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The AstroBiology Explorer (ABE) MIDEX Mission Concept

Kimberly Ennico,[a] Scott Sandford,[a] Sylvia Cox,[a] Benton Ellis,[b] Dennis Gallagher,[b] Nick Gautier,[c]
Thomas Greene,[a] Craig McCreight,[a] Gary Mills,[b] William Purcell[b]

[a]NASA-Ames Research Center, Moffett Field, CA 94035 USA
[b]Ball Aerospace & Technologies Corporation, Boulder, CO 80306 USA
[c]Jet Propulsion Laboratory, Pasadena, California 91109

ABSTRACT

The Astrobiology Explorer (ABE) is a MIDEX mission concept under study at NASA's Ames Research Center in collaboration with Ball Aerospace & Technologies, Corp. ABE will conduct IR spectroscopic observations to address important problems in astrobiology, astrochemistry, and astrophysics. The core observational program would make fundamental scientific progress in understanding the distribution, identity, and evolution of ices and organic matter in dense molecular clouds, young forming stellar systems, stellar outflows, the general diffuse ISM, HII regions, Solar System bodies, and external galaxies. The ABE instrument concept includes a 0.6 m aperture Cassegrain telescope and two moderate resolution (R = 2000-3000) spectrographs covering the 2.5-16 micron spectral region. Large format (1024x1024 pixel or larger) IR detector arrays and bandpass filters will allow each spectrograph to cover an entire octave of spectral range or more per exposure without any moving parts. The telescope will be cooled below 50 K by a cryogenic dewar shielded by a sunshade. The detectors will be cooled to ~8K. The optimum orbital configuration for achieving the scientific objectives of the ABE mission is a low background, 1 AU Earth driftaway orbit requiring a Delta II launch vehicle. This configuration provides a low thermal background and allows adequate communications bandwidth and good access to the entire sky over the ~1-2 year mission lifetime.

Keywords: Astrobiology, infrared spectroscopy, Explorers, interstellar organics, telescope, spectrometer, infrared detectors

1. INTRODUCTION

The AstroBiology Explorer (ABE) mission concept consists of a modest dedicated space observatory having a 60 cm class primary mirror cooled to $T < 50$ K, equipped with two moderate resolution cross-dispersed spectrographs having large format near- and mid-IR detectors cooled by cryogens. Such a system would be capable of addressing outstanding problems in Astrochemistry and Astrophysics that are particularly relevant to Astrobiology and addressable by astronomical observation. The mission's observational program would make fundamental scientific progress in each of the following key areas:

- Evolution of Ices and Organic Matter in Young Planetary Systems
- Chemistry of Complex Organic Molecules in the Interstellar Medium
- Distribution of Organic Compounds in the Diffuse Interstellar Medium
- Nature of Organics in the Solar System (comets, asteroids, satellites)
- Cosmic History of Molecular Carbon
- Deuterium Enrichments in Ices, PAHs (Polycyclic Aromatic Hydrocarbons), and Diffuse Medium Organic Refractory Materials

ABE could make fundamental progress in all of these areas by conducting a 1-2 year mission, during which a coordinated set of infrared (5-16 μm) medium resolution (R = 2000-3000) spectroscopic measurements are made of over 1000 galaxies, stars, planetary nebulae, young stellar objects, and solar system objects. More details of each area of the ABE core science mission can be found in these proceedings.[1]

While the principal goal of the ABE mission is to obtain a better understanding of the origin, distribution and evolution of organic compounds in the universe, this observatory would have the capability of addressing a number of other issues of scientific interest. It is our plan to set aside approximately 20% of ABE's total observing time for guest observers, available on a competitive basis, to the general astronomical community. Thus, the capabilities of ABE will be used to address a wide variety of astrophysical issues that extend well beyond the central scientific goals of the ABE mission.

In Sect. 2 we discuss in more detail the AstroBiology Explorer (ABE) instrumentation. In Sect. 3 we discuss the ABE spacecraft. Orbit and mission operations are discussed in Sect. 4. Team members and organizations are highlighted in Sect. 5. The paper is summarized in Sect. 6.

2. ASTROBIOLOGY EXPLORER (ABE) INSTRUMENTATION

Our observational program could be accomplished in 1-2 years with a relatively modest dedicated space observatory. For the purposes of estimating observing time, we modeled such a mission as consisting of a 60 cm aperture (primary mirror) which is passively cooled to $T < 50$ K and equipped with a suite of two moderate order ($m \sim 8$) dispersive spectrographs equipped with first-order cross-dispersers. We envision using very large format (1024×1024 pixel) near- and mid-IR detector arrays. The two spectrographs share a common slit, which allows simultaneous spectral measurements across the entire 2.5-16μm wavelength range. The split in wavelength coverage, achieved by a dichroic in the optical path, is set to be around 4.9-5.0μm, chosen to allow maximum efficiency by detector choice [Sect. 2.3], and also not to split any important expected emission and absorption spectral features. The instrument would require a modest amount of cryogen [Sect. 2.4] in order to cool its detectors to their operating temperature. An image of the current layout concept for the observatory is provided in Figure 1.

2.1 Scientific Requirements

The vast majority of the infrared bands produced by organic compounds fall in the infrared from 2.5 to 20 μm. This is a natural consequence of the masses and interatomic bond strengths of C, H, O, and N. While many chemical functional groups and some classes of molecule display distinctive characteristic infrared bands, it is necessary to detect multiple bands of a molecule to derive meaningful information. Thus, the ABE instrumentation must be capable of providing spectral coverage across most or all of this range.

A spectral resolution ($R \equiv \lambda/\Delta\lambda$) of about 2000-3000 is also desirable for this work; it is high enough to resolve almost all the bands produced by organics in solids and provide sufficient detail of gas phase rotational lines and envelopes that they can be separated from the solid state features.

Additionally, many of the absorption and emission features that will be studied have strengths that are only a few percent of the continuum flux. Moreover, the target list for this mission will contain over 1000 objects, many of which are relatively faint, on the order of 0.01–0.10 Jy. Thus, achieving the goals in the ABE science mission will require high sensitivities, with signal-to-noise (S/N) values of 100 in almost all cases.

Based on realistic expectations, we anticipate that obtaining the spectra of our target objects with the needed quality will require a mission duration of approximately 1-2 years, a timescale that will allow us to study objects in all parts of the sky.

The main scientific requirements that the AstroBiology Explorer will have to meet if it is to properly carry out its science mission are summarized in Table 1.

2.2 Optical Design

The resolution requirement is met by an effective aperture of approximately 0.6 m. A diffraction-limited Cassegrain telescope with a 0.6 m primary mirror at a temperature of <50 K, allowing for some incident stray light from a warm radiation shield, would also meet the sensitivity requirement.

The 2.5–16 μm desired wavelength range spans over two full octaves. To avoid overlapping of orders, three separate spectrographs (or 3 grating configurations of single spectrograph) would optimally be desired. However, to reduce cost and mass constraints on the ABE design, we have found a solution which utilizes two spectrographs: 1) a short wavelength module covering 2.5-5 μm; and 2) a long wavelength module covering 5-16 μm. Since the design uses diffractive dispersion elements, an order sorting filter (~10 μm long band pass filter) is required in the long wavelength module to separate overlapping octaves.

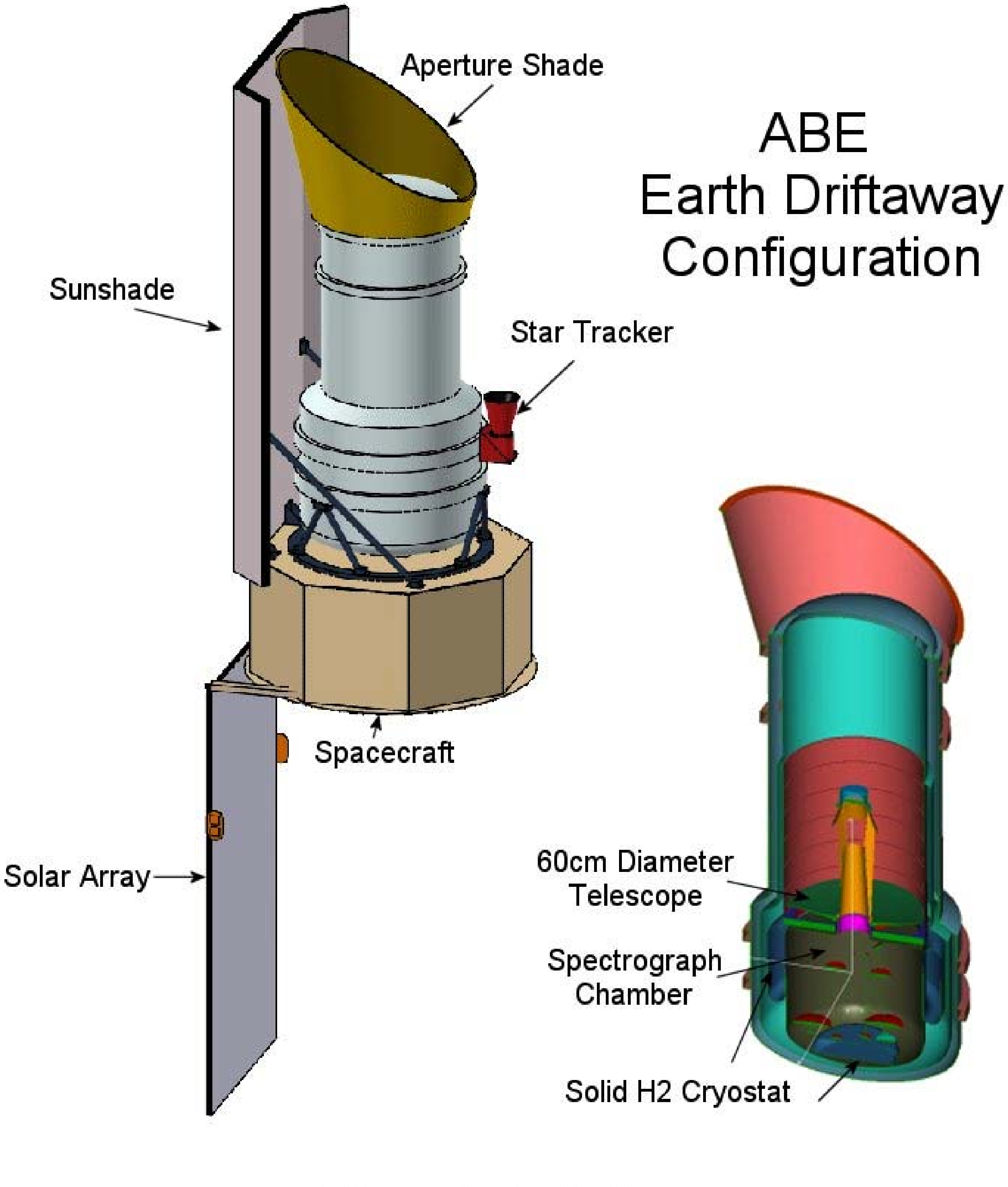

Figure 1. ABE Earth drift away configuration with solid H_2 cryogen concept [Sect. 2.4].

Table 1. Nominal Scientific Requirements for the AstroBiology Explorer

Wavelength Coverage	2.5 - 16 μm (no gaps)
Spatial Resolution (slit width)	< 10" at all wavelengths
Spectral Resolution R $\equiv\lambda/\Delta\lambda$	2500-3500 (2.5-4.8 μm) 2000-3000 (4.8-16 μm)
Slit length	≤ 30"
Sensitivity @λ=10 μm in 1 hr (S/N=100)	50 mJy
Calibration	Absolute flux accuracy 25% Wavelength dependent relative accuracy 5%
Operational Lifetime	≤1 yr
Pointing Stability	<3" for a 1000 sec exposure
Slit position on sky	Co-spatial on sky

Since we require at least 2R pixels in the spectral direction in order to Nyquist sample the spectrum where R $\equiv \lambda/\Delta\lambda$ = 2000-3000, we need large format IR detector arrays. Both near and mid-IR detector arrays up to 1024×1024 pixels in size are expected to be available for launch in 2007 or 2008. We have found a solution for the ABE design utilizing a single 1024×1024 pixel device per spectrograph arm. The R = 2000-3000 spectra are cross-dispersed onto the arrays, providing a more compact and lower mass design compared with one having multiple detector arrays arranged linearly in the dispersion direction.

The two spectrographs share the telescope field of view [Figure 2]. A dichroic beam splitter is used to direct light into each spectrograph arm. The slit size is chosen to maximize sensitivity across the large spectral range. Our baseline concept consists of an 8.3" wide slit, which allows the detection of the full point spread function of the Airy disk at 10 μm for a 60 cm telescope. We have found that larger slits, although lowering slit loss effects at the long wavelength end, will decrease our estimated ABE sensitivity significantly at the longer wavelengths. The slit is mapped to a two-to-three detector pixel width in order to maintain full spatial resolution and high optical throughput without a noise penalty when background limited.

Both spectrographs share the same fundamental design. Each shares the entrance slit located at the focal plane and a beamsplitter. The beam is then dispersed by an "echellette" and cross-disperser gratings and then focused onto a detector by the camera optics. The collimator is a single element parabola, while the camera consists of a few reflective surfaces and a single refractive element (ZnSe lens).

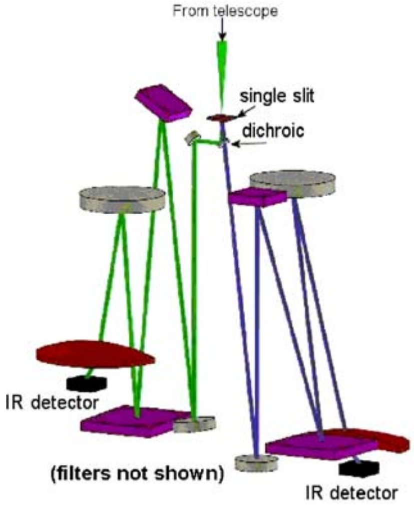

Figure 2. Common slit spectrometer design

The first order telescope and spectrograph parameters are summarized in Tables 2 and 3. The required gratings demand rulings that can be easily fabricated.

Table 2. First-order Telescope Parameters

Telescope Diameter	600	mm
Telescope f/#	6.67	

Table 3. First-order Spectrograph Parameters

	Short Wavelength	Long Wavelength	Units
Array size	1024	1024	pixels
pixel size	27	27	µm
Minimum λ	2.5	5.0	µm
Maximum λ	5.0	16	µm
Final Cam f/#	5.38	2.83	
pixel size	1.73	3.28	arcsec
Slit width	8	8	arcsec
Slit length	21	21	arcsec
Resolution (λ/Δλ)	2500	2500	
Pupil Diameter	48	48	mm
Collimator Focal length	320	320	mm
Camera focal length	258	136	mm
Collimating mirror R	640	640	
Echelle grating, d	60	125	µm
Orders	5-9	8-24	
X dispersor grating, d	28	80	µm
Orders	1	1	

2.3 Detectors

In addition to meeting the above format (≥ 1024×1024 pixels) and wavelength (2.5–16 µm) requirements, detectors should have high quantum efficiency (η > 50%) and low noise.

Ideally, total detector noise [defined as $(\text{readnoise}^2 + \text{dark\_counts})^{0.5}$] should be less than the photon flux background on the detectors at all wavelengths. With a cold telescope ($T < 50K$), ABE's expected performance will be dominated by detector properties, except for bright sources where the shot noise from the object itself will dominate. At a resolution of $R = 2500$, the expected photon background (for the ecliptic pole, a $T = 50$ K 60cm diameter telescope, and minimal scattered light) per pixel detected with a conservative optical system (DQE ~0.7, optics efficiency ~0.3), can be as low as 0.07, 0.2, 4 and 26 photons per second at wavelengths of 2.5, 5, 10, and 16µm, respectively, when mapped to a 2x2 resolution element for a 8" wide slit. Thus, attempts to minimize both detector dark currents (electrons per second per pixel) and read out noise will be required to optimize ABE's performance.

For the ABE long wavelength (5-16 μm) spectrometer, the detector of choice is Raytheon IR Center of Excellence's (CoE) 1024×1024 pixel format Si:As detector arrays, currently under development for NGST and Origins observatories (i.e., low background, low noise, high sensitivity) under the direction of NASA Ames Research Center. We (Ames) have recently tested the first generation hybrid device, after a pre-selection of candidate cryo-processed readout designs. Dark currents <0.1 e/s have been measured at T ≤ 8 K. Power dissipation, for a full-frame scan time of 3.8 s, was measured to be below 500 μW. These two items are lower than required for ABE. The read noise measured, ~35 e^- (Fowler 4), although adequate for ABE's required sensitivity, is too high for NGST. Raytheon is presently developing second generation multiplexer designs for decreased noise performance. Such devices are expected to be ready for test in late 2001.

These Si:As detector arrays have good quantum efficiency (~60-70% non AR coated, >80% with appropriate AR coatings) over the 5-25 μm range. Unfortunately, the quantum efficiency degrades rapidly for wavelengths shorter than 4 μm. For ABE, where sky backgrounds at wavelengths $\lambda < 5$ μm are negligible, observations will likely be detector-noise limited there. The Si:As detector was found to be inadequate in performance to meet ABE's sensitivity requirements over 2.5-5 μm.

The detector of choice for ABE's short wavelength (2.5-5.0 μm) spectrometer is a 1024×1024 pixel format InSb, with the same mutiplexer as for the Si:As device above, from Raytheon IR CoE. It has good quantum efficiency (~85% with appropriate AR coating) in this region, read-noise ~25 electrons (Fowler 4), and dark currents < 0.1 electrons/second.[2] These devices operate at T ≤ 32–35 K to maintain this low dark current.

Although the ABE instrument concept includes two different detector types, both are manufactured by the same company (Raytheon) and share the same read-out multiplexer. Additionally both array types share heritage with SIRTF IRAC and IRS focal plane arrays.[3,4,5]

The main detector properties required by ABE to achieve its science mission are summarized in Table 4.

Table 4. ABE Detector Performance Requirements

	Short wavelength spectrometer	Long wavelength spectrometer
Type	InSb	Si:As
Format	≥ 1024x1024	≥ 1024x1024
Unit cell size	27 μm	27 μm
Wavelength range	2.5-5 μm	5-16 μm
Operating temperature	T ≤ 35K	T ≤ 8K
QE	> 80%	> 60%
Read Noise (Fowler 4)	≤ 25 electrons	≤ 35 electrons
Dark Current at operating temperature	≤ 0.1 e/s	≤ 1 e/s
Power dissipation	< 2 mW	< 2 mW
Well capacity	> 2.5e5 electrons	> 2.5e5 electrons

2.4 Thermal Design and Cryogenics

Calculations show that the sensitivity requirements can be met with a cryogenically cooled instrument design. The telescope, spectrograph optics, and infrared array detectors are contained within a cryogenic dewar. The outer shell of the dewar is protected from solar radiation by a sunshade, and an aperture shade minimizes radiative loading of the dewar when tipped toward the Sun. The dewar is thermally isolated from the spacecraft bus by minimizing connections and the careful placement of insulation. The anti-sun side of the dewar is coated to act as a radiator, cooling the dewar outer shell.

To meet our sensitivity requirements, the ABE sunshade must be cooled to <70 K, and the telescope primary and secondary mirrors must be cooled to <50 K. Both detector arrays are cooled to 8 K. In addition to meeting the above primary, sunshade, and detector thermal requirements, high emissivity elements (order-blocking filters and gratings) in the spectrometers must be cooled to $T \leq 18$ K to limit self-generated thermal backgrounds that hurt sensitivity.

We wish to minimize cryogen mass and volume in order to conserve these resources for other instrument components. For 8 K cooling of the detectors, two choices among conventional cryogens are available: solid H_2 or liquid He. Solid H_2 is the better option for two reasons. First, the latent heat of liquid He is only 0.05 times that of solid H_2. Even with its higher density, 12 times more volume of liquid He would be required than for solid H_2. Secondly, the optimal launch vehicle to deliver ABE to a drift away orbit is a Delta 2425, which has a final spin-stabilized stage. The ABE instrument and cryostat cannot use liquid cryogens because of stability problems on a spin-stabilized system. Solid H_2 is also a good candidate for the second stage ($T < 50$ K telescope, $T < 18$ K optics). Solid Ne is an alternative at these temperatures, but would require 4.3 times as much mass as solid H_2. Therefore, we baseline a two stage solid H_2 dewar with primary solid H_2 at 7 K and a secondary solid H_2 stage at 12 K.

Solid cryogen dewars have considerable flight history and experience base and are the best option for an Explorer class mission that can afford very little development cost or schedule. Mechanical closed cycle coolers have the potential for longer lifetimes than stored cryogen coolers, but they induce vibration and there are no flight-qualified models which meet the ABE thermal requirements. Thus, they are currently not realistic candidates for a very low temperature Explorer-class mission.

The cryogen load must be large enough for the core science mission lifetime plus some margin. Once the cryogens are exhausted there is the possibility of an extended observational mission using the short wavelength spectrograph, as the telescope and optics are expected to passively cool to sufficiently low temperatures that useful data can still be obtained from this instrument. Depletion of the cryogens will, however, result in the loss of the longer wavelength operations. The ABE cryogen concept requires 40 liters of solid H_2 to achieve a lifetime of ~1.6 years. Figure 1 illustrates the ABE drift away solid hydrogen cryogenic concept.

2.5 Sensitivities and comparison with existing/planned IR platforms

The ABE mission concept also fits nicely into a gap in discovery space among existing and planned space and airborne infrared platforms. This is shown schematically in Figures 3 and 4.

Based on the detector properties described in Sect. 2.3 and the thermal design described in Sect. 2.4, it is possible to calculate the expected sensitivities of the instrument system. Figure 4 shows a plot of the wavelength-dependent 1-σ, 500 s continuum sensitivity that we expect to achieve for a $R \equiv \lambda/\Delta\lambda = 2500$ spectrum with a 0.60 m, $T = 25$ K telescope. Also shown in the plot are the sensitivities achieved by comparable infrared spectrographic platforms shown in Figure 3. ABE will provide at least an order magnitude improvement over the ISO SWS spectrograph, at similar resolutions.

3. THE ASTROBIOLOGY EXPLORER (ABE) SPACECRAFT

The top-level spacecraft and mission requirements for the ABE mission are provided in Table 5. The spacecraft bus will contain all of the uncooled spacecraft components for command and data handling/storage, power, pointing, and control and communication. This portion of the spacecraft will be isolated from the passively cooled telescope and instrument deck by a standoff support structure and thermal insulation [see Figure 1].

The thermal control system uses passive thermal design techniques (sun shades, multilayer insulation blankets, paint and thermal tape, and localized radiators), coupled with limited-use active heaters, to allow continuous operations in all allowed sun angles and modes of operation. A sunshade will be used to provide passive cooling of the cryostat outer shell to <70 K. The sunshade, backed by insulation, extends above the top deck of the spacecraft and reduces radiative heat transfer to the cryostat. As a result, the spacecraft attitude during flight must be within ~±30° from normal to the spacecraft-sun line. Thus, at any given time, the spacecraft will only be able to observe objects within an annulus on the sky which, during the course of the mission, will sweep across the entire sky.

Power is generated by the solar array using high efficiency triple-junction solar cells. To enable the solar cells to operate at their peak efficiency, the solar array is deployed adjacent to and below the spacecraft, allowing the back of the array to radiate to space. A small Nickel Hydrogen (NiH) battery will be used for power during initial orbit insertion and for safe hold mode. Battery power will not be required during normal operations since the spacecraft will be in an Earth drift-away orbit and no solar eclipses will occur during the mission.

The spacecraft will be 3-axis stabilized using reaction wheels. The instrument pointing stability requirements of 1 arcsec will be met using an inertial reference unit, a bore-sighted star tracker, and an acquisition camera/focal plane guider located in the instrument. Sun sensors are also used to keep the solar array pointed at the sun. Four reaction wheels will be used for redundancy.

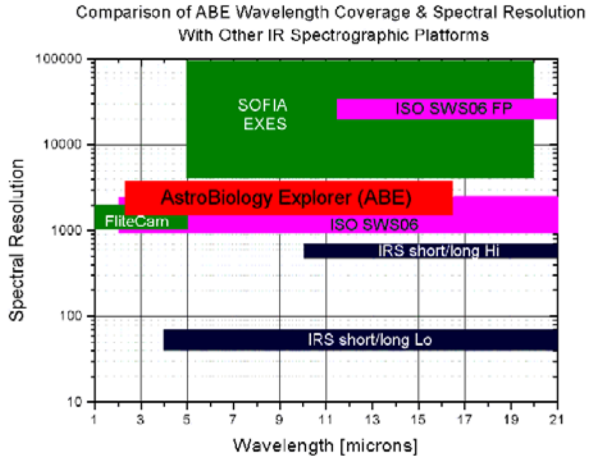

Figure 3. Comparison of the ABE mission concept with existing and planed space and airborne infrared platforms.

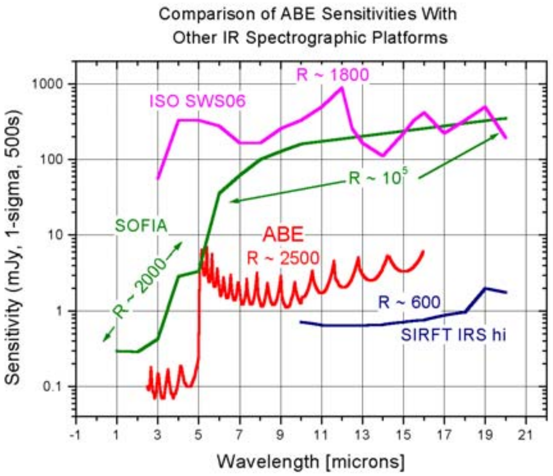

Figure 4. The modeled wavelength-dependent sensitivity of the AstroBiology Explorer compared with other infrared spectroscopic platforms.

A cold-gas propulsion system will be employed to offload momentum build-up due to external torques, such as initial upperstage tip-off separation and solar pressure. The cryogenic H_2 boiloff from the optics dewars will be ‘equal reaction’ vented so that it imparts no net contribution to the spacecraft momentum.

Communication with ABE would be carried out using an X-band transponder with a 30 W amplifier and a high-gain antenna mounted on the base of the spacecraft bus. The high-gain antenna will be mounted to the bus with a 2-axis gimbal to enable data downlink and command uplink contemporaneous with ABE data-taking observations. At the end of the ABE mission the spacecraft will be about 3×10^7 km from the Earth. At this distance, the DSN standard deep space transponder can be run at its maximum downlink capability of 4.4 Mbps for the entire mission when tracked from the 34M HEF antennae, well over the predicted ABE rates. An omni-directional X-band antenna receiver would also be included to listen for unscheduled ground commands.

The ABE command and data handling (C&DH) subsystem uses a bus-based architecture to provide a significant level of software-based, higher order processing within a modular, fully integrated spacecraft control unit (SCU) using a RAD 750 processor. The SCU localizes all processing needs in a central computer with remote sensors and actuators. This concept differs from previous avionics architectures by allowing higher order “processing” functionality previously accomplished in hardware to be transferred to software applications on the central computer. This transfer allows a reduction in the number of recurring hardware components and provides functional flexibility through data table configurable software applications.

4. ORBIT AND MISSION OPERATIONS

The current mission plan has the ABE spacecraft launched from the Eastern Test Range (Cape Canaveral) by a Delta-II 2425 three stage expendable launch vehicle. With the 2.9 m fairing, the vehicle has a payload lift capability of ~600 kg with a 20% margin. Current estimates of the ABE mass lie below this limit. Volume is also not constrained by the 2.9 m fairing. An Earth-trailing trajectory has been selected to simplify flight operations while satisfying all mission design requirements. This trajectory minimizes pointing restrictions, avoids the Earth’s thermal and radiation environments, and does not require orbital maintenance. An Earth-trailing trajectory meets all spacecraft pointing requirements for power, thermal, communication, and telescope orientation. The launch trajectory is characterized by a C3 of 0.4 km^2/sec^2, slightly over Earth escape, to account for the three-body gravitational affects. Within ~30 days after launch it enters a heliocentric orbit in the ecliptic plane with a period of ~372 days. In such an orbit, similar to that of SIRTF, the spacecraft only slowly drifts away from the Earth, never getting more than 0.12 AU from the Earth in its first year and never more than 0.22 AU over two years.

Table 5: Spacecraft System Requirements

Parameter	Value
Launch vehicle	Delta II 2425
Orbit	Heliocentric Drift-Away
Mission Lifetime	16 months
Attitude Control	3-axis stabilized
Pointing Accuracy	3 arc-sec (3σ)
Pointing Stability	1 arc-sec / 1000 s (3σ)
Telecommunications	X-band to DSN 34m HEF subnet
Payload Data Volume	10 Gbit / day
Payload Power	54 Watts
Payload Mass	276 kg

The AstroBiology Explorer can, in principle, be launched at anytime of the year. However, given that the mission has a nominal lifetime of about one year and that the list of target objects is significantly biased towards objects within our own galaxy, an optimal observation strategy would use a launch time when the annulus first viewable by the spacecraft is just beginning to sweep across the inner galaxy. This would allow the most target intensive portions of the sky to be observable at least twice, once early in the mission and once late in the mission. Within this broad requirement, the launch time can be selected to minimize the impact of launch dispersions as there will be no propulsion on the spacecraft for orbital corrections.

Mission operations for the ABE would consist of standard flight operation facilities and activities necessary to maintain and control the spacecraft, support science and engineering data acquisition, and provide for data processing and distribution of data to the users. Spacecraft maintenance includes tasks for pointing and orientation control, communications for command and telemetry, orbit determination for tracking and the onboard spacecraft ephemeris, and momentum off-loading. Data acquisition will consist of both telemetry to monitor the status of the spacecraft subsystems and science data acquisition. Typical ABE flight operations will include the preparation, transmission, and verification of command memory loads used by the spacecraft to control its subsystems and instrument observations. Science operational activities include analyzing, archiving, and distribution of science data together with ancillary data such as spacecraft orientation and flight path information. Mission operations for the ABE project would use the facilities and personnel of the DSN for the tracking and data acquisition (TDA) support. Both telemetry and command capability will be required.

Flight operations would be controlled from a spacecraft operations center which houses the computers, communications, and software needed to support real-time monitoring and control. Operation plans must specify operations procedures, command sequences, and payload performance requirements to evaluate real-time spacecraft and instrument status. The spacecraft operations center will also contain a science data unit responsible for the project science database and the ancillary trajectory and spacecraft pointing information. The science data unit would also be responsible for science data processing, science data archiving, and science data distribution.

The nominal ABE mission operations system would consist of a small organization reporting directly to the project manager and the mission director. Two primary teams, Mission Operations and Science, will be responsible for real-time spacecraft operations. A support organization, the ground data system, would coordinate the DSN tracking and the data flow requirements.

5. TEAM MEMBERS

Ball Aerospace & Technologies, Corp. is the contracting partner for the ABE mission. Project Management and Mission Operations will be out of NASA's Ames Research Center. The Science Team reflects contributions from a number of institutions. The science team includes Louis Allamandola (NASA Ames), Geoffrey Blake (CalTech), Jesse Bregman (NASA Ames), Martin Cohen (Univ. of California @ Berkeley), Dale Cruikshank (NASA Ames), Kimberly Ennico (NASA Ames), Thomas Gautier III (Jet Propulsion Laboratory), Thomas Greene (NASA Ames), Douglas Hudgins (NASA Ames), David Koch (NASA), Sun Kwok (Univ. of Calgary), Steven Lord (IPAC/Caltech), Suzanne Madden (Service d'Astrophysique, C.E.A. - Saclay), Craig McCreight (NASA Ames), Scott Sandford (PI) (NASA Ames), Donald Strecker (Ball Aerospace), A.G.G.M. Tielens (Kapteyn Astronomical Institute), Michael Werner (Jet Propulsion Laboratory). The ARC Project Team includes Sylvia Cox (PM), Jill Bauman, Lisa Chu-Thielbar, Ken Galal, David Lozier, Kevin Martin.

6. SUMMARY

We have described a potential new Explorer-class space mission, the AstroBiology Explorer (ABE), consisting of a relatively modest dedicated space observatory having a 60 cm aperture (primary mirror) which is passively cooled to $T < 50$ K, resides in a low-background orbit (heliocentric orbit at 1 AU, Earth drift-away), and is equipped with a suite of two moderate order ($m \sim 8$) dispersive spectrographs equipped with first-order cross-dispersers and large format (1024×1024 pixel) infrared detectors cooled by a modest amount of cryogen. Such a system would be capable of addressing outstanding problems in Astrochemistry and Astrophysics that are particularly relevant to Astrobiology and addressable via astronomical observation. The observational program of this mission would make fundamental scientific progress in each of the key areas of the cosmic history of molecular carbon, the distribution and chemistry of organic compounds in the diffuse and dense interstellar media, the evolution of ices and organic matter in young planetary systems, and the deuterium enrichments in ices, PAHs, and diffuse medium organic refractory materials. ABE could make fundamental progress in all of these areas by conducting an approximately 1.5 year mission to obtain a coordinated set of infrared spectroscopic observations over the 2.5-16 µm spectral range at spectral resolutions of $R \geq 2000$ of approximately 1000 galaxies, stars, planetary nebulae, and young star planetary systems.

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