National Aeronautics and Space Administration

NASA Strategic Needs for Ground-Based Optical and NIR Astronomy

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Presentation to Committee on a Strategy to Optimize the U.S. Optical and Infrared System in the Era of the Large Synoptic Survey Telescope

Astrophysics

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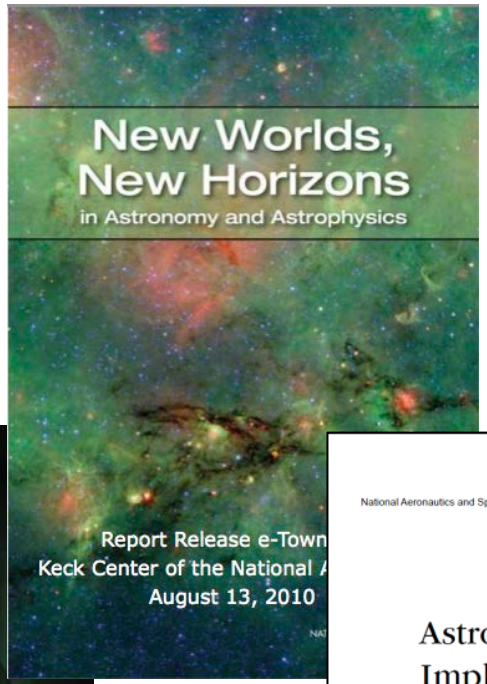
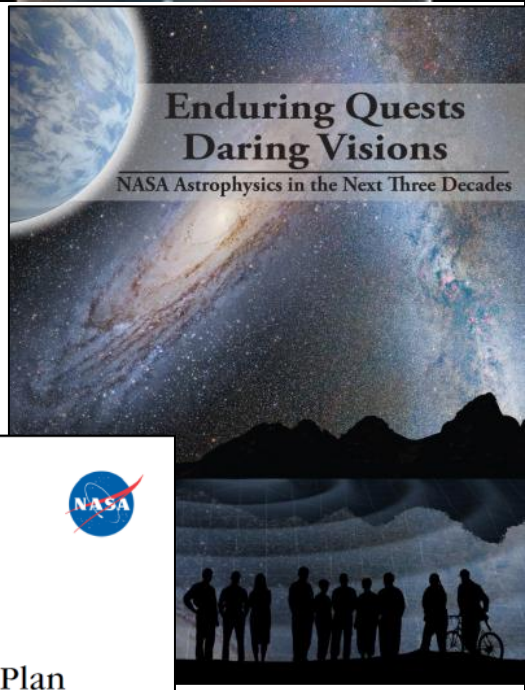
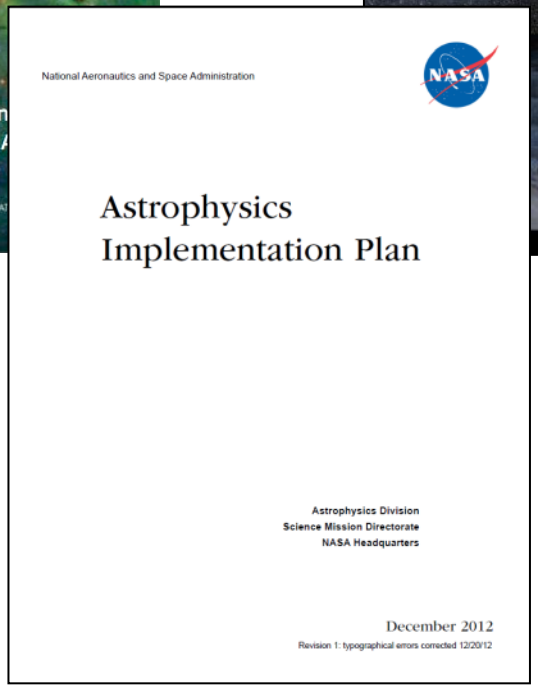
Astrophysics Driving Documents







http://science.nasa.gov/astrophysics/documents

NASA Strategic Needs

- NASA use of optical and NIR ground-based telescope facilities is based on strategic and specific needs that respond directly to the:
  - development of space science missions (e.g., technology testbeds & instrumentation)
  - interpretation and understanding of space data (e.g., science & mission support)
  - exploitation and maximization of space data and archives (e.g., simultaneous observations, collection of ancillary data, independent validation and verification).
- NASA-funded involvement in ground-based facilities has included:
  - NASA-owned: Infrared Telescope Facility (IRTF, 3.0m) – Mauna Kea, HI
  - NASA partnership
    - Keck Observatory (2x10m telescopes and interferometer; 1/6 investment of facilities and operations since 1996) – Mauna Kea, HI
    - Large Binocular Telescope Interferometer (2x8.4m) – Mount Graham, AZ
  - NASA dedicated time
    - UK Infrared Telescope (3.8m, UKIRT) – Mauna Kea, HI
    - Arecibo Radio Telescope (305m) – Arecibo, PR
  - Others (NEO search facilities, optical communication testing facilities, DSN antennae, etc).

Astrophysics –Examples of Current Strategic Mission Support Needs (1 of 2)

- **Hubble Space Telescope**
  - NIR spectra of deep field high-redshift galaxies
  - Direct imaging of large scale structure features (i.e., gravitational lensing)
  - Extensive spectroscopic studies of supernovae (Type Ia) and progenitor environment using adaptive optics
  - Synoptic monitoring of Solar System planets (Mars, Jupiter, Saturn, Neptune, Pluto)
- **Spitzer Space Telescope**
  - NIR observations of transiting exoplanets and planet atmospheres
- **SOFIA**
  - Contemporaneous observations of planetary occultations
- **Herschel Space Observatory & Planck Mission**
  - Far-infrared observations of millimeter-bright and -faint AGN and radio galaxies

Astrophysics –Examples of Current Strategic Mission Support Needs (2 of 2)

- **Swift Gamma-ray Burst Explorer & Fermi Gamma-ray Space Telescope**
  - Pulsars and GRBs optical follow up and identification of X-ray and Gamma-ray flashes
- **NuSTAR**
  - Supportive observations of AGNs, black holes and center of the Galaxy
- **Kepler Prime Mission**
  - Doppler studies of exoplanets (40 V=12 mag stars/yr, <1.5 m/s) from radial velocity measurements obtained by Keck/HIRES.
  - Imaging with Laser AO critical for validating smallest planets (RV too small)
  - Stellar spectra of host stars to validate candidate exoplanets
- **Kepler K2 Mission**
  - Validate and characterize V=12 to 14 mag KOIs, including galaxies, stars, exoplanets, nebula, etc.

Astrophysics - Examples of Future Strategic Mission Support Needs

- **LBTI (operations: 2015)**
  - Exozodi detection and characterization of up to 3 to 6 zodies of 50 nearby stars.
  - Science results will inform and influence a future exoplanet direct imaging mission concept
- **ASTRO-H w/ JAXA (launch: 2015), Athena/L2 w/ ESA (launch: 2028)**
  - Identify new x-ray sources such as supernovae in external galaxies and other transient x-ray phenomena
- **TESS (launch: 2017)**
  - Validate 40-130 (V=12-10 mag) rocky planets/yr using; 25+ nights/yr at Keck using high dispersion spectrometer. Other PRV facilities are being considered.
  - Host star spectral measurements to determine metallicity and age.
- **JWST (launch: 2018)**
  - Keck MOSFIRE multi-object imaging/NIR spectra in HST/Spitzer/Chandra deep fields of z>7 galaxies for Cycle 1-2 NIRSpec targets (most popular competitive instrument)
  - Discovery and early epochs for young planets for JWST coronagraphy
  - Early validation of transiting planet candidates from multiple surveys
- **WFIRST/AFTA (launch: 2024), Euclid w/ ESA (launch: 2020)**
  - Spectra for SN survey follow up, e.g. H ~24-25 AB mag in 4hr, R=1000
  - Identifying long period RV planets for ~150 stars: Jupiter (13 m/s), Saturn (5 m/s) , Uranus (0.3 m/s) at 5 AU critical for target acquisition @ Inner Working Angle. Planet masses complement AFTA photometry/spectra
- **Missions prioritized by the next decadal survey (2020+)**
  - Possible candidates are presented in the 30-year NASA Strategic Roadmap (*Enduring Quests, Daring Visions, 2013)*

Planetary Science –Examples of Current Strategic Needs

- **Planetary sciences have traditionally relied heavily on ground-based observations to advance its exploration objectives:**
  - Long ground-based history of support for space missions such as Voyager, Galileo (Jupiter), Cassini (Saturn, Titan), Deep Impact/EPOXI (comets, exoplanets), LCROSS (Moon), MESSENGER(Mercury), Comet Shoemaker-Levy 9 and Comet ISON campaigns
  - New Horizons in cruise to Pluto; atmosphere and rotation characterization, moons, dust hazards, search for KBO follow-up target
  - Mars spectroscopic campaigns leading to the detection of methane (IRTF and Keck)
  - Ongoing comet observations, such as those used to assess the hazards to Mars orbital assets during the October 2014 close flyby of Mars by Comet Siding Spring and potential science observations by spacecraft
  - Near Earth Object (NEO) characterization

Planetary Science – Examples of Future Strategic Needs

- **Potential new mission support:**
  - New Horizons at Pluto with possible KBO follow-on (2015-2016+)
  - Juno orbit insertion for targeting, supporting observations with UVS , JunoCam, JIRAM (2016+)
  - OSIRIS-Rex asteroid sample return, precursor spectroscopy (2018+)
  - KBO imaging (binaries) and spectroscopy in advance of JWST for target selection and complementary short wavelength spectroscopy (2019+)
  - Outer planet science, characterization of time-variable phenomena, refine objectives for future missions (2020+)
  - Continued NEO characterization in support of future science and exploration missions and planetary defense
  - Future studies of science and potential mission targets as outlined in the most recent planetary decadal survey

Future Plans and Concerns (1 of 2)

- Keck collaboration will be reassessed for relevance to NASA strategic needs prior to the renewal decision for the Cooperative Agreement (current agreement ends in 2018).
  - NASA currently competes through solicited proposals about 90 nights per year for Keck I & II via solicitation of observing proposals.
- NASA is likely to continue IRTF operations beyond the end of the current contract with U. Hawaii (current contract ends in 2019).
  - NASA currently competes through solicited proposals all available nights made available to astronomers and planetary scientists.
- Other facilities (UKIRT, Arecibo, LBTI) will be assessed based on science needs and relevance to NASA missions.
  - NASA competes access to NASA time at these facilities.

Future Plans and Concerns (2 of 2)

- New capabilities will be required for new instruments and facilities to address the needs of Kepler, TESS, JWST, and Planetary missions, such as:
  - Precision Radial Velocity (PRV) is required for enhanced precision (10-20 cm/s). Astrophysics Division is in discussion with NSF/AST about the availability of U.S. PRV capabilities to support TESS, JWST and WFIRST.
  - Extreme AO capabilities for spectroscopic and direct imaging observations is required for high impact follow up observations.

- Technology challenges suitable for ground-based testing, such as:
  - Demonstrate coronagraph and high-contrast imaging designs on monolithic and segmented telescopes.
  - Achieve noiseless detection in the optical and NIR for large focal plane arrays.
  - Develop advanced wavelength and photometric instrumental stability for RV for Earth-size planet detection.
  - Implement nulling and interferometry detection at visible and NIR wavelengths.