (think screwdriver). All they had to do was insert the tool into each entrance opening of the FCP, go down to the fastener, back it out into its respective capture volume, then go on to the next fastener. Ought to be fast, and in the end it was. During Neutral Buoyancy Laboratory (NBL) training runs at JSC, this manual approach to STIS repair eventually resulted in all 111 fasteners being removed in about 30 minutes. So the robot gave way to conventional repair methods, and the FCP was the key.

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There were other extremely challenging aspects of STIS repair, among them removing the locked-in LVPS2 board and safely installing the replacement board. Analogous to the FCP, special tools were developed for these operations. We also performed thorough studies of space plasma and tribolelectric charging effects. With the STIS electronics cavity opened up to space and the replacement board being held “out in the wind” for a brief moment, the last thing we wanted was to incur electronic damage through charging, either of STIS’s innards or of the replacement LVPS2 board.

The STIS repair effort at GSFC was capably and indefatigably led by the STIS Repair Manager Tammy Faulkner, and it was a pleasure being a member of her team. Thank you, Tammy.

ACS Repair

At least the repair of STIS was a challenge that had the advantage of time—there would be four years to develop techniques and EVA strategies. ACS repair was another matter. ACS’s CCD channels—including the hugely important Wide-Field Channel (WFC) that had produced the iconic Hubble Ultra Deep Field in 2004—went down on Side 2 in January, 2007, leaving barely a year and a half to understand what went wrong, consider what options were available, pick the best one, and then design the repair techniques and build the hardware and the astronaut tools to get the job done. At that time SM4 was scheduled for an August, 2008 launch. Talk about a short runway! Like the SI C&DH effort, ACS repair was a rush job from start to finish, with very little room for error. Thankfully, some of the techniques we learned from the STIS repair development could be applied to ACS repair, absent which the repair would not have been possible on such a short schedule. But the truth is that the real heart of ACS repair lay elsewhere and presented a daunting challenge, even with the head start provided by the STIS effort.

ACS has three scientific channels, the two-most used of which—the visible/red-optimized WFC and the High-Resolution Channel (HRC)—have CCDs as their detectors. Of these, WFC was historically far more used, comprising about 70% of all of ACS science. In June of 2006, the +15V power rail which supplied Side 1 power to the WFC and HRC CCD Electronics Boxes (CEB) went down, rendering the CCDs unusable on Side 1. A switch to Side 2 brought back the CCDs and operations returned to normal. But in January of 2007, a major Side 2 electrical event occurred which released ~3000 Joules of electrical energy, taking down all three channels and generating enough “smoke” to produce a substantial spike in the pressure sensor located in the telescope’s aft shroud. The CCDs were now down on both sides, but a return to Side 1 at least brought the Solar Blind Channel (SBC) back into operation.

With the STIS repair effort in the background, it was natural to ask: is ACS repair in SM4 possible? Is it even justified? The second question was easy to answer: WFC3 and ACS complement each other, and together would offer the highest available sensitivities at all wavelengths from the UV through the near-IR. Working in tandem, extremely ambitious deep-sky surveys not feasible with only one imager *would be possible*, as would significantly more efficient studies of Dark Energy through detection and measurements of distant Type Ia super-

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novae. And those are just two examples that don't even speak to ACS's still-strong standalone science capabilities.

The comparison between a Side 1 and a Side 2 repair was ugly: Side 2, whose Main Electronics Box (MEB) would directly face an EVA astronaut in the aft shroud and hence be completely accessible, did not have a definitive failure location analogous to STIS's LVPS2 board. Moreover, the whole electronics cavity had likely suffered substantial collateral damage due to the energy of the failure—not a good place to work. Side 1 presented a much more benign failure, but it too was not precisely located. In any case, the Side 1 MEB was "around the side" of the instrument and EVA astronauts would not be able to remove the panel without taking the entire instrument out of the aft shroud. Great, just great.

Technicians at GSFC working on the replacement ACS/WFC CEB, a drop-in module containing four replacement electronics boards and a SIDECAR ASIC

If Ed Cheng proved anything during the successful development of a cryocooler for the cryogen-depleted NICMOS prior to SM3B, it was that he loves a challenge. Here's what the team he and Pete Alea led came up with. Repair of Side 1 was the only way to go, but it couldn't be accomplished by replacing anything damaged inside the instrument because an astronaut couldn't get to it. What was needed was an alternative way to get power to the CCD CEBs (thought not to be damaged), and the only way to do that was to mount a new power supply on the outside of the instrument, clamped to an astronaut handrail. The access panels to the CEBs were located high on the beveled corner between the front face of the instrument (think Side 2 MEB) and the inaccessible face (Side 1 MEB). The CEBs *were* accessible by EVA astronauts, though it was by no means an easy reach.

If the four electronics cards in each CEB could be removed and replaced with cards modified with the ability to receive power *from the outside as opposed to inside ACS*, then the CCDs would be restored to operability. But it wasn't this simple. There almost certainly was not enough development or EVA time to do a cards changeout on both CEBs, meaning we would have to choose one channel over the other. That was easy. As mentioned earlier, the historical WFC:HRC:SBC usage percentages were 70:20:10% (for the most recent, as-approved Cycle 17 proposals, the numbers were 83:15:2%). And there was this hopeful fact: there was wiring inside ACS that connected the WFC and HRC CEBs, and depending on where the original 2006 fault lay, it might be possible to "back-power" the HRC by applying external power to the WFC

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CEB. The whole effort was deemed well worth it if WFC alone came back—HRC restoration would be a possible and wonderful bonus, but in no way would the repair be viewed as a failure if it didn't happen. The repair effort was about WFC.

CCD performance is coupled very closely to achieving the best match of timing patterns, voltages, etc., between the CCD preamp (which is attached to the detector) and all those electronics downstream from it—in this case, the CEB. But how could we do that given that we couldn't bring the CCDs down to test against the new CEB electronics being developed? This was a critical piece—really, *the critical piece*—of the entire effort. The replacement CEB would have to be tunable from the ground to make up for our lack of knowledge of how the flight CCDs and the new hardware would work together, and the answer was the System Image, Digitizing, Enhancing, Controlling, And Retrieving (SIDECAR) Application Specific Integrated Circuits (ASIC) manufactured by Teledyne Scientific and Imaging. Board-mounted ASICs would allow engineers to find, then lock in, the right combination of parameters to optimize WFC CCD performance *after* SM4 was over.

Five amazing days in space

As in past servicing missions, the Hubble Team was split up during the mission. A large contingent went to JSC and interacted directly with the Shuttle management and JSC SM4 teams with whom we'd been developing the mission for over two and a half years. The other, mirrored half (including the author) participated in the mission at GSFC's Space Telescope Operations Control Center (STOCC). It needs to be said that "Team" included not only the GSFC-resident Hubble Program members, but our Baltimore colleagues from STScI as well as team members from key HST contractors.

The official crew patch of STS-125; these names will never be forgotten

On the theory that boring spelled success, it was said by many prior to lighting the candle that they hoped for a boring mission.

Boring we didn't get. Success we did.

After *Atlantis* Commander Scott Altman and Pilot Greg Johnson chased down Hubble over the course of two days, Remote Manipulator System operator Megan McArthur did a fabulous job grabbing HST, drawing it into the cargo bay, and depositing it on the Flight Support System—the platform which rotates the worksites on Hubble to the proper locations so that EVA astronauts can perform their tasks. And then, the next day, the fun really began.

The spacewalkers on the first EVA were John Grunsfeld and Andrew ("Drew") Feustel. They had two principal tasks: install WFC3 and the replacement SI C&DH. Installation of the latter we'd had a few worries over in the run-up to SM4. It went on the telescope like a dream.

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Despite my dark humor with the SOC, we knew that WFC3 installation would be easy. And then we heard Drew over the "squawk box" on air-to-ground: "Cannot break torque on A-latch with ratchet." Translation: the A-latch didn't turn; what *did* turn was many stomachs, and many minutes and multiple attempts on the A-latch later, WFPC2 was still firmly bolted in the telescope.

E-mails and squawk box chatter flew back and forth between JSC and GSFC. A colleague e-mailed "things are grim here"; I replied "same here." We were approaching the point about 50 minutes later where steadily increasing torque would have to be applied by Drew without the torque limiter, and either the latch would turn or the head would break. I stepped into an adjoining room in the STOCC and talked to Bill Freeman, hunched over detailed drawings of the A-latch. The latch shaft was incredibly long—something like 18 inches, and if it broke, there was no way to get deep enough into WFPC2 to release it—the 15.5 year-old instrument was going to age some more inside HST.

WFPC2 is finally out of the telescope (note the gaping hole), and John Grunsfeld awaits the retrieval of WFC3 on EVA 1

One last shot—for all the marbles. We heard Drew say on air-to-ground "A-latch torque broken [the bolt turned!]". Cheers and backslapping all around—WFPC2 came out, and a short time later the scientific centerpiece of SM4 was installed on Hubble. In short order it passed its aliveness test (AT), then later in the evening the functional test (FT) was passed. With all the A-latch drama, it was a long EVA: 7h:20m.

Mike Massimino and Mike Good went out on EVA 2 to install the gyros and the first of two battery modules (containing three batteries). "Mass" and "Bueno" got the job done, though one of the Rate Sensing Units (each containing two gyros) was far trickier to install than anyone had thought, and one of the units just wouldn't go—Bueno and Mass had to install the spare unit. With the success of EVA 2, that made twenty straight EVAs during all SMs to-date in which all planned tasks had been completed. Not bad. EVA 2 was another long one: 7h:56m.

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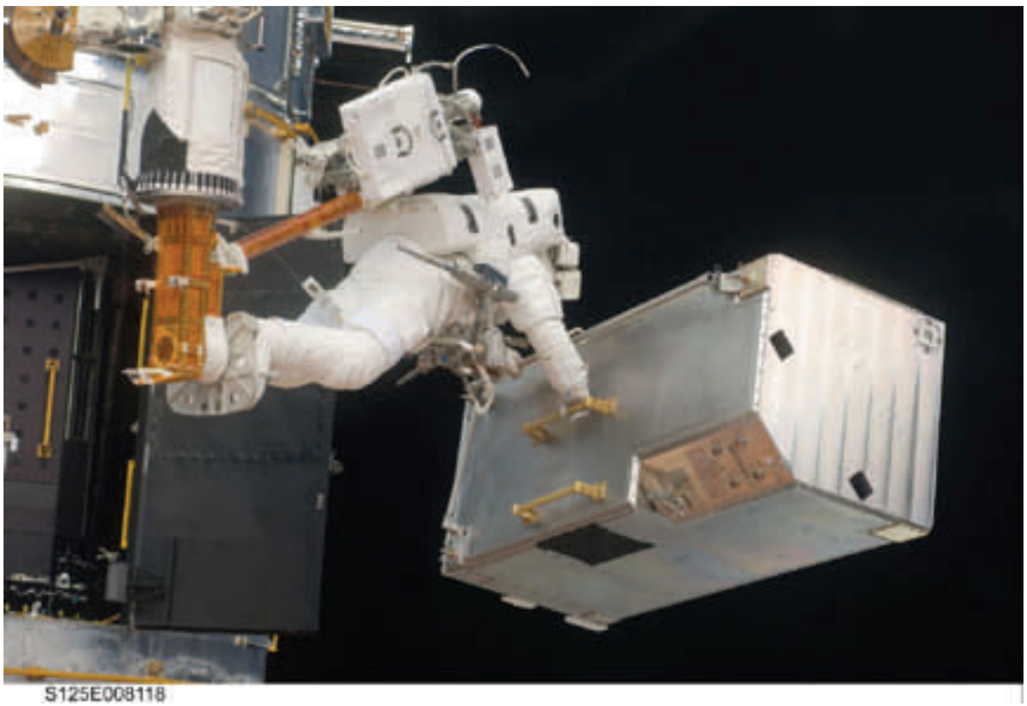
EVA 3 was the one that had consumed everyone during the run-up. COSTAR removal/COS installation looked like a standard axial instrument changeout, but ACS repair was a very tricky, complex job. The official EVA timeline showed only “ACS, Part I,” but the hope and very real expectation was that Grunsfeld and Feustel would get the entire repair done on this EVA. Heaven only knows that John in particular had trained to the point of obsession with that goal in mind. Not getting all of ACS done on EVA 3 would mean that either ACS repair wouldn’t be completed, or something would have to be thrown off EVA 5 to make room for ACS Part II—which of those occurred would depend on how STIS repair went on EVA 4. Nobody wanted to see this scenario.



COSTAR removed from Hubble, making way for COS on EVA 3.

Getting COSTAR out and COS in did go smoothly, and to have the second of two new instruments on Hubble was cause for great rejoicing, especially after COS passed its AT and, later, its FT. The hard, obsessive training for ACS repair paid off beautifully, as John was an absolute maestro of efficiency. At the end of an EVA which lasted only 6h:36m—the shortest of the mission as it would turn out—the replacement WFC CEB and new power supply were on ACS. The translation of *that* fact was that ACS repair was complete! The AT passed, and several hours later the FT was passed when the WFC came up. Unfortunately, HRC did not come up, meaning that the 2006 electrical fault was upstream of its CEB. HRC was viewed as a small, tolerable loss, however: the entire repair effort had focused on the all-important WFC, *and that had been a smashing success.*

The first of two instrument surgeries, the first of their kind, was completed. Successfully. It was unbelievable—you literally couldn’t believe what you’d just seen. And during the EVA I got my first look at a real fastener capture plate in action: ACS repair used a small version of the STIS FCP to capture the CEB fasteners, and when John pulled the FCP off after all 32 fasteners had been backed-out, the cover (attached to the FCP) also came off, revealing the CEB cavity. An astronaut helmet light caught the freed fasteners swimming around like fish in their FCP capture volumes. Beautiful sight.

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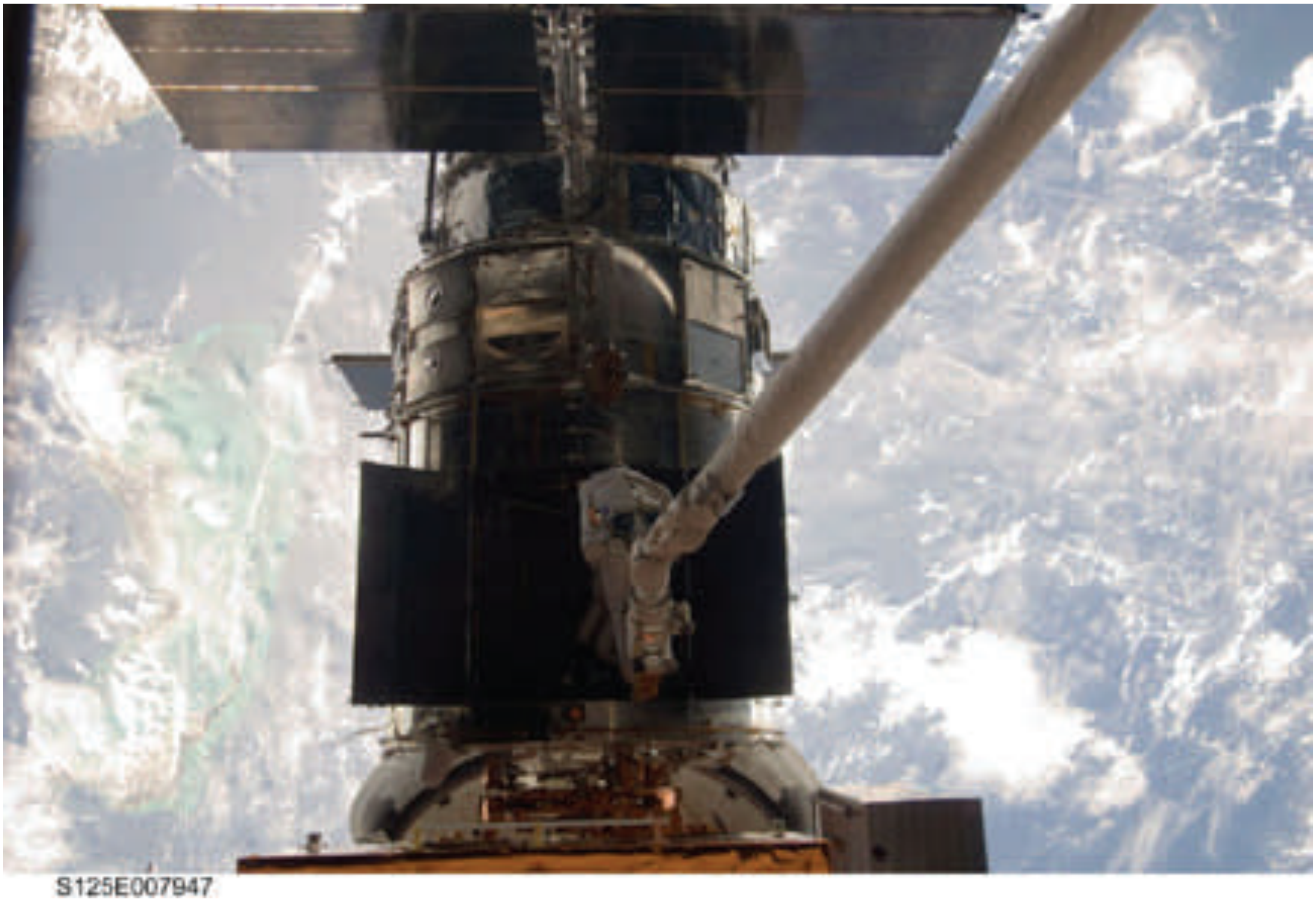

ACS repair going at full throttle on EVA 3—John Grunsfeld is deep inside the aft shroud (legs only visible) and Drew Feustel assists on the end of the remote manipulator arm

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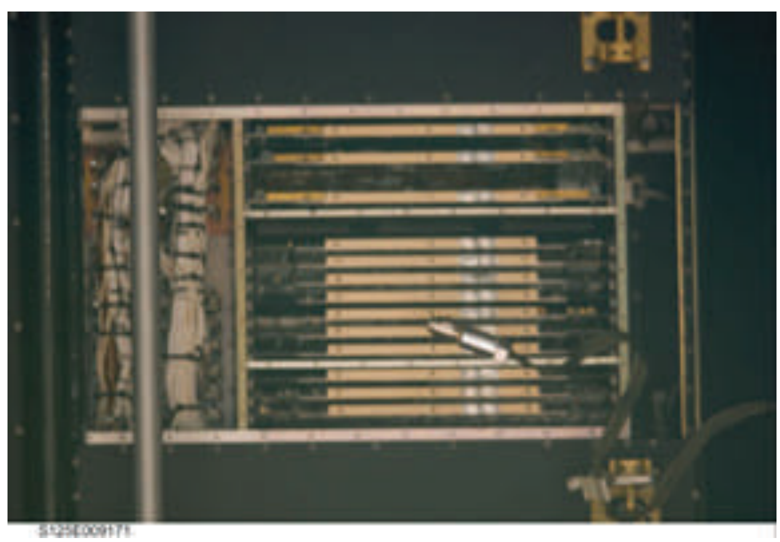
EVA 4 and time to wake up STIS after a nearly 5-year nap and install some NOBLs. There's nothing easy about instrument repair, and although ACS had worked like a charm everyone knew that STIS might fight back. It did, but in an unexpected way. One of the first repair steps was the removal of an astronaut handrail—it was in the way of where the STIS FCP had to go. One of the four handrail screws got stripped, and for a while it looked like STIS repair was dead in its tracks. But then engineers at GSFC did a little test on a handrail mock-up held in place by just one screw. With enough force, the handle could be broken off the side of STIS. Then Mass did just that and the repair was on for real.



With 111 fasteners backed-out, the cover removed, and the Side 2 electronics cavity exposed, the removal of STIS LVPS2 card is only minutes away during EVA 4.

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The huge FCP was installed, the fasteners backed out, the FCP and cover came off, many fish swam, the LVPS2 board was swapped out, the two-clamp replacement cover (no fasteners!) was installed, the AT passed, and later the FT did as well. With the handrail drama, the EVA had run long—8h:02m—and the NOBLs would have to wait until EVA 5. What a day it was—at that point we were two-for-two on instrument repairs and had two new instruments!

EVA 5 was an important day, despite the lack of activities directly related to science. Installation of the second battery module would give Hubble six new batteries and prevent the dreaded “hybrid” configuration of three new/three old batteries that we had studied and planned contingencies against. The FGS was very important as well—we wanted the pointing system to be as robust as it could be. Finally, there were NOBLs to do—a leftover from EVA 4. No one really thought that after all the long EVAs up to that point that the batteries, the FGS, and all three NOBLs would be installed, but that’s what happened, aided by the early cargo bay egress of Grunsfeld and Feustel. It was 7h:02m for the final EVA. What a finish.

Hubble after release from *Atlantis* and a spectacularly successful five EVAs and a brilliant mission.

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What can we say? What can anyone say? SM4, the mission that was seemingly forever in the making, the one that was gone with the January 2004 cancellation, then back again, then delayed multiple times, was suddenly over. Just like that. After five remarkable EVAs that represented years of dreams and toil and defined a mission unlike any other, Hubble was released from *Atlantis.* It is now being checked out and calibrated in a ~ 4-month long program called “SMOV” (Servicing Mission Observatory Verification). I can tell you that the data look great and Hubble is scientifically thin no longer. We have much to look forward to in the next 5+ years.

Even the Near-Infrared Camera and Multi-Object Spectrometer (NICMOS), on which no work was done during SM4 and whose cryocooler resisted nine start-up attempts since last September following a spacecraft safing, started up early last Saturday (August 1). We appear to have five working instruments (six including FGS/astrometry) for the first time since the days before the First Servicing Mission. But now we don’t have spherical aberration—just superlative instruments on a miraculous platform in space called the Hubble Space Telescope. Lyman Spitzer and John Bahcall would have been so pleased. Aren’t we all!

Malcolm B. Niedner (Code 667)
HST Deputy Senior Project Scientist

Quotes To Think About

“The future depends on what we do in the present.”
-Gandhi-

“Perfection has one grave defect. It is apt to be dull.”
-W. Somerset Maugham-

“It was impossible to get a conversation going. Everybody was talking too much.”
-Yogi Berra-

“Not all successful managers are competent and not all
failed managers are incompetent.”
-Jerry Madden- (lesson #21)

“If your actions inspire others to dream more, learn more, do more
and become more, you are a leader.”
-John Quincy Adams-

The Cruising Cauffmans—Yorktown Wins!

If you walk by Sandra Cauffman's office at the Goddard Space Flight Center, you will see proudly displayed on her office door a photo of her son Stephen and his crew on the awards dock at the Virginia Scholastic Rowing Championships after receiving their gold medals and trophy for winning the men's 1st eight state championship. Stephen, a junior at Yorktown High School in Arlington, Virginia rowed in the four seat of this championship crew. This was the first state championship in the men's 1st eight for Yorktown in the 41 year history of rowing at the school.

This has been a big season for Yorktown Crew. The men's first eight has been dominant in local rowing, notching wins at the Charlie Butt Regatta on the Potomac and at the State Championships on the Occoquan. The state championship qualified the crew to go to the Scholastic Rowing Association of America (SRAA) National Championship, held on Lake Mercer in West Windsor, New Jersey, where the Yorktown men finished fourth in a very close Petite Final. This was a courageous race for a crew that almost didn't make it to the qualifying heat.

On Thursday at SRAA Nationals, the crew struck a submerged obstacle during a practice on the race course. The collision severed the bow of the boat and forced the bow four rowers to swim to shore so that the remaining crew members could row the boat back to the dock. While the shell is repairable, an overnight repair was out of the question, so the coaches went in search of a boat to borrow. McLean High School, offered use of a demonstration boat they were testing.

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Gonzaga College High School's new head coach, Marc Mandel, graciously offered his time and spare parts to get the boat rigged properly for the Yorktown crew.

The men quickly proved that they were neither rattled by the accident the day before nor bothered by rowing an unfamiliar boat. In their qualifying heat, they finished a close second behind Gonzaga and both crews advanced directly to the semifinals, to be held the next day. In the semi-finals, Yorktown started quickly taking a lead in the first 500 m. Rowing all out the men finished in third place, 0.248 s behind second place St. Augustine and narrowly missing the opportunity to row for the National Championship in the Grand Final. The men did advance to the Petite Final, where in a terrific and very close race they finished fourth behind Eden Preparatory School, Thomas Jefferson High School, and St. Alban's. Less than a boat length separated first from fourth and less than 0.7s separated first from fourth. In the Grand Final, Gonzaga College High School went on to win a well-deserved National Championship, fending off a late challenge from St. Joseph's Prep.

The winning ways don't end with Sandra's son. Her husband Steve is an Assistant Women's Varsity Coach at Yorktown and his Women's third eight also won a State Championship and qualified to race at SRAA Nationals, advancing as far as the semifinals. In all, Yorktown's crews amassed three State Championships (Men's first and second eights, Women's third eight) and two silver medals (Women's first eight, Men's freshman eight) and qualified five crews for Nationals, four of which advanced to semifinals or beyond.

Sandra Cauffman (Code 400)
GEMS Project Manager

Cultural Tidbits

Did you Know………

…that many transsexual people have been married for years, without much incident or controversy. However, new challenges are emerging as the national controversy over marriage for same-sex couples grows. In some cases, a marriage where one person has changed gender has been found to be a marriage between a same-sex couple and, therefore, impermissible under state law. Some transgender people have also been told by their employers or others, incorrectly, that at the moment their gender transitions are complete, their marriages become null and void. However, no law anywhere in the country has established that to be the case.

Excerpt from *Transgender Americans: A Handbook for Understanding*, published by the Human Rights Campaign (http://www.hrc.org)

Do you have a cultural tidbit to share? Send it to the Code 400 Diversity Council c/o Andrea Razzaghi @ andrea.i.razzaghi@nasa.gov and we'll publish it in a future issue.

NASA News of Note

- Charles Bolden and Lori Garver, nominated by President Obama, were confirmed 'without objection' by the Senate to be NASA Administrator and Deputy Administrator respectively. As NASA's 12th Administrator, Marine Corps General Bolden had earlier spent 14 years in the NASA Astronaut Office and performed on four space missions including the deployment of the Hubble Space Telescope. Lori Garver, too, had a stint with NASA culminating as Associate Administrator for the Office of Policy and Plans. Both individuals have already visited Goddard and spoken before a packed house in the Building 8 auditorium.

- Throughout July celebrations were held around the nation in commemoration of the 40th anniversary of the July 20, 1969 Apollo moon landing. The crew of the Atlantis mission to the Hubble Space Telescope visited Goddard on July 23, gave presentations to a full house in the Building 8 auditorium, and then visited with employees on the Goddard Mall.

- Repair of the Hubble Space Telescope successfully accomplished! Read the cover story about this epic event narrated by HST Deputy Project Scientist Mal Niedner beginning on Page 1.

- Goddard's Lunar Reconnaissance Orbiter (LRO) successfully launched on June 18. Begun five years ago as an in-house Goddard project, it also provided one of the seven key instruments aboard: the Lunar Orbiter Laser Altimeter (LOLA). For the story on this mission see Page 11.

- Goddard's Solar Dynamic Observatory arrived at KSC on July 9, a few days after it left Goddard where it was built and tested. Launch is anticipated in December 2009. SDO will be the first space weather research network mission in NASA's Living With a Star Program.

- A new astrophysics mission led by Goddard, the Gravity and Extreme Magnetism Small Explorer (GEMS) will detect polarized x-rays from supernova remnants, neutron stars and black holes. It is part of the Small Explorer (SMEX) series of satellites and is anticipated for launch in 2014. Sandra Cauffman, Assistant Director of Flight Projects is the Project Manager. See story on page 4.

- Just hours after the successful restoration of the Hubble Space Telescope, an Air Force Minotaur 1 lifted off from a Wallops Flight Facility launch pad, placing into orbit the Air Force Research Laboratory's TacSat-3 satellite. Also aboard were two secondary payloads: NASA's PharmaSat microsatellite (Ames Research Center), and NASA's CubeSat Technology Demonstration experiments. Jack Vieira led the Wallops team in the successful launch.

- PM Challenge 2010 – "Above and Beyond," will take place on February 9-10, 2010 near JSC. Attendee registration is from October 26, 2009 until January 8, 2010. Contact Co-Chairs Dorothy.J.Tiffany@nasa.gov or Walt.Majerowicz@nasa.gov for more information.

Comings & Goings

Comings:

Jim Lohr to 448/International Dark Energy Cosmology Survey (IDECS) Project Office

Jahi Wartts to 427/LANDSat Project

Miles Glasgow to 450/Exploration & Space Communications Projects Division

Lorrie Eakin to 480/POES Project

John Leon to 420/IceSAT II Mission

Goings:

Tracy Parlate reassigned to 703/Deputy Resource Management Officer

Richard Schonbachler retired from 452/Space Network Project

Gil Colon to 100/Office of the Director

Laurie Kleppin resigned from 480/POES Project

Tammy Wang retired from 450.1/Networks Integration Management Office

Peg Luce transferred to NASA HQs/SMD

Kitty Hanlon retired from 422/GPM Project

Gail Regan retired from 403/FPD Business Management Office

Nancy Rinker retired from 400/Flight Projects Directorate

Goodbye

Although both have more than earned many years of happy retirement, the Code 400 office notes with sadness the recent retirement of two of its most conscientious, effective, and always pleasant employees: Nancy Rinker, secretary to Code 400 Deputy Director George Barth and Gail Regan, COTR for the PAAC II contract. Each served nearly 40 years at the Center in a variety of positions culminating in the Code 400 0ffice. We wish them well.

(Grady Tintype continued from page 3)

“Teaming with our international partners has been quite a rewarding experience. It has been very exciting to be part of the team defining this international observatory.” The IXO team has recently
completed a series of extensive submissions to the National Academy of Sciences for the Astro 2010 decadal review, which will prioritize astrophysics missions for development over the next decade. Jean observes that being a Goddard employee has indeed been a great pleasure, with interesting and challenging projects and a top-notch work force.

On Family: Jean is married to Kevin Grady (GSFC Code 448). They have two sons: Patrick (12) and Brendan (10) and reside in Columbia, MD.

Life Outside of Goddard: Raising two boys is the primary focus in the Grady household. Jean spends much of her leisure time cheering her sons on in their many sports endeavors including baseball, basketball, soccer and swimming. She is actively involved in her son’s cub scouting and is currently the Cubmaster for Cub Scout Pack 1954. When time allows, Jean enjoys some of her favorite outdoor activities with her family and friends including downhill and cross country skiing, biking, and hiking.

(Ottenstein Tintype Continued from page 3)

going to RCA in 1963, who said to come on down to Goddard. He was sent to provide resource support to Frank MacDonald and Les Meredith, who at different times led the old code 610. While there, he left for one year at the Maritime Administration as Resource Manager for the Director of R&D. The big deal there at the time was their nuclear ship Savannah, long since mothballed. Back to Goddard after that where Howard spent 10 years in MUD (Manpower Utilization Division). There he specialized in writing detailed explanations of a series of Goddard Center-wide organizational changes for the signature of then Director John Clark for Headquarters approval. Subsequently he was appointed Head, Personnel Services Branch. Seeking other challenges, Howard moved over to Code 400 for the first time and served as Resource Manager to Margie Townsend, Goddard's first female PM who was also an early proponent of 'no smoking'! He was then offered a position in PAO where he spent four tumultuous years as a supervisory public affairs specialist before leaving for Code 400 once again. This time as Facilitator for the new PMDE program that had just been approved by GSFC management in late 1989.

Concurrently Howard served for a number of years as Goddard representative to the Baltimore Federal Executive Board, and while there as President for another year of the Maryland Federal Personnel Council. He also was President of the Goddard Chapter of NEBA for 33 years (NASA's own insurance program) and Member of the NASA-wide NEBA Board of Directors. There he successfully advocated coverage for wives and children, as well as coverage beyond the age of 70. He also served as Chairman of the CSC campaign in 1986 under then Center Director Noel Hinners. Other responsibilities included: Chairing an SEB; serving as Code 400 Section Editor of Goddard's Annual R & T Report for several years; functioning as a Center EEO officer for a number of years, and recruiting at many universities. In his spare time, he wrote a weekly column for The Baltimore Evening Sun entitled: The Federal Worker (for two years), authored a book on "How to Beat the Bureaucracy" (he's still trying to do it himself), and taught a similar course in the evening at Catonsville Community College and the former Towson State University.

Back to Goddard and code 400, Howard has helped develop PMDE over the years from its early beginnings, and continuously enjoys seeing the growth of its participants into senior management positions (especially project) at Goddard, Headquarters, other agencies and the private sector. Equally enjoyable has been his role as Editor of The Critical Path assigned to him to start in 1993 (with Rich Long and George Barth) by then Director of Projects Vern Weyers. In January of 2005, having acquired nearly 43 years of Civil Service experience, Howard decided to retire, but immediately commenced work (part time) with Computer Sciences Corporation on the PAAC II contract (now with ARTS as part of PAAC III). In all, Howard has served under every Center Director at Goddard, going back to its first, Dr. Harry Goett.

Family: Marcia has put up with Howard for more than 48 years together. They have three adult children all over the country (New York, Florida and California) and two teenage grandchildren in Florida. Of course they always hope for a few additions in this category. Howard has always had a penchant for writing Letters to the Editor and Marcia is no longer surprised to see his name in the Baltimore Sun, Washington Post, and other publications. They have been on sixteen cruises over the years, with perhaps the most memorable being the first. That began one day after President Kennedy was slain. It was a very quiet voyage.

Social News

Congratulations:

Mark Hubbard, Code 442, recently learned that his oldest son, Matthew, and his wife, Mary, of Frederick, Maryland, are expecting their first child in January. This will make grandchild #4 for Mark & Barbara Hubbard!

Zac Dolch (Code 401) became engaged to Catherine Paschal in March. They will be married in Davidsonville, Maryland on September 12, 2009. After honeymooning in Cabo San Lucas, Mexico, Zac and Cat will be living in Arnold, Maryland.

Cori Ottenstein, granddaughter of TCP Editor Howard Ottenstein (Code 403), recently graduated cum laude from Bartram Trail High School in Jacksonville, Florida. She will begin her studies in physical therapy this fall at the University of North Florida. Cori was a member of her high school's synchronized dance team that won two consecutive national high school championships, and is also skilled in sign language interpretation and presentation.

Births:

Julia (Code 403) and Lyle Knight became grandparents for the first time on Monday, June 8. Julia and Lyle's son Jason and his wife Carol welcomed Olivia Elizabeth Knight into their family. She weighed 7 pounds, 3 ounces and was 19 inches long.

Ann Travis (403) became a Grandmother on December 29th. Her granddaughter, Olivia Marie Travis, was born to Ann's son, Todd, and his wife Stephanie. Olivia weighed 7lbs. 15 oz., and arrived on her parents first anniversary. Todd, Stephanie and Olivia live in Glenelg - 3 miles from Granny.

Transitions:

Best wishes to Laurie Kleppin (formerly 480). Her last day with GSFC was on May 8. She has transferred to the DOE/National Nuclear Security Agency as Federal Project Director at Y-12 in Oak Ridge, TN. Last summer, Laurie went to her 30th high school reunion and was reunited with a former schoolmate, Chris Folden. Laurie and Chris were married in June of this year, and they will live in their home town of Powell, TN. Laurie's daughter, Carolyn, and Matt Brugh, were also married in June, in Stone Mountain, GA, and they will live in Birmingham while he finishes seminary. Her son, Joshua, graduated in June from Severna Park High School and has been accepted to the Commercial Music degree program (drum set) at Belmont University in Nashville, TN. June sure was a busy month for Laurie and her family!

A Little Note

Many thanks to Laura Paschal (Code 443) for helping put together this issue of The Critical Path, while Production Assistant Nancy White recuperates from her recent surgery.

We all wish Nancy a full recovery, and look forward to her return to work very soon.

Mark Your Calendars for…

The Flight Projects Directorate, Code 400

2009 Peer Award Ceremony and Social Event

Date: Thursday, September 24, 2009

Time: 3:00-5:30PM

Place: GSFC Rec Center

FUTURE LAUNCHES CALENDAR YEAR 2009	
NOAA-N'	Launched
HST SM4	Launched
GOES-O	Launched
LRO	Launched
WISE (MIDEX-6)	DEC
SDO (LWS)	DEC

ATTENTION INTERNET BROWSERS:

We're on the WEB
http://fpd.gsfc.nasa.gov/news.html
Or via the New "Code 400" Homepage
http://fpd.gsfc.nasa.gov

The Critical Path

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Howard K. Ottenstein,
Editor

Nancy L. White,
Production Assistant/Photographer

Paula L. Wood,
Editorial Assistant

If you have a story idea, news item, or letter for The Critical Path, please let us know about it. Send your note to Howard Ottenstein via Email: Howard.K.Ottenstein@nasa.gov, Mail: Code 403, or Phone: 6-8583. Don't forget to include your name and telephone number. Deadline for the next issue is November 23, 2009.