HUBBLEÕS SCIENCE LEGACY: FUTURE OPTICAL-UV ASTRONOMY FROM SPACE
INVITED TALKS

Speaker **Anne Kinney, NASA Headquarters**
Title **Building the vision of the Future in Space Astronomy & Physics**
Abstract This talk will present the NASA and OSS process and rationale for the strategic planning and road mapping. The content of the current program in the Astronomy and Physics division will be presented, and the possibilities and procedures for including new content will be discussed.

Speaker **Alvaro Gimenez**, ESTEC, The Netherlands
Title **The Future of Optical Astronomy in ESA's Science Programme**
Abstract A summary of the present status of the Science Programme of the European Space Agency will be presented, followed by a more focused discussion on the main activities in the field of optical astronomy. The missions are defined in response to specific and relevant scientific questions rather than trying to provide general-purpose facilities. In this context, GAIA will provide the necessary tool to understanding our Galaxy and its content, by surveying around one billion stars, whilst Eddington is aimed at the study of stellar structure and the search for extra-solar earth-like planets in the habitable zone. Moreover, technology developments are being pursued to ensure the availability of focal plane arrays of detectors with the required performances as well as to test capabilities in space interferometry.

Speaker **Roberto Gilmozzi**, ESO Munich, Germany
Title **Ground based astronomy in 2010-2020**
Abstract The second decade of the third millennium will be characterized by the mature phase of the present generation of 8 to 10m telescopes, with a complement of instruments performing at the diffraction limit through adaptive optics. Interferometry will have entered the 'faint object' regime, with VLTI obtaining milliarcsecond(s) resolution on K~20 sources. ALMA will explore the mm and sub-mm universe both locally and at very high redshifts. And one or more of the new generation of 30 to 100m telescopes (CELT, GSMT, OWL) will be in construction or starting operations. I will review the expected performance and science cases for these projects (with a slight bias for those in which ESO is involved). I will also briefly discuss the complementarities among these facilities, and between these and space missions.

Speaker **Alan Dressler**, Carnegie Observatory
Title **The Optical-IR Astronomy Landscape in 2015**

Speaker **Martin Harwit**, Cornell University
Title **Thoughts on a Powerful New Ultraviolet Facility**
Abstract The talk will seek to examine the potential of a large ultraviolet space telescope and its prospective instrumental components in the context of our continuing search through the Universe.

Speaker **Michael Shull**, The University of Colorado at Boulder
Title **Highlights of the SUVO Study**
Abstract I provide a summary of the scientific and technological goals of the SUVO (Space Ultraviolet-Visible Observatory) mission study, commissioned by NASA in 1998-99. The full report may be obtained as the SUVO white paper, available at astro-ph/9907101 and on the UVOWG website: http://origins.colorado.edu/uvconf/uvowg.html. The UVOWG was asked to study the scientific rationale for new missions in ultraviolet/optical space astronomy. A large-aperture telescope in space would provide a major facility for understanding the Emergence of the Modern Universe and for addressing such issues as: (1) mapping dark baryons, metals, large-scale structure, and dark-energy equation of state; (2) detecting unseen matter through weak gravitational lensing; (3) studying the feedback from star formation; and (4) measuring the evolution of stars, planets, and elements from red shifts z = 3-4 down to the current epoch. In the last several years, it appears possible that the SUVO concept might also address exciting new goals in the study of extra-solar planets and their atmospheres, through UV/O coronagraphy. The UVOWG studied both 4m and 8m telescopes, and made recommendations about the critical technology development for high-quantum-efficiency ultraviolet detectors, gratings, mirrors, spectrographs, and wide-field optical/UV imagers (at least 16K x 16K).

Speaker **Peter Garnavich**, The University of Notre Dame

Title **The Future of Supernova Research**

Abstract Supernovae are the movers and shakers of the Universe. They provide most of the heavy elements, energize the interstellar medium and their shocks can induce stars to form. Type Ia supernovae are the brightest, most precise distance indicators around and provide estimates of key cosmological parameters. The future of supernova research is bright as new facilities can help address key problems in a variety of fields. Supernovae are UV beacons which permit us to measure properties of the interstellar medium in our own and other galaxies. The slow-motion train wreck that is SN 1987A has really just begun and over the next 20 years X-ray, UV, optical and IR observations will illuminate how shocks work and how massive stars evolve. There is some evidence today that SN and GRB are linked, but much more needs to be learned about the symmetry of SN explosions and jets. And a key cosmological question concerns the progenitors and properties of type Ia supernovae. Future facilities require a rapid response to new discoveries to fully utilize the power of supernovae.

Speaker **John Hutchings**, Dominion Astrophysical Observatory

Title **Accretion binaries and other stellar problems**

Abstract I will discuss accretion phenomena in binaries that also have wider implications. Future progress in some of these will require new optical-UV facilities in space, which will be outlined. Some other stellar topics will be mentioned that also require a new orbiting facility**.**

Speaker **Andrea Dupree,** Harvard-Smithsonian, Center for Astrophysics

Title **Cool Stars And The Future**

Abstract Recent discoveries selected from ultraviolet spectroscopy and imaging of cool stars define challenging questions for future observations ranging from planet-cool star interactions, imaging of stellar surfaces and environments, to pursuit of faint objects populating the depths of globular cluster cores. Spectroscopy of fiducial galactic stars and star clusters and study of abundances, atmospheric structures, winds and mass loss drive future opportunities involving stars and clusters associated with extragalactic objects.

Speaker **Guisseppe Bono,** Observatory of Rome Italy

Title **Evolutionary and pulsational properties of intermediate-mass stars: current odds and future perspectives**

Abstract We briefly discuss the theoretical scenario concerning evolutionary and pulsational properties of intermediate-mass stars. In particular, we focus our attention on current discrepancies between predicted and empirical Color-Magnitude diagrams during the helium burning phases (blue loops). We also outline the impact that new Optical-UV data will have on the pulsation properties of classical Cepheids, and in turn on the Cepheid distance scale.

Speaker **Michael Meyer**, The University of Arizona, Steward Observatory

Title **Beyond the Cosmic Veil: Space-based Star and Planet Formation Research after SIRTF & NGST**

Abstract What physical processes are responsible for determining the final masses of forming stars and ultimately the initial mass function? How do planets form from circumstellar disks of gas and dust? The Hubble Space Telescope has made major contributions in helping to address these fundamental questions. In the next decade, the Space Infrared Telescope Facility (SIRTF) and the Next Generation Space Telescope (NGST) will build on this heritage in the near- to far-infrared. However several crucial questions will remain. We will review recent progress made in star and planet formation with HST, key science objectives for SIRTF and NGST, and suggest problems that are uniquely suited to large aperture UV/optical space-based telescopes. We will focus on studies that take advantage of high spatial resolution and the unique wavelength range inaccessible from the ground such as: 1) extreme populations of young stars in the local group (UV observations of massive star-forming regions); and 2) circumstellar disk structure and composition (observed in scattered light images of dust and UV spectroscopy of gas).

Speaker **Lee Hartmann**, Harvard-Smithsonian Center for Astrophysics

Title **Problems in Star and Planet formation**

Abstract I outline some of the major unresolved questions in the field of star formation and early evolution of proto-planetary disks, with special emphasis on those issues that might be best resolved with a large space optical/UV telescope. One possible area is to determine whether the high-mass end of the stellar IMF is or is not environment-dependent; extragalactic studies in regions with much more extreme conditions than found in the Milky Way may be essential to settling this question. Our knowledge of the rate of material accreting through proto-planetary disks is dependent on observations in the blue-ultraviolet region, and needs to be expanded dramatically if we are to understand the physics of disk accretion. The chemistry and possibly evolution of proto-stellar disks may be crucially dependent upon FUV fluxes from young stars, which are poorly known at present. UV observations may also be essential to understanding how the gas is dispersed from disks, an unknown but crucial issue in understanding planetary formation and migration. Understanding the basic properties of proto-stellar jets and winds may only be possible with UV observations. Finally, images in scattered light at short wavelengths may reveal disk structure with sensitivity unmatched at other wavelengths.

Speaker **Glen Schneider,** University of Arizona

Speakers **Melissa McGrath**, STScI, Baltimore
John Clarke, Boston University
Walter Harris, University of Wisconsin

Title **Solar System UV/Optical Astronomy & the Future of Space-based Observations**

Abstract Solar system observations using HST have been tremendously successful in many scientific areas, taking advantage of the wealth of information from high angular resolution images and high sensitivity UV to IR spectra. These capabilities have led to major advances in the areas of planetary atmospheres, surfaces, aurora and magnetospheres, and planetary satellites. While solar system objects are normally considered to be bright, they are often quite faint in the UV, and much new science could be accomplished with a larger aperture, extending existing studies to the outer planets and fainter satellites, Kuiper belt objects, etc. These observations would assist in the still-incomplete inventory of solar system objects and compositions. At the same time, many solar system objects have now been visited by space missions, and characterized in greater detail than remote telescopic observations could do. In these cases, the major new scientific thrusts tend to be on temporal coverage to establish causal relationships between known and variable phenomena. Therefore, the future of solar system observations would greatly benefit from increased time coverage with a modest aperture but more observing time, in addition to other kinds of science that would be made possible with a larger aperture. The three solar system talks will provide a brief overview of the potential science that could be done with the next generation UV-optical space telescope. We intend to cover the broad areas of comets, Kuiper Belt Objects, satellites, and planetary atmospheres (including aurora), detailing the most promising areas for advancement in the coming decade. The first two talks will concentrate on the science goals. The last talk will summarize the most important capabilities and considerations, driven by the science goals, for future solar system observations.

Speaker **Chas Beichman**, JPL, Pasadena

Title **NASA's Origins Theme: results from TPF architecture studies**

Abstract NASA has made the search for life, both inside and beyond our solar system, a focus of its space science program. The goal of the Terrestrial Planet Finder (TPF) is to search for earth-like planets and signs of life. Recently completed architecture studies suggest that both infrared and visible light techniques offer plausible solutions to the daunting observational problems this goal presents. I will summarize NASA's program, the results of recent studies, and the prospects for international collaboration on TPF.

Speaker **Mark Clampin** STScI, Baltimore

Title **Strategies for extra-solar planet characterization with large aperture telescopes.**

Abstract We will discuss current issues in the study of extra-solar planets where a large aperture, optical space telescope (OST) could make a significant impact. Strategies suitable for extra-solar planet detection will be reviewed, and constraints placed on the required telescope performance. We will discuss in detail the problem of detecting terrestrial planets with a large aperture OST, including strategies for their detection, and characterization.

Speaker **Wes Traub**, Harvard-Smithsonian Center for Astrophysics

Title **Extra-solar Planets and Biomarkers**

Abstract Several recent studies have shown that it is technically feasible to use a 10-m class optical telescope to detect and characterize nearby terrestrial planets. The proposed designs are based on a general-purpose UV-optical telescope, with no obscuration (i.e., an off-axis design), about 10 m diameter along the major axis and about 4 m on the minor axis, equipped with a variety of focal-plane instruments. For planet finding, the instrumentation can include selectable field masks and pupil-image masks, allowing operation as a high-dynamic range coronagraph. The scientific efficiency of this class of coronagraphs is very high, as is indicated by one study, which showed that 150 nearby stars could be searched for an Earth-like planet, with a signal-to-noise ratio of 5, at an angular separation corresponding to each star's habitable zone, within a total time of about 1 month, including maneuvers, give or take a factor of two, depending on the details of the design. In this talk I will discuss the types of coronagraphs, which appear capable of carrying out this program. I will focus particularly on the types and strengths of biological markers, which we might use to search for life on a terrestrial planet, once it is found. These markers include the presence of UV-visible-near-IR absorption features due to O_2, O_3, H_2O, CH_4, and CO_2, and also enhanced-reflection features due to Rayleigh scattering and chlorophyll in land-based vegetation. The expected spectral signatures of various cases of the early Earth will be discussed.

Speaker **Jonathan Lunine**, The University of Arizona, Lunar & Planetary Lab.

Title **The occurrence and observability of giant planets and terrestrial planets around other stars.**

Speaker **Mike Rich**, UCLA

Title **Stellar Populations Science in the era beyond Hubble and NGST**

Abstract I consider the role for an 8-10 m optical/ultraviolet successor to the Hubble Space Telescope and NGST, and its application to the study of stellar populations in the Milky Way and beyond. The white dwarf cooling age will be measurable for most Galactic and Magellanic globular clusters as well as for the Galactic bulge. Among the problems such a telescope might address would be main sequence turnoff ages for the populations of galactic halos, even at the distance of the Virgo cluster, as well as in high surface brightness regions such as the disks and bulges of Local Group galaxies. I consider what requirements the facility must meet to be capable of addressing these problems.

Speaker **Eva Grebel,** MPI for Astronomy, Heidleberg

Title **Evolutionary Processes in Galaxies**

Abstract We still do not know what governs evolutionary processes in galaxies. In particular, it is unclear what impact environment has versus the importance of the intrinsic properties of the galaxies themselves. The Local Super cluster and Local Void provide an ideal and diverse environment to investigate these questions in detail. Studies of this kind require a reliable three-dimensional picture of the field galaxies, galaxy groups, and galaxy clusters (e.g., Virgo and Fornax) in our neighborhood. I will discuss how we could connect our knowledge of galaxy loci to their structure and evolution. Ideally, future space facilities should provide data from which we can derive (1) accurate star formation histories from resolved stellar populations, (2) high-quality distances based on well-calibrated distance indicators, (3) kinematical information and three-dimensional motions, and (4) chemical evolution.

Speaker **Harry Ferguson**, STScI, Baltimore

Title **Stellar Population Challenges for the Next Decade**

Abstract Stellar populations outside the Milky Way provide both the fossil record of galaxy formation, and valuable laboratories for studying stellar evolution. We outline a variety of challenging issues unlikely to be fully addressed by HST or NGST in the next decade. Issues range from the formation of galactic halos, bulges, and disks, to investigating stellar evolution in the core-helium burning phase and beyond. We outline the requirements for wavelength coverage, sensitivity, resolution, and field of view necessary to meet these challenges.

Speaker **Jill Bechtold**, The University of Arizona, Steward Observatory

Title **Studies of the IGM with the next generation space facility**

Abstract The work being done now with the Hubble Space Telescope has only begun to tap the richness of the information on cosmology and galaxy formation contained in high-resolution spectroscopy and deep optical/UV imaging. With the next generation facility, we can do comprehensive studies of the structure and evolution of the IGM, the role of galaxy winds in chemical enrichment and heating of the IGM, as well as make the first studies of rare and reddened objects. By combining UV spectroscopy with optical imaging, we can get a clear picture of one of the most compelling stories in modern astronomy: exactly how the large galaxies like our Milky Way were assembled out of the small star-forming fragments and intergalactic gas during the last ten billion years.

Speaker **Jason Prochaska**, Carnegie Observatory

Title **Probing Chemical Evolution, Dust Formation, Nucleo-synthesis, and Star Formation in the ISM of z<1 Galaxies.**

Abstract Over the next decade, the combined observing power of ground-based telescopes will yield an enormous database of physical diagnostics on the ISM of high z galaxies via QAL studies: chemical abundances, dust depletion patterns, nucleo-synthetic histories, photo-ionization properties, etc. These studies are limited, however, by the challenges of studying high z galaxies in emission. In contrast, one can apply the same techniques at z<1 and study the absorbing galaxies in emission to relate the gas properties with galaxy luminosity, type, etc. This can only be achieved with high resolution, high S/N UV spectroscopy and the light gathering power of the next HST is essential. Irrespective of comparisons with the high z sample, these observations will reveal the chemical enrichment history at z<1, track the formation of molecular hydrogen and dust grains, enable the study of the multi-phase ISM, and probe star formation rates for galaxies with a wide range of luminosity, mass, and Hubble Type. In concert with the extensive optical observations, these UV surveys will have tremendous impact on our understanding of galaxy formation and evolution and provide complimentary diagnostics to the results obtained from galactic imaging and spectroscopy.

Speaker **Jane Charlton**, Penn State University

Title **Studying the gaseous phases of galaxies with background QSOs**

Abstract High resolution rest frame UV quasar absorption spectra covering low and high ionization species, as well as the Lyman series lines, provide remarkably detailed information about the gaseous phases of galaxies and their environments. For redshifts less than 1.5, many important chemical transitions remain in the observed ultraviolet wavelength range. In this talk, I will present examples of absorption that arises from lines of sight through parsec scale pockets of gas at solar metallicity that are not associated with giant galaxies, from a group of galaxies at redshift one, from a pair of dwarf galaxies, and from super wind structures. These examples are drawn from UV spectra recently obtained with HST/STIS. Even with the greater sensitivity of COS there is a limit to how many systems can be studied at this level of detail. Yet there is great variety in the morphology of the phases of gas that we observe, even passing through different regions of the same galaxy. In order to compile a fair sample of the gaseous structures present during every epoch of cosmic history, hundreds of systems must be sampled. Multiple lines of sight through the same structures are needed, as well as some probing nearby structures whose luminous hosts have been studied with more standard techniques. Combined with high resolution optical and near-IR ground-based spectra, it will be possible to uniformly study the gaseous morphologies of galaxies of all types through their entire evolutionary histories.

Speaker **Ken Sembach**, STScI, Baltimore

Title **Probing Baryons in Galactic Halos and Gas Near Galaxies**

Abstract The Milky Way and other galaxies have gaseous envelopes produced by a variety of processes. Some of these galactic halos may be the direct result of evolutionary changes in the galaxies (e.g., starburst activity, tidal interactions), and others may be remnants from the galaxy formation process itself. Understanding the origin of these galactic halos and the hot gas in the vicinity of galaxies in the nearby universe presents a major observational challenge. Ultraviolet absorption-line spectroscopy is a direct means for exploring the gas in galactic environments, but even with present (and near-term) facilities the number of background objects available to probe nearby galaxy halos and low-redshift cosmological structures is limited. Identifying and mapping these structures over a range of impact parameters and angular separations would provide fundamentally new information about the baryonic content of the gas, its extent, its physical conditions, and its origin. A large space-based telescope optimized to perform high-resolution spectroscopy in the 900-3200A wavelength region at sensitivity sufficient to observe faint AGNs at angular separations of 1 degree would be ideal for such studies

Speaker **Jeffrey L. Linsky,** The University of Colorado at Boulder

Title **Precise measurements of Hydrogen, Deuterium, and Metals and the structure and physics of the Nearby Interstellar Medium**.

Abstract High-resolution spectra in the ultraviolet and optical from HST, FUSE, and ground-based telescopes are providing important information on the structure and physical properties of the local region of the Galactic disk. This ongoing study is critically important because a detailed understanding of our local region of space provides essential guidance for understanding the ISM elsewhere in the Galaxy, in other galaxies, and even the IGM. I will describe the important questions that must be answered and the observational capabilities that are needed in future space telescopes to answer these questions.

Speaker **Laura Ferrarese**, Rutgers, The State University of New Jersey

Title **The Formation and Evolution of Super massive Black Holes**

Abstract The study of super massive black holes (SBHs) received a tremendous boost with the launch of HST. At optical wavelengths, the factor 10 increase in spatial resolution compared to ground-based facilities allowed morphological and dynamical studies on a few parsec scales for galaxies as far as the Virgo cluster. By resolving the SBH "sphere of influence", i.e. the region of space within which the SBH gravitational potential dominates over that of the surrounding stars, HST has lead to the dynamical detection of SBHs in approximately two dozen galaxies. Although this sample is by no means complete, it has revealed a tight connection between the masses of the SBHs and the large-scale properties of their host galaxies. It is probably unrealistic to hope that HST's contributions to this field during its second decade in orbit will equal those of its first. However, many outstanding issues remain, most notably, the poorly contained low-mass end of the SBH mass function, possible connections between SBHs and the mass of the DM haloes in which they presumably formed, and the evolution of SBHs binaries. In this contribution, I will identify the technological advancements that are required to address these questions.

Speaker **Tim De Zeeuw**, Sterrewacht Leiden, The Netherlands

Title **Integral-field spectroscopy of galactic nuclei**

Abstract High-resolution imaging and long-slit spectroscopy with HST, combined with ground-based integral-field spectroscopy, provides the kinematics of stars and gas in nearby galactic nuclei with sufficient accuracy to derive the intrinsic dynamical structure of the nuclei, and to measure the mass of the central black hole. This has revealed that many nuclei contain decoupled kinematic components and asymmetric structures, and that nuclear and global properties of galaxies are correlated. Higher spatial resolution and significantly increased sensitivity are required to cover the full range of galaxy properties and types, including the nearest powerful active radio galaxies, and to study the evolution of galactic nuclei as a function of redshift. The prospects in this area will be discussed, starting with AO-assisted instrumentation on 8m class ground-based telescopes.

Speaker **Brad Peterson**, Ohio State University

Title **The Structure and Energetics of Active Galactic Nuclei**

Abstract While the black-hole/accretion-disk paradigm for active galactic nuclei (AGNs) is now reasonably secure, there are still important questions to be addressed, and some of these will require the capabilities of an 8 to 10-m class UV/optical space-based telescope. Imaging spectroscopy with a diffraction-limited large telescope will be required to measure AGN black-hole masses from stellar dynamics for direct comparison with reverberation mapping-based masses. High spectral resolution in the UV is required to determine the mass and kinetic energy of the outflows observed in the absorption spectra of AGNs and to understand the energetics of the accretion process. As with ground-based astronomy, however, effective use of a large UV/optical space telescope requires complementary smaller facility instruments; a meter-class UV spectroscopic telescope, for example, can fit comfortably into a Medium Explorer budget.

Speaker **Erica Ellingson**, The University of Colorado at Boulder

Title **Galaxies in Groups and Clusters: Linking Mega-parsec to Parsec Scale**s

Abstract One of the most compelling themes in the study of nature is the interconnection between phenomena on different scales. Galaxy groups and clusters provide important opportunities to connect the cosmologically driven evolution of the universe on Mpc scales, to the formation and evolution of galaxies, to the physical conditions, which control star formation. The Hubble Space Telescope has provided key information about the distribution of light and dark matter in clusters, and the evolution of galaxies in groups and clusters. However, we still lack a detailed physical understanding of the forces, which affect the formation, and evolution of galaxies in different environments, and the feedback from galaxies into the intergalactic medium. High-resolution optical/UV observations, particularly across a wide field of view, will allow us to trace gas and stars in galaxies, galaxy dynamics and morphologies, and their relation to the assembly of large-scale structure.

Speaker **Kurt Adelberger**, Harvard-Smithsonian Center for Astrophysics

Speaker **Rachel Somerville**, The University of Michigan

Title **A Theorist's Wish list: what we want to know about galaxy formation and how Hubble's successor can help**.

Abstract A basic framework for understanding how the primordial density fluctuations that left their imprint on the CMB evolved into galaxies and clusters is now in place. However, with improved constraints on the values of the cosmological parameters, and correspondingly on the initial fluctuation spectrum, it has become clear that there cannot be a very straightforward connection between the dark matter halos that form via gravitational collapse, and the baryons that we can directly observe. Some of the major unanswered questions that arise in the attempt to make this connection include the following: How are the angular momentum of the dark matter and baryons related, and does this relationship change over the history of a galaxy? What is the importance of various feedbacks, including heating, outflows, and photo-ionization from massive stars and AGN? What regulates star formation? What determines the fraction of light that is reprocessed by dust, and how does this quantity change with cosmic epoch? What is the physical origin of scaling relations such as the Tully-Fisher and fundamental plane relation? What determines the "Hubble type" of a galaxy, and how does their large-scale environment affect galaxy properties? I shall attempt to suggest observations that would help to answer [some of] these questions and would be uniquely attainable by a space-based optical-UV telescope. I shall also identify areas of synergy with other recent or planned non-optical facilities such as Chandra, SIRTF, and NGST.

Speaker **Matthias Steinmetz**, The University of Arizona

Speaker **Chris Kochanek,** Harvard-Smithsonian Center for Astrophysics

Title **Gravitational Lenses**

Abstract The use of lenses to study cosmology, dark matter and galaxy evolution is limited by the difficulty in finding and characterizing the systems. Current samples are approaching 100 lenses and near term projects should be able to find 1000 lenses, so we discuss how future projects can produce a sample of 10000 lenses.

Speaker **Michael Turner**, The University of Chicago

Title **Dark Matter and Dark Energy: The Critical Questions**

Abstract More than 99% of the Universe is dark. Two-thirds exists in a strange, diffuse energy form with repulsive gravity (dubbed dark energy). We have strong evidence that the bulk of the other third (about 29% of the total) is not ordinary matter. Unraveling the nature of the dark matter and dark energy will not only complete our knowledge of the composition of the Universe, but will also likely shed light on the fundamental forces and particles of nature. Astronomical observations are at present our best (and only) hope for understanding dark energy. They also have promise for shedding light on the nature of the dark matter. Equally interesting -- but not the topic of my talk -- is what form the dark baryons take on (almost 90% of the baryons are dark).

Speaker **Harley Thronson, NASA Headquarters**

Title **Long-Range Technology Planning in NASA's Office of Space Science**

Abstract The Strategic Plan for the Office of Space Science (OSS) lays out a very ambitious set of science goals to be achieved over the next few decades. In turn, these goals will require complex and highly capable space observatories operating at a number of wavelengths. And, if these missions are to succeed, it will be essential that investments in enabling technologies be undertaken sufficiently early that they will be mature in time for mission readiness. Aspects of identifying and prioritizing key technologies will be discussed in this presentation, including (1) coordination among the OSS Divisions; (2) relevant investments by the Office of Aerospace Technology (Code R) that enable future OSS missions; (3) coordination across Enterprises and with other government agencies; (4) Priorities of NASA's agency-wide planning team that may be relevant to future space astronomy missions; and (5) the priority technologies within OSS to enable future space astronomy missions.

Speaker **Roger Angel**, The University of Arizona, Steward Observatory

Title **Ground vs. space platforms for future large optical/infrared telescopes**

Abstract New research areas in cosmology and extra-solar planets place extraordinary demands on post-Hubble telescopes. We will explore the complementary uses and relative strengths of ground and space for exploratory missions and long-lived observatories to take advantage of emerging technologies. These include new ways to make large optics and deployable, lightweight, cryogenic space mirrors, larger expendable launch vehicles, multi-conjugate adaptive optics with laser guide stars and extreme starlight suppression for exo-planet spectroscopy

Speaker **Bruce Woodgate,** NASA GSFC

Title **UV and Optical Detectors for Space — Progress and Prospects**

Abstract I will discuss the findings of a recent NASA committee, chaired by Chris Blades, which advised on a roadmap for UV and optical detectors. Two-dimensional photo-emissive and photoconductive array detectors, and three-dimensional energy-resolving detectors will be covered.

Speaker **Tone Peacock**, ESTEC, The Netherlands

Title **Super conducting tunneling junctions for optical-uv astronomy**

Abstract Superconducting tunnel junctions are being developed by ESA as non-dispersive photon counting spectrometers for optical and UV astronomy. The current state of development will be reviewed and the projected performance based on low band gap materials will be discussed.

Speaker **David Spergel**, Princeton University Observatory

Title **Coronagraphs for Terrestial Planet Finding**

Abstract A properly designed 4-meter class optical telescope will be capable of imaging and studying Earthlike planets around nearby stars. I will discuss the design requirements for such a telescope: thermal and dynamical stability, exquisite control of scattered light, and a coronagraph that not only suppress the star light but also corrects for amplitude and phase errors in the wave front. While the baseline design for a "TPF-lite" would be a 4 meter diameter telescope, a 2m x 6m elliptical or square telescope would be capable of studying the habitable zone in 3 times as many stars, so is worthy of consideration.

Speaker **Ph. Gondoin, ESTEC, The Netherlands**

Title **The Darwin-GENIE experiment: an ESA-ESO partnership**

Abstract Darwin is one of the most challenging space projects ever considered by the European Space Agency (ESA). Its principal objectives are to detect Earth-like planets around nearby stars and to characterize their atmospheres. Within the frame of the Darwin programme, the European Space Agency (ESA) and the European Southern Observatory (ESO) intend to build a ground-based technology demonstrator. Such a demonstrator built around the Very Large Telescope Interferometer (VLTI) in Paranal (Chile) will test some of the key technologies required for the Darwin Infrared Space Interferometer. The presentation will describe the objectives of the project.

Speaker **Jerry Nelson,** Lick Observatory

Speaker **Larry Simmons** JPL, Pasadena

Title **Technology Considerations: The First Steps**

Abstract The planning and building of a major observatory in space has taken 15 or more years in the past. Recent experience has identified some of the elements that prolong the process. Clear science objectives, which are used to establish requirements, are essential. In addition, a clear vision of how the observatory will be developed and used is necessary if its approval requires concurrence by independent reviewers (and it almost always does). The needed technologies must be defined and credibly available. A large telescope may require some critical deployments. A Hubble class observatory will need a high precision pointing control system. Instruments in the observatory will be based on yet undefined sensor technologies, which must mature early in the development cycle. Launch and operations will depend on where in space the observatory is to be located, as will the requirements for lifetime and maintenance. Most of these factors will have to be addressed in an observatory level cost/benefits evaluation led by the science community.

Speaker **Joe Rothenberg**

Title **Human construction and servicing of space observatories beyond low earth orbit**

Abstract I plan on talking about the utilization of Humans to enhance Science. Specifically I will discuss the considerations and advantages, based on recent studies, of having Humans construct and potentially service large aperture telescopes at places beyond Low Earth Orbit.

Speaker **Steve Kilston**, Ball Aerospace & Technologies Corp.

Title **Large-Optics Technology Lessons from Ball's NGST and TPF Programs**

Abstract Ball Aerospace and Technologies Corp. and its partners have been considering many large space-astronomy design concepts, especially through our work on the Next Generation Space Telescope (NGST) and Terrestrial Planet Finder (TPF) programs. During those efforts our teams strove to be open-minded and creative about design approaches and suitable technology elements. Our evaluations of the candidate concepts were based on performance, costs, and technology risks and required development. We assessed many performance factors relevant to an optical-UV successor to the Hubble Space Telescope (HST), such as system sensitivity, angular resolution, and usable fields of view. Our teams investigated key technology issues such as attitude control, thermal and vibrational disturbances, ease of launch and deployment, and operational reliability beyond Earth orbit (if that's required). In the case of TPF we considered several large-optics designs operating at optical wavelength bands, with wave front quality more than adequate for UV operation too. We'll discuss here some of our work's potential implications for choosing an HST optical-UV successor's technologies.

Speaker **John Mather**, NASA GSFC

Title **Starting a New Project: Thoughts from NGST**

Abstract I will review some key elements of the history of NGST that made a new mission possible, from the very beginnings to the present moment in the middle of selecting a prime contractor. I will make a few forecasts of the possible discoveries that may precede the launch of a new UV telescope, in hopes of inspiring sufficiently ambitious goals that they will still be exciting in 15 or 20 years. I will also discuss the enabling technology for NGST and my thoughts on enabling technology for a UV telescope. Hint: they are not all about detectors and mirrors!