

## Report on the Structure and Evolution of the Universe

### NASA Advisory Subcommittee Meeting,

July 26-28, 2004

San Diego, California

### “Exploration without Science is Tourism”

<<<<<Meeting: Day 1>>>>>

Monday, July 26, 2004, dawned temperate and nearly cloudless at the Shelter Pointe Hotel and Marina on Shelter Island in San Diego. This meeting, perhaps the last of the SEUS, was taking place at the same time as ASO, SEC, and SSE, the other three NASA OSS advisory subcommittees, and preceded the SScAC meeting.

Michael Salamon is the acting SEU theme scientist, having replaced Paul Hertz, who became Associate Administrator Weiler's science deputy only a few months ago. It was recently announced that Dr. Weiler was replacing Mr. Al Diaz, director of GSFC, effective August 1<sup>st</sup>. Diaz will become the Associate Administrator for the Science Mission Directorate, effectively taking Dr. Weiler's position. In the meantime, Dr. Jonathan Ormes, director of Space Sciences at GSFC, has retired. NASA is in the midst of a reorganization, which means that it is difficult to receive clear instructions because directives are likely to change without notice depending on the judgment and policies that Mr. Diaz chooses to implement. This situation clouded the effectiveness of some of the meeting in general, and the roadmapping process in particular.

FACA rules of engagement were in effect, with people obligated to call out potential or real conflicts of interest. Failure to take proper note of conflicts meant that our vote on the two-SMEX vs. one-SMEX and one-MIDEX options in the previous meeting was nullified. The SScAC had made this decision in the meantime.

Congress mandates NASA to produce a strategic plan, so the NASA Enterprise themes have to produce a Roadmap every three years. It is already time to start the Roadmapping process, even though *Beyond Einstein* was only rolled out a year ago and is still current. *BE* has already achieved a main objective of obtaining a funding line in budget. The goal for delivery of the new SEUS Roadmap is next spring, so the roadmapping process is on a short timeline.

Dr. Katherine Flanagan was appointed head of the roadmapping process on the SEUS side; Adam Burrows has that duty on the OS side. Prof. Dr. Rocky Kolb chaired the SEUS and Prof. David Spergel chaired the OS. A small cloud looming over the proceedings was the issue that *the Origins and the SEUS themes were to be dissolved*.

This made it a little difficult to decide on the composition of the Roadmap: one from OS, one from SEUS, or a joint roadmap? Or a third roadmap that melds the overlapping science and also fixes up “Cycles of Matter and Energy” which, as was noted, *sounds like a dog food, cycle 3*. The Cycles of Matter and Energy obviously needs work. (Dr. Dan Lester headed it up last time, and I was part of it.) A better title might be *The Evolution of Structure*. In either case, it can be improved and brought to the *BE* standard (though preferably with fewer historical footnotes, and more pictures and descriptions of planned “garbage cans with wings.”

An issue was how to proceed with the Roadmap, which required guidance from Dr. Anne Kinney, director of the A&P Division in the OSS. After the reorganization, she becomes Director of the Universe within the Science Directorate. She will not receive directives on how to proceed with the roadmap until August 1<sup>st</sup>, when Al Diaz is in place and sets his agenda. We were instructed to proceed as if nothing had changed.

Kathy Flanagan was tasked with setting something up regarding the roadmapping process at the HEAD in New Orleans, so take notice if you’re going.

Dr. Michael Salamon introduced the meeting and brought up issues related to the Aldrich Commission report:

## Report of the President’s Commission on Implementation of United States Space Exploration Policy

# A Journey to Inspire, Innovate, and Discover”

in particular Finding # 7, which calls out some language favorable to SEUS.

### Finding 7

The Commission finds implementing the space exploration vision will be enabled by scientific knowledge, and will enable compelling scientific opportunities to study Earth and its environs, the solar system, other planetary systems, and the universe.

In contrast to the less detailed President's Space Exploration mission statement, this finding provides reasonable assurance that scientific exploration is still a priority with NASA. A quotation by Mr. O'Keefe was mentioned that begins, "I cannot overstate how much NASA will change..."

The OSS is now divided into four missions: Exploration Systems, Space Operations, Science (Al Diaz), and Aeronautics Research. Science has authority over Ames, GSFC, and JPL. Within Science is Sun-Earth (the old SEC including Code Y – Office of Earth Science—though without a geo-component), Solar System (the old SSE plus a geo-component plus lunar exploration), and the Universe (formerly A&P). As noted, Anne Kinney is Director of the Universe.

To make a new Roadmap, whatever final shape it takes, means a call for white papers, as was done previously. It would be useful to dust up the old white papers with a standard technology sheet, such as the document Mel Montemerlo was assembling in the previous meeting. The question came up as to whether Industry should provide some input, but that suggestion was nixed, as it was pointed out that the input might turn into marketing brochures.

The Aldridge Commission provides a basis for implementing the President's Exploration Initiative. The SEUS also noted

#### Recommendation 7-1

The Commission recommends that NASA seeks routine input from the scientific community on exploration architectures to ensure that maximum use is made of existing assets and emerging capabilities.

and the Notional Science Research Agenda in the Commission Report

#### **Origins**

- \_ The Big Bang, the structure and composition of the universe including the formation of galaxies and the origin of dark matter and dark energy.
- \_ Nebular composition and evolution – gravitational collapse and stellar ignition.
- \_ Formation of our solar system and other planetary systems; clues to the origin of the solar system found in meteorites, cosmic dust, asteroids, comets, Kuiper Belt Objects, and samples of planetary surfaces.
- \_ Pre-biotic solar system organic chemistry – locations, histories, and processes; emergence of life on Earth; interplay between geological and astronomical processes.

#### **Evolution**

- \_ The Universe – processes that influence and produce large-scale structure, from sub-nuclear to galactic scales.
- \_ Stellar Evolution – nucleosynthesis and evolutionary sequences, including the influence of particles and fields on the space environment.
- \_ Planetary Evolution – the roles of impact, volcanism, tectonics, and orbital or rotational dynamics in shaping planetary surfaces; structure of planetary

interiors.

\_ Comparative Planetology – study of Earth as a terrestrial planet; divergence of evolutionary paths of Earth, Venus, and Mars; comparisons of giant planets and extrasolar planets.

\_ Atmospheres – early evolution and interaction with hydrospheres; longterm changes and stability.

\_ Search for Habitable Environments – identification and characterization of environments potentially suitable for the past existence and present sustenance of biogenic activity.

### **Fate**

\_ Biology of species in space – micro- and fractional gravity, long-term effects of exposure to variable gravity; radiation; avoidance and mitigation strategies.

\_ Impact Threat – cataloguing and classification of near-Earth objects; estimation of the recent impact flux and its variations; flux variation with position in solar system; hazard avoidance and mitigation.

\_ Natural hazard assessment – Advanced space-based characterization of meteorological, oceanic, and solid Earth natural hazards to diminish consequences and advance toward predictive capability.

\_ Temporal variations in solar output – monitoring and interpretation of space weather as relevant to consequence and predictability.

\_ Climate change – assessment of recent climatic variations; solar controls on climate change; quantitative modeling and testing of the greenhouse effect; and possible effects on planets and life.

\_ Long-term variations of solar system environment – galactic rotation and secular variations; local supernovae.

There is considerable language in the Aldridge report that is favorable to SEUS and science of the universe.

Marc Allen talked about the reorganization, the combination of Code S and Code Y, including its new advisory structure (yet to be precisely defined), the creation of the Administrator's staff, and the target date for completing the roadmap (1<sup>st</sup> quarter of 05).

The roadmapping process should

1. Survey the current state of knowledge;
2. Refine science objectives of the RFAs (research focus areas);
3. Consider a timescale for science activities for the next decade, extending to 25 years; and
4. Indicate mission representation in a preference network (see BE).

One suggestion for the title of a Universe roadmap was *Beyond Pluto*.

Kathy Flanagan talked about the Roadmapping Process, including the ordering and prioritizing Con X and LISA that were in part related to parallel ESA activities, and the role of JDEM. Some of the questions were, “How do we accommodate exploration within our Roadmap?” “Do we retain separate technology, theory, and R&A for the BE part of our roadmap?” “Is it joint with OS?” Where does Balloon and Suborbital fit in?” “What about EPO?”

Dr. Anne Kinney gave the A&P update. Within the reorganization, Dr. Kinney becomes the highest-ranking PhD scientist, and Mr. Diaz becomes the first Science AA who is not a PhD scientist. Two big issues pending with budget impact are return to flight and the HST servicing. Regarding HST, planning was in progress to extend its operating lifetime, servicing was moved to Code T, the science program was being optimized, and plans were being made for a robotic servicing mission.

Besides the HST activism, the significant events within A&P are the GP-B launch, the Chandra and Spitzer SSUs, the response to the Origins probes (amounting to a factor of 3 oversubscription), and a TPF reformulation. The SSUs included imaging extrasolar planets with microlensing, hot studies of dark energy from Chandra, and the planetary construction zone as imaged with Spitzer.

The budget issues for A&P are; the Science Mission Directorate's share of the HST Robotic mission; the LISA spacecraft and payload integration; the Swift launch slip (to October 7<sup>th</sup>); adjustments to Herschel and Planck; some adjustments for GLAST; parts and an Australian tracking station for Radioastron; SEU theme support for JDEM; SOFIA (about which more later); and cost reserves and increased costs on ELVs for GLAST, LISA, and SIM.

The operating missions with the highest fevers were SOFIA and EUSO, which were each bright red. SOFIA was asking for a 15 – 20 M\$/year budget increase for 20 years. EUSO, the ultra-high energy cosmic ray detector of nitrogen fluorescence from a science payload attached to the ISS, is expected to be canceled by ESA (it was a mission of opportunity: the US part was OWL). The Keck interferometer and JWST were also running a fever.

Dr. Kinney reviewed the science centers and GO operations associated with the various missions. The theory budget shows an augmentation by as much as 40% over 4 years. This was accomplished in part by adding a theory component to mission operating costs. In fact, I just won a theory proposal through Swift, but I had the lowest grade ever on my Chandra theory proposal (we attacked a sacred CfA cow, namely, that the X-rays in the extended Chandra jets are due to Compton-scattered CMB). The ATP deadline is later this month, so I'll give that another shot (rejected last time). Thanks, Anne!

Michael Moore, having yet to see his movie, gave an HST update on the Robotic Servicing Mission. There are two major issues: power (battery life) and HST gyro life. HST is not permitted to fall back to Earth after it fails, and safety issues proscribe a human servicing mission. HST needs 3 operating gyros. Two of the six onboard gyros have failed, and one is degraded. Engineering estimates of failure rates with time were presented; they look like human mortality charts. The boldest plan was to have a Hubble Recovery Vehicle dock with HST, using the Special Dexterous manipulator "spidem." This robot could install the two instruments, gyros, and an autonomous reentry vehicle. The final design has not been decided, nor is there money identified for the project (probably in the 2 B\$ range). It would have to be developed in a very tight timeframe. Very ambitious, very high risk, very exciting, and very expensive.

Paul Hertz gave a presentation on the Explorer program, which is for launches capped at the ~250 M\$ level or less. Swift is Explorer #83. The first explorer was launched in 1958. The success of the Explorer program is because it is based on “ruthless capitalism.” Typically, over 30 proposals are submitted to realize two flight opportunities. Tough love is imposed, as witness the fates of FAME, IMEX, and SPIDR. Five SMEXes remain in Phase A competition (DUO, IBEX, JMEX, NEXUS, NuSTAR), in addition to ANITA, a mission of opportunity. Al Diaz will make the final up or down decision. In the near future, we have Swift, AIM in Sep 06, THEMIS in Oct 06, and WISE in Jun 08.

A list of the SEUS members with conflicts of interest (including me) was presented. The plan, in light of the redirection of funds in NASA’s budget, is now to downselect to two SMEXes in Nov 04, and to have a MIDEX AO in Summer 05. The practical effect is to have an AO delay of slightly more than one year, and the loss of approximately 2 launches during 2008 – 2012. (Note that Explorers are part of OS, SEUS, and SEC; Solar System Exploration has the Discovery AO.) If EUSO is canceled, the money, amounting to ~20 M\$, remains within the Explorer program.

Drs. Tom Greene, Jackie Davidson, and Chris Wiltsee (ARC) gave an Update & (discussion of) Operations Issues of SOFIA (Stratospheric Observatory for Infrared Astronomy). SOFIA is a 2.5 meter mid- to far-IR (0.3 – 1600  $\mu\text{m}$ ) telescope mounted on a Boeing 747 that flies into the stratosphere. It reaches better than 1.5 arcsecond sensitivity at 10  $\mu\text{m}$  and a 1 sigma, 1 hour limiting sensitivity of 1 mJy at 10  $\mu\text{m}$  (corresponding to  $\sim 3 \times 10^{-13}$  ergs  $\text{cm}^{-2}$   $\text{s}^{-1}$  at 10  $\mu\text{m}$  or  $3 \times 10^{13}$  Hz). Herschel will equal or better these stats between 100  $\mu\text{m}$  and 1000  $\mu\text{m}$ , and Spitzer currently has better sensitivity between 3 and 80  $\mu\text{m}$ . One of SOFIA’s assets is its broadband coverage.

SOFIA will contribute to galaxy evolution (SCUBA faint galaxies), provide a better image of the Galaxy’s central black hole, map high-mass star-tracing IR lines (e.g., [N III], [OIII], [SIII]) in nearby galaxies, study cradles of star formation, explore emerging stellar systems formed from protostellar accretion, as well as image protoplanetary dust and gas disks, chart the cycle of organic molecules in red giants and comets, measure transits of extrasolar planets, etc. This is very similar to the science performed by Spitzer, Herschel, SAFIR, and before it, ISO. No science unique to SOFIA was identified in response to a question, and the science linkage to other wavelength ranges was not mentioned.

SOFIA was designed to swap-out and upgrade instruments. It is facing considerable budget growth, not only for upgrading the instruments, but because of a plan to change it from a PI class mission to one supporting a GO program. The requested cost increase was ~15M – 20M\$ over a 20 year baseline mission, on top of an ~55 M\$ baseline budget, amounting to some 2 B\$ in a 20 year runout. This adds up to the costs of a facility class mission. Besides mission creep requirements, the SOFIA scientists were facing some changes in FAA regulations which contributed to cost growth. It also faces the prospect of Herschel, and retains a discovery time window in this waveband if it can be up and flying by 2007. Most missions face a cancellation review after they exceed 15-20% of their in-guide budgets, and SOFIA was in the 20 – 25% range, but there are extenuating

factors, as just described. A big issue (to some) is where that money would come from. An alarming possibility is that it would come out of suborbital (sounding rockets and balloons), and ballooning already faces its own budget challenges.

The SOFIA presentation appeared disjoint and unrehearsed and the science case was weak. I doubt SOFIA would compete favorably in a science per dollar/senior review. The SOFIA project staff should look for Air Force, DoD, or some homeland agency support at least to demonstrate that there is some interest outside their niche astro-community. They should enroll a theorist to promote their science; at least this part of the presentation left me disappointed.

Later that afternoon, Jonas Zmuidzinas (CalTech) presented a report on the NASA APWG (Astrophysics Program Working Group), a technology-planning group. There were the familiar issues: the mid-TRL gap; inter-agency technology development (e.g., with Code R [Technology]); the Technology Requirements Document that Mel Montemerlo was developing; enabling technologies for Origins and SEU; theory support; the balloon and sounding rocket programs. Several of these issues are overshadowed by the ongoing reorganization.

One issue noted by APWG that led into the next presentation was the fact that TPF (Terrestrial Planet Finder) had morphed into two missions: TPF-C (coronagraph) and TPF-I (interferometer). This has to do with parallel planning with ESA.

The last talk of the afternoon was by Dr. Chas Beichman (JPL) on TPF. He described the programmatic events leading to change in architecture of TPF into TPF-C, planned for visible light observations and to launch first in the 2015 time frame, and TPF-I /Darwin, developed jointly with ESA for mid-IR observations providing complementary and confirming data for planet characterization and biomarkers before the end of the data. At the time of the SEUS, a meeting on TPF/Darwin science was taking place locally. I got a copy of the abstract booklet. There is great science and cannot be adequately summarized here. TPF begins to realize some of Carl Sagan's ideas in *Pale Blue Dot*.

I asked Beichman if TPF-C could discover the nonthermal halos around star-forming (i.e., GRB-active) galaxies that I predicted in a 2002 ApJ paper. Unfortunately, the coronagraph blocking filter is as small or smaller, which is too small to block the galaxy light. It will, however, be good for host galaxy measurements of AGNs.

<<<<<End of Meeting on Day 1>>>>>

Evening of Day 1: we went to a Padres/Giants arranged by Paul Hertz. We took a water taxi from Shelter Island to the downtown stadium and had a wonderful boat tour of the San Diego Harbor. Paul was quite anxious and excited that we see "Padres welcomes NASA Space Science" on the opposite (small) monitor. Finally the message flashed, and we were thrilled for about 5 minutes when, on the really big board, the following

message was flashed: “PADRES WELCOME FORMER CHIEF ADMINISTRATOR OF NASA DAN GOLDIN HE OVERSAW 160 SUCCESSFUL MISSIONS...”

It was a great game, with the Padres losing 4-2 on a double play in the bottom of the ninth after having bases loaded and no outs. The symbol of the San Diego Padres is a fat friar striking out. Things haven't changed since I was a grad student at UCSD (except the Padres just moved this season from Jack Murphy to PetCo stadium).

Thanks for setting the game up, Paul!

<<<<<Meeting: Day 2>>>>>

The day began with an annual exercise to comply with the Government Performance Results Act (GPRA) by grading metrics established for the SEUS. The result was all green except for one blue for measuring the evolution of dark energy (WMAP and Chandra results).

Dr. Ed Weiler gave the Space Science Update, which was in effect his swan song as Associate Administrator. Dr. Weiler discussed the Aldridge Commission report, assessing it with the quotation that entitles this report, and summarized his accomplishments during his tenure, which are many and impressive (he did not mention the demise of CGRO). Dr. Weiler criticized Recommendation # 2 (out of 15) in the Aldridge Commission Report for NASA to implement a large presence of private industry in space operations, citing some prior examples in that model that left expensive messes for NASA to clean up.

Dr. Weiler reviewed his many successful Space Science mission launches, culminating in GP-B; budget augmentations saving OSS going from out of business; recent science highlights; EPO events; and upcoming launches, including Messenger to Mercury (August 2<sup>nd</sup>), CINDI and Deep Impact. Dr. Weiler argued that returning management to HQ from the centers was a major success (contra Goldin), and had the effect of doubling the NASA staff at HQ. He was questioned on how to handle the roadmap, answering that we should “... [be] on board with the vision,” and to “...get us off the beltway.” The blue vs. gray science dichotomy was described. From some past chart, NASA science was denoted as blue science if it's inline with the President's vision of exploration, and gray if it was high quality space science, but not directly related to the vision. For SEUS, is it better to be top gray or bottom blue?

Later that afternoon, we had updates on GP-B (Prof. Bradford Parkinson, Stanford), and on Herschel and Planck by Drs. Frerking and Parks (JPL NASA). The Herschel and Planck ESA-led missions are scheduled for a mid-2007 launch to L2 on an Ariane 5. Jeff Hayes from NASA/HQ gave a report on GO funding for A&P mission. The main issue was to protect R&A, and he concluded with the rule to “... try and grow R&A, but don't call it R&A.” Note that Spitzer oversubscription was only 3 to 1, much better than other GO programs.

<<<<<Meeting: Day 3>>>>>

Professor Garth Illingworth (Minnesota) reported on the AAAC (Astronomy and Astrophysics Advisory Committee, formerly the NAAAC). This committee, as recommended by the NAS, issues a report to the Executive Branch and Congress on Astronomy and Astrophysics in the US and interagency issues involving NSF and NASA (and evolving to include DOE). Some of the joint projects are the GSMT (Giant Segmented Mirror Telescope), JWST, LSST, JDEM, ATST, SDO, and a CMB task force. The programs are laid out in the AASC Decadal Survey, "Connecting Quarks with the Cosmos," and "The Physics of the Universe."

Later that morning, Jeff Hayes gave a second report on the Senior Review. Here are the points that I noted:

The Senior review will consider GALEX, XMM, FUSE, WMAP, RXTE, CHIPS, INTEGRAL, and HETE. RXTE will be terminated in 2006. HETE-2 has a 1 year overlap with Swift, and is then terminated. INTEGRAL had a FY 04 budget of 5.2 M\$. It needs to develop a healthier user community; right now the GO funding is deleted for the out years with no support for theory. INTEGRAL will pass through a gate to decide on removing GO funding in the out years. GALEX had an April 2003 launch and a 28 month prime mission. XMM was launched December 1999 and has a 5 year prime mission. FUSE was launched June 1999.

Data retrieving and archiving activities, including ADS, MAST, HEASARC, NED, IRSA, LAMBDA (a CMB archive), and the Interoperability Initiative, were discussed. ADS has become (and I speak not only for myself) a vital astro resource.

Michael Salamon gave the SEU Theme Update.

Swift was shipped the previous day. The first tower on GLAST had been completed during the summer. Astro-E2 is scheduled for launch Feb. 2, 2005. Regarding EUSO, ESA has declined to endorse it for flight at high priority. The US contribution is a large Fresnel lens. After an extended Phase A study, ESA will give it a go or a no-go. Because of the President's Exploration Initiative, as previously noted, LISA funding was significantly reduced. They are negotiating with ESA over mission responsibility, system engineering, and project management. Application for membership in the LIST is due 2 months after August 1<sup>st</sup>.

NASA is looking at an alternative architecture for Con-X, in light of a different design for a large European X-ray mission with two rather than 4 spacecraft.

In order to put a mission in the queue to be developed, it is important first to have a science definition team that devises Level 1 Science Requirements. Then a Strawman Design concept is developed. ACT scientists take note, if there is to be an ACT in my lifetime's lifetime.

The final issues that arose for the SEU were: Should SEU be gray or blue? How to respond to the Aldridge Commission Report? Is STEP a good thing to do? How to mobilize Code U fundamental physics in the Universe R&A program? What will be the impact of the requested augmentation of the SOFIA budget?

I left the meeting early, escaping any duties related to drafting the Letter to Anne Kinney. I caught an early (12:30 pm) plane, hoping to get home that evening. My flight made a connection through D/FW, but the airport and cities were rained out, so I spent the night in a hotel in San Antonio. American Airlines: Distressed Passenger.

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p.s., since this meeting, NASA has announced plans to develop a robotic servicing capability to repair HST. They have not announced from where this money is to come.