Whitepaper:
Research on SOFIA s Upper Deck
in support of the Vision for Space Exploration.

SOFIA is the NASA/DLR "Stratospheric Observatory for Infrared and Sub-millimeter Astronomy" – a world-class astronomical observatory with a projected 960 flight hours/year for 20 years. Expanding its research capabilities to include a research facility on the Upper Deck of the SOFIA B747 aircraft for measurements during nominal operations will enable interdisciplinary scientific investigations in support of the Vision for Space Exploration.

In order to investigate the science questions that would be addressed uniquely from a SOFIA Upper Deck Research Facility (SURF), NASA's Space Science APRA program and NASA's Earth Science Enterprise have co-sponsored the "SOFIA Upper Deck Science Opportunities Workshop" at NASA Ames Research Center on June 22 - 23, 2004. Fifty participants from five countries put forward suggested science studies that both enable, and are enabled by, NASA's exploration activities. Extended abstracts are posted at: http://surf.arc.nasa.gov. From these contributions, the scientific organizing committee has extracted the following four exploration-related research main focus areas for interdisciplinary scientific investigations that would be enabled by a facility on the SOFIA Upper Deck and that would directly support the Vision for Space Exploration:

a) Earth atmosphere as a proxy for other planetary atmospheres to understand the processes that create a habitable planetary atmosphere: How does the Earth atmosphere evolve? What are the short-term and long-term drivers of the radiative balance? How does the radiative balance vary in a changing atmosphere, especially the feedback of water vapor - a key greenhouse gas and prerequisite of life. What are the radiation properties of thin clouds and aerosols? What drives water vapor concentration in the stratosphere? What is the extent of aerosol transfer across the upper-troposphere/lower stratosphere boundary? Because of the high altitude, the SOFIA Upper Deck can facilitate endo-atmospheric radiation measurements extending into the far infrared to study the outgoing long wave radiation over long periods of time. In-situ measurements of radiatively important trace gases in the tropopause region are feasible over decades to study feedback mechanisms and the impact of Global Change. Long-term Earthshine measurements are possible in the near-IR due to the low water vapor and low sky background at altitude and will give a global average of outgoing radiation. SOFIA permits frequent and long-term autonomous whole-air sampling during ascents and descents and during flight with a minimum of effort, permitting the monitoring of numerous trace compounds on a frequent basis. Moreover, the low water vapor column permits mid-IR and sub mm remote sensing observations of trace gases.

b) The dangers imposed by contamination and atmospheric chemical reactions threatening human exploration: What are the dynamical, chemical, and micro-physical processes that control water vapor, ozone, radical constituents, aerosols, pollutants and clouds in the Upper Troposphere and Lower Stratosphere (UTLS) region? How frequently do Stratosphere-Troposphere Exchanges occur? What chemistry occurs in the tropopause region and above? What chemical reactions occur on the surfaces of clouds? How does long-range transport of pollutants affects air quality across the globe? What is the relative importance of long-range frontal uplifting versus local deep convection influences for the radical and ozone budgets? What similarities exist between Earth and planetary atmospheric chemistry and what dangerous hazardous gases could be present elsewhere? SOFIA will fly frequently through the tropopause (about 4 times a week for 20 years), with a cruising altitude in the lower stratosphere (39,000 climbing to 41,000 ft when fuel burns off). The flight paths are at the US doorstep for airborne pollutants from Asia. Long-term monitoring can follow the impact of the increased use of the upper atmosphere as a pathway to space. Studying such processes on Earth will improve planetary chemical transport models. Powerful techniques exist to assimilate randomly gathered observations into sophisticated atmospheric models.

c) The resource benefit and impact danger of minor bodies: What are the chemical and physical composition of the different Earth-threatening asteroids and comets? Which objects are on a potential collision course with Earth? From what mass distribution of the fundamental grains did these minor bodies originate? What range of materials are present in comets? What are the safest routes to Mars, avoiding streams of meteoroids? Meteors are the most readily available samples from known comets and asteroids in the important mm - cm size range. From the airborne perspective of SOFIA, the horizon has low extinction so that 4 - 5 times higher rates are detected than from the ground, enabling remote sensing of meteoroid main element composition and the detection of dust trails in the orbit of long-period comets. Infrared observations are enabled. Low scintillation permits observing small irregularities in meteor light curves at high frame rates. SOFIA makes it possible to observe with moonlight and in cloudy weather. In addition, SOFIA enables wide-field comet imaging in the mid-Infrared and follow-up on near-Earth object detections. In the same context, SOFIA will fly high enough to facilitate the collection of interplanetary dust particles and meteoric debris among terrestrial aerosols from volcanic and anthropogenic origins. An interactive capability would enable a frequent exchange of the collection container for high temporal (and spatial) resolution of dust and condensed aerosol grain collection.

d) The discovery of extrasolar planets: What other worlds are out there? How frequent are planets among nearby stars? The low scintillation environment of SOFIA permits accurate photometry of large star fields for occultation measurements. New video-rate CCD and orthogonal-transfer CCD technology permits aircraft-motion free diffraction-limited exposures through small (12-15") telescopes. Such small optical telescopes have the same spatial resolution as the mid-IR telescope of SOFIA, suggesting collaborate observations. The low water vapor column (<1% @ ground) permits photometry in the near-IR and mid-IR. The 20-year time span would cover more than one orbit of Jupiter.

SOFIA – SURF Science Opportunities Workshop - Scientific Organizing Committee:

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