electrons at 3s resolution, and magnetic and electric fields at 12vectors/s resolution. Additionally superthermal ions and electrons along the spin plane are required, for CD and Rx timing. Sensitivity should permit differential measurements of average cross-tail current, pressure gradients and flow vorticity to within 10%. Since inter-probe distances are planned to be comparable to the variation scale-lengths of B ($0.5R_E$ in Z), P and V ($1R_E$ in X,Y) the plasma moments and magnetic field should be known to within 10%. This accuracy can be easily achieved by instruments flown on previous missions. THEMIS instruments are shown in Figure D-13. Requirements and adherence to them are summarized in the table inserts.

h. Baseline versus minimum mission.

THEMIS depends on four tail-aligned probe conjunctions and on cross-tail or cross-sheet probe pairs to address its main question. Science closure can be achieved by a minimum mission of four probes, in three years of tail crossings (Figure D-1/ A_{II}). Inclusion of a fifth probe in the baseline mission reduces the required lifetime to 2 years, reduces risk and increases science return. Lower risk comes from the fact that the fifth probe has sufficient fuel reserves to replace any other probe during the mission. Science increase from the fifth probe allows two-probe measurements in both X and Y dimensions the first year (X and Z dimensions the second year). Additionally, THEMIS's primary science can be achieved, in principle[145], with a 3D, fluxgate magnetometer and a 2D, spin-plane, electric field measurement. The increased sensitivity of the SCM in the range of ~10Hz and above, and the robustness in mode identification through a 3D EFI experiment are descopes of the baseline mission.

D2. SCIENCE IMPLEMENTATION

The five spin-stabilized (T_{spin}=3s) probes carry identical instruments which exceed the requirements of the primary science objective. The guiding principles are: 1) Selection of existing, low power, low weight units, to ensure no new development costs. 2) Common instrument DPU (IDPU) electronics to maximize science and simplify interfaces, motivated by FAST. 3) "Common buy" parts procurement to minimize expenditures. 4) Significant foreign contributions in instruments and analysis, ensuring wide international community participation. 5) Rapid, web-based dissemination of data and IDL analysis code accompanied by a $4M guest investigator program to ensure maximum benefits for the US science community.

a. Instrumentation

THEMIS instruments are summarized in Table D-5. Detailed specifications and accommodation are provided in Figure D-13. The five high-heritage instruments are identical (or require minor modifications) to ones flown recently. Two of those (FGM, SCM) are provided by foreign institutions, two by UCB (EFI, ESA) and one is a collaboration between UCB and a foreign institution (SST). THEMIS builds on existing close working relationships of its team members with each other and/or with UCB on Cluster, WIND, FAST, POLAR and Equator-S.

Instrument	Mass (kg)	Power (W)	Recent Flight	Institute
FGM @ sensor	0.1	Equator-S		TUBS
FGM boom	1.2		FAST	UCB
FGM @ DPU	0.2	0.6	MIR	IWF
ESA @ sensor	2.1	2.0	FAST	UCB
ESA @ DPU	0.2	0.6	FAST	UCB
SST @ sensor	0.9	0.8	WIND	UCB, ESTEC
SST @ DPU	0.1	0.2	WIND	UCB
SCM @ sensor	0.6		Cluster	CETP
SCM boom	0.5	Lunar Prospector		UCB
SCM pre-amps	0.2	0.1	Cluster	CETP
EFI (4) @ spin-plane	7.0	2.0	Cluster	UCB
EFI (2) @ axials	4.0	1.0	POLAR	UCB
EFI/SCM @ DPU	1.2	3.8	FAST	UCB
DPU process, compress & store	1.1	1.1	FAST, Lunar Prospector	UCB
Total	19.3	12.2		
Available	25.1	15.9		
Margin	30%	30%		

Table D-5. *Summary of each probe's instrument characteristics.*

a1. Fluxgate magnetometer (FGM)

A triaxial fluxgate magnetometer built to the heritage of units flown on AMPTE/IRM (1985), Phobos (1988), Interball (1992), Equator-S (1997) and MIR (1998) will measure the 3D ambient magnetic field. The sensor and electronics are identical to ones of the ROMAP instrument package delivered for the Rosetta mission (launch 2003), and similar to the ones flown[146] on Equator-S and MIR. The sensors will be built by TUBS, and the electronics breadboarding will be performed by IWF. The same team has delivered the ROMAP unit and has the expertise, and established working relationships to perform the task seamlessly. The flight electronics will be implemented at UCB. In-flight calibration will be performed by UCLA, deriving from Galileo and CLUSTER practices. The science requirements are to: 1) Measure DC and low frequency perturbations of the magnetic field, 2) Time

This is foldout Figure D-13

wave and structure propagation between probes, 3) Provide information on plasma currents based on instantaneous magnetic field differences on two or more probes, separated by >0.2 R_E. Adherence to them is summarized in Figure D-13/A.

FGM specifications. The unit (Figure D-13/A) consists of two orthogonal ringcore elements of different diameter, made of an ultra-stable 6-81-Mo permalloy band (2mm×20µm), fixed within a bobbin. The unit is mounted on a 2 m double-hinge carbon epoxy boom (Figure D-13/B) identical to FAST's. The electronics consist of the driver and control circuits (Figure D-13/A), on a 10x12 cm^2 board within the IDPU. The controller controls digital excitation[147], data acquisition, feedback and compensation making the device low power. Its low noise permits easy intercalibration with the search-coil magnetometer at frequencies ~10Hz. Specifications and in-flight sensitivity are shown in Figures D-13/A.

Early establishment of a magnetic cleanliness program is commensurate with a low cost, high performance flight unit. THEMIS will benefit from the IWF, TUBS, UCLA and UCB experience in magnetic characterization, modeling and compensation of panel currents and latch valve/SST magnets.

FGM calibration. Although a 1 nT absolute accuracy requirement is achievable with independent sensor calibration, it is important to ascertain that two separate probes provide identical values when properties of the medium are steady. Once per orbit we will acquire calibration data at 32Hz to determine (on individual probes) zero levels, gains, and sensor orientation[148]. After Khurana et al.[149] we will also intercalibrate the magnetometers on all five probes during the early part of the mission (L&EO) using traversals of current-free (or low current density) regions of the magnetosphere. If the divergence-free approximation cannot be easily met then time-lagged data from probes traversing the same region will be compared for trend-recognition after long-term averaging.

a2. Electrostatic analyzer (ESA).

A "top hat" back-to-back pair of hemispherical ESAs will be built at UCB to the heritage of AMPTE/IRM, Giotto, FAST, Wind and CLUSTER, to measure the thermal ions and electrons. The proposed pair of units is of identical design to that flown on FAST (Figure D-13/C). It has geometric factors ideal for the fluxes expected at the THEMIS orbit. THEMIS's science requirements are to measure: 1) Plasma moments to within 10%, at high time resolution (10s or better) for inter-probe timing studies. 2) Instantaneous differences in velocity and ion pressure between probes, to estimate the scale size of transport, the size and strength of flow vortices and the pressure gradient. 3) Distribution functions of ions and electrons, to ascertain the presence of free energy sources. Adherence to those is summarized in Figure D-13/C.

ESA specifications. Both the ion and the electron ESA (Figure D-13/C) have a look direction of 180° in elevation, split in eight, 22.5° bins (one per anode). Measurements over a 4π str, are made once per spin as the probe rotates. The particles are selected in E/q (where q is the charge) by a sweeping potential applied in 32 steps, 32 times/spin (32 azimuths) between the outer (0 kV) and inner (~0-3 kV) concentric spheres and are focussed onto an MCP pair arranged in a Chevron configuration. The proposed ESA already has significant shielding to avoid MeV electron penetration and employs scalloping of both hemispheres for improved secondary-electron rejection. On-board moment, pitch angle and averaging computations are implemented at the IDPU. These operations routinely utilize FGM data and SST data (to ensure correct values when the peak flux extends beyond the plasma instrument energy range).

ESA calibration. Science requirement of 10% accuracy on moment computation can be met by independent calibration of the ESAs. However by inter-calibrating hour-long averages of the distributions and their moments during quiet-time probe-conjunctions we expected to surpass the accuracy obtained from independent ESA calibration.

a3. Solid state telescope (SST).

A solid state telescope unit, built by UCB to the heritage of ISEE1/2/3 and WIND (Figure D-13/D) will measure the super-thermal part of the ion and electron distributions. The detectors are identical to the SST telescope pairs flown on WIND[150]. Each probe carries two such pairs. The SST geometric factors are optimized for THEMIS. The electronics are comprised of miniaturized hybrid electronics on a VLSI chip, developed for ESTEC by a commercial outfit. The chip has been tested at ESTEC and has been delivered for flight on the IMPACT/SEPT telescopes on Solar Stereo. ESTEC has been a traditional collaborator of UCB, with most recent joint work on WIND/3DP in similar roles to the ones proposed herein. The primary science needs for the SST are: 1) To perform remote sensing of the tailward-moving current disruption boundary (at P3, P4, P5). 2) To measure the time-of-arrival of super-thermal ions and electrons (30-300 keV, at 10s resolution or better) during injections, and ascertain the Rx onset time (P1, P2).

SST specifications. Each double-ended telescope unit is equipped with three stacked, fully depleted, passivated, ion-implanted, 1.5 cm^2 silicon detectors (Figure D-14). The center (T) detector is 500 μ thick, while the outside (O & F) detectors are 300 μ thick. The two detector pairs are mounted such that two telescope units point on the spin-plane (~ecliptic), one points above and the other below the spin-plane. One of the two spin-plane telescopes has detectors of area $0.075cm^2$ and provides a geometric factor 20 times smaller that all the others to ensure no saturation at times of very high flux levels near the radiation belts. Specifications are tabulated in Figure D-13/D.

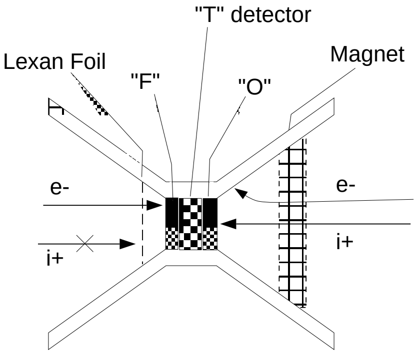

Figure D-14. SST telescope operation.

UV avoidance, i.e., the requirement that sunlight is to remain $>7^o$ away from the field of view (FOV), is guaranteed for the up- and down-looking telescopes with a tolerance of $\pm 11.25^o$ by virtue of the mounting angles (Figure D-13/D). For the spin-plane-mounted, large geometric factor detector fast recovery electronics (100 ns) ensures that no more than 2 sectors will be UV-saturated. This approach was successfully implemented on WIND. The spin-plane, low geometric factor ion detector is covered by a 1300Å Lexan foil with 900Å of Al deposited on either side, preventing direct sunlight from hitting the detector, while still enabling >30keV ions to be detected.

SST calibration. Absolute calibration points are determined by monitoring the highest energy of protons stopped and by placing the pairs (or triplets) of detectors in coincidence and monitoring the minimum ionizing energy for penetrating particles. Such practices have led to superb agreement between SST and ESA fluxes on WIND, and result to <10% absolute flux uncertainty. Inter-probe calibration will also be performed at times of low plasma sheet activity, when the flux anisotropy is low.

a4. Search coil magnetometer (SCM).

The SCM instrument built by CETP to the heritage of GEOS 1&2, Galileo, Ulysses, Cassini, Freja and CLUSTER will extend with appropriate sensitivity the measurements of the FGM beyond the 1 Hz range. The sensor (Figure D-13/E) is identical to the one flown on the CLUSTER/STAFF instrument, while its electronics are a simplification of the ones flown on the FAST IDPU. The science requirements derive from the need to measure with appropriate sensitivity ($<1\mathrm{pT}/\sqrt{\mathrm{Hz}}$ @ 10Hz); the cross-field current disruption waves ($\sim 0.1 f_{LH}$) at least as close to Earth as $8R_E$ (f_{LH}=60Hz). Adherence to those is summarized in Figure D-13/E.

SCM specifications. The SCM measures the variation of the magnetic flux threading three orthogonal high permeability μ-metal rods. The unit sensitivity is $0.5\mathrm{pT}/\sqrt{\mathrm{Hz}}$ @ 10Hz. A flux feedback loop is employed to ensure phase stability. The triaxial sensor is mounted on a single-hinge, 1m graphite epoxy boom (Figure D-13/B) identical to the one flown on Lunar Prospector. The unit specifications are shown in Figure D-13/E. The signals from the three sensors are pre-amplified and then processed together with EFI data at the IDPU. The IDPU consists of one analog and one digital board. The analog board serves primarily the **B**- and **E**-fields processing and includes the SCM pre-amplifiers. The analog signal is pre-amplified and then filtered (together with the E-fields signals) and processed for routine waveform (DC-32samples/second) and for burst waveform (128Hz-8kHz) production. The Digital Signal Processor (DSP) takes 2^n continuous segments (n=0...7, commandable) of 1024 data points and performs FFTs of the data and subsequent averaging in frequency. Consecutive spectral averaging reduces noise further. These operations represent a rather small subset of the fields signal processing of the FAST IDPU; they can be implemented by low cost, rad-tolerant parts. Specifications are detailed in Figure D-13/E.

SCM calibration. Absolute amplitude and phase calibration takes place with calibration coils that create a known AC pseudo-random noise consisting of a series of discrete frequencies covering most of the bandwidth (10Hz-8kHz). Calibration switch-on is commanded by the DPU according to a pre-scheduled sequence. This procedure has negligible power and weight requirements and has been applied successfully on previous missions.

a5. Electric field instrument (EFI).

A three dimensional EFI experiment consists of 4 spin-plane spherical sensors each on a 20m deployable cable and 2 axial tubular sensors, each mounted on 5m-long stacer elements. The experiment is built by UCB to the heritage of S3-3, ISEE1, CRRES, POLAR and CLUSTER. The 8cm diameter spherical sensors (Figure D-13/F) are identical to the ones delivered for flight on the

CLUSTER II satellites. The axial, two-stage stacer elements are identical to ones used on POLAR, FAST and rockets. The 1m long, 2mm diameter, stowable tubular sensor element is of the standard STEM line built by commercial outfits (Orbital/ TRW/AEC-ABLE). The sensor electronics are simplified versions of the CLUSTER design. THEMIS's simpler science and instrument interface requirements result in considerable volume, weight and power savings. The (digital) fields processing electronics are a simplified version of the FAST electronics (see SCM section). The proposed spin-plane sensor incorporates a design improvement flown on the CLUSTERII-EFW experiment: the insertion of a thin wire between the hockey-puck stub and the sphere sensor. This wire increased the CLUSTERII-EFW sensitivity (tenfold) relative to previous designs. In-flight performance data show that a wire length twelve times the spacecraft diameter is sufficient to guarantee high sensitivity electric field measurements. THEMIS baseline has wires 20 times the probe diameter. The proposed use of a tubular element, instead of a sphere, along the axial direction is afforded by the symmetry of the probes which are spinning nearly on the ecliptic plane. This design permits longer, lighter axials while the tube's thinness at its base minimizes photoelectron interaction with the stacers.

The primary science requirements are derived from the need to determine at the times of onset at 8-10R_E: 1) The plasma pure convective motion, i.e., without the effects of diamagnetic drifts that ESA measurements are subject to. 2) The low frequency (T~1min) wave mode and Poynting flux. Adherence to these is summarized Figure D-13/F.

The $\mathbf{E}\cdot\mathbf{B}=0$ approximation, commonly used at low frequencies to derive the third electric field component is ideally applicable for the THEMIS conditions at the primary region of interest (8-10R_E). The approach is error-free when **B** is away from the spin plane by >10^o. By design THEMIS is expected to obtain data near 6:30 UT, near winter solstice, i.e., at dipole tilt >30^o. Thus even under extremely thin plasma sheet conditions the inner probes will determine the axial component independently from the axial boom measurement and provide both a method for calibration of the axial measurement and a backup solution.

EFI specifications. The preamplifier electronics for the wire sensors are housed inside a hockey-puck arrangement, which also acts as a stub for the wires (Figure D-13/F). The deployment mechanism is identical to CLUSTER's but packaging is analogous to FAST due to the reduced volume requirements of the THEMIS EFI experiment. The sphere and stub release is shown in Figure D-13/B.

The boom electronics, located at the EFI housing, perform stub and guard voltage control and sphere-biasing. Signal processing takes place in the IDPU, together with the SCM. Routine waveforms (at 32samples/s) or burst waveforms (at 128 - 8192 samples/s) are captured and processed just as for the SCM data. Spectral processing of the low frequency (<8 kHz) data occurs in the DSP in a fashion identical to the SCM. The wire booms will be deployed with near real-time monitoring of a release and spin-up sequence, each lasting 1-2 hours / probe. Alternating between different THEMIS probes in science and sphere-release phase, mission-total EFI deployment lasts <10 days.

EFI calibration. The aforementioned individual probe calibration results in absolute DC measurement accuracy of 0.1 mV/m, i.e., <10% of the field value anticipated during fast flows. Increased confidence in the measurements will be obtained from inter-spacecraft calibration at quiet times.

a6. Ground observations.

The comprehensive THEMIS approach to solving the substorm problem calls for monitoring the nightside auroral oval with fast (<1s exposures), low cost and robust white-light imagers and high-time resolution (1s) magnetometers. The ASIs will be provided by UCB based on its recent experience with the Automated Geophysical Observatories (AGOs) deployed in Antarctica, while the magnetometers will be provided by UCLA based on its recent experience with the UC-LANL, MEASURE, SMALL ground magnetometer networks. Our choice of sites and instruments complements existing CANOPUS all sky stations which carry multiple filters, and space-based platforms which might be available in 2006 (IMAGE, TIMED, LWS). Proposed THEMIS stations are shown in Figure D-8. Additional dual-purpose (EPO and scientific) mid-latitude THEMIS magnetometer stations will complement the existing mid-latitude network. The proposed deployment in Canada will receive on-site technical personnel support and maintenance from the University of Calgary (UC), based on its experience with the ongoing NORSTAR all sky imager network deployment, and from the University of Alberta (UA) based on its CANOPUS experience.

b. Mission Design.

Data accumulation. An average of ~750 Mbits per day will be collected (Table D-6). Existing methods for instrument-specific loss-less compression will be applied to reduce data volume by a factor of two (<375 Mbits). Baseline primary science can be accomplished with routine data accumulation. High-time resolution particles & fields datasets are afforded by the particle burst mode.

	Routine Accumulation Mode t_R=80% t_{total}	Particle Bursts: For 24hr orbits: t_{PB}=20% t_{total}	Wave Burst Mode t_{WB}=20% t_{PB}	Total
Collection, hrs	38.50	4.20	0.84	42.70 hrs
FGM, bps	256	2048	8192	91 Mbits
ESA, bps	608	4395	0	151 Mbits
SST, bps	512	1707	0	97 Mbits
SCM, bps	555	5120	16384	204 Mbits
EFI, bps	555	5120	16384	204 Mbits
Total (Mbits)	345	278	124	746 Mbits

Table D-6. *Data volume/orbit (uncompressed). For P4/P3/P5f, particle bursts occur 20% of the time. For P2 and P1, bursts occur only within days/times of THEMIS tail-aligned conjunctions. For P1, routine data are nominally gathered around tail-aligned conjunction times.*

Burst mode can be of two types: *particle* or *wave*. Particle bursts collect high resolution distributions and low frequency waveforms. They aim at capturing the components of the global magnetospheric substorm instability (-5min to +10min from burst trigger). They will be triggered by local plasma conditions. Since substorms occur ~10% of the time (15min collection / 3hr substorm recurrence time) which is similar to the occurrence rate of bursty flows[33,29] and current disruption in the region of primary interest ($X>-13R_E$) our memory allocation of 20% of the observation time to particle bursts leads to full coverage of all surge intervals by this mode. *Wave* bursts are intended to capture the **E&B** field waveforms of the waves anticipated within the disruption region. Broadbanded low frequency waves occur nominally 10-20% of the bursty flow time (and proportionately less at higher frequencies). Memory allocation to wave bursts (20% of the particle burst time) results in waveform accumulation during most onset-related waves.

Data collection. The THEMIS tracking needs (1370 passes/year) will be met primarily by the 11m UC Berkeley ground station BGS (1030 passes/year). Wallops Island (WGS) has been budgeted as secondary (185 passes/year). Downlinks not feasible during high priority orbits at the standard transmission bit-rate will be (i) stored on board for transmission at the next contact (10 orbits/yr) (ii) downlinked on longer range, lower bit-rate sessions (90 orbits/yr), or (iii) downlinked using NASA/ DSN station RIT (55 orbits/yr).

Spacecraft performance. The requirements are outlined in Figure D-1/A_I. Absolute spin stability (and knowledge) is required to within 1^o (for current sheet measurements). The SST instrument performance spin control (ACS) to within $\pm 11.25^o$ from the ecliptic normal is derived from the need to maintain solar UV more than $\sim 7^o$ away from the top and bottom SST fields of view. No attitude, but some orbit conditioning (i.e., to phase appropriately the probe mean anomalies) is required prior to each tail- and dayside- mission phase.

Mission operations concept. Data are stored on-board and dumped over a several-hour-long window of opportunity near perigee. After an early post-launch check-out period, operations are automated. Commands and time are uplinked and instrument health status downlinked once per contact (1-4 days). No real-time data link is required. The dataset is stored locally and transmitted over a dial-up ISDN line, or over the internet. This is the scheme employed on FAST. An on-call operator responds to automated paging if housekeeping data are beyond limits.

Mission operations requirements. Position knowledge is required at 10% of minimum inter-probe separation in science regions. This amounts to knowledge within 100 km, which is easily achievable using the on-board transponder for 2-way coherent ranging.

Launch and lifetime. THEMIS's baseline mission calls for a 2-year lifetime. The inertial pointing of the probes during ascent has a power-positive configuration and a healthy link margin at all epochs, resulting in no seasonal restrictions on launch date. Nominal launch date is June 21, 2006, i.e., four months prior to the prime mission phase.

c. Analysis and Archiving

Data flow. Level-zero processing at the science operations center extracts housekeeping information and produce simplified level zero ".cdf" files containing individual instrument data. Daily automatic processing will produce "level 1" calibrated data files within 3hrs of downlink. Science team validated data will be updated daily on the web along with standardized-format plots (.gif and.ps). Data will also be sent in CDROM format to co-I sites and for archival to NSSDC monthly. These practices are identical to the FAST handling. Inter-probe calibration will be performed in the early mission phase to confirm individual probe calibrations, but will be part of the data analysis efforts thereafter, so as to not hold up data dissemination.

Analysis software. Four IDL-based software suites are proposed: (1) *Single probe analysis software,* is directly transferable to THEMIS from FAST and WIND analysis. (2) *Multi-point data* *analysis software from* ISTP and CLUSTERII analysis to compute the flow shear/curl and pressure gradient along with their standard error will be directly implemented or modified for THEMIS. (3) *Ancillary data software.* An existing distributed database of such data will be upgraded with IDL decommutators for plotting them seamlessly relative to THEMIS quantities. These will include ground magnetometers, all sky cameras, ancillary ground chains and solar wind data. (4) *Event modeling.* IDL codes that fly virtual probes within simulation run results under specific, idealized solar wind external conditions already exist and will be fine-tuned for THEMIS use. A library of event-specific MHD, hybrid and kinetic simulations will be assembled for useful conjunctions, enabling quantitative comparisons between models and observations.

Community participation. The PI and co-Is are integral parts of the vibrant substorm, GEM and ISTP communities. They intend to spare no effort in engaging and facilitating the optimal use of the THEMIS dataset by their colleagues. A $4.0M for a guest investigator (GI) program and for non co-I training in analysis tools is planned so as to enhance the US community productivity under this GI or future SR&T programs. The active involvement of the international community through instrument and data analysis contributions further guarantees maximal THEMIS data utilization.

d. Science team

Table D-7 describes the science team members, roles, most recent pertinent experience and funding sources. At UCB, **V. Angelopoulos** will lead the science team as PI, based on his experience in magnetotail data analysis and theory over the last 12 years. He will ensure that the decisions taken during mission development will be in the best interest of science and will meet the mission objectives. The PI will lead the magnetotail data analysis efforts. Individuals responsible for instrument development are named in Figure D-13/A-F. Their experience from previous projects is detailed in Table D-7; their respective institutional heritage is described in the first paragraph of the corresponding instrument section (Section D2 a1-a5). Key instrument personnel at UCB are: **P. R. Harvey**, who will manage the EFI and SCM electronics development based on his experience in similar roles on CLUSTERII, POLAR and FAST; **D. W. Curtis**, who will manage the ESA, SST electronics development and the IDPU development based on his similar roles on FAST; **D. Pankow**, who will manage the mechanical design and development of all instruments based on his similar experience on FAST and HESSI and **R. P. Campbell**, who will be responsible for SST sensor development and ground calibrations based on his similar roles on ISEE1/2/3 and WIND.

Additionally at UCB, team member **G. T. Delory** will be responsible for integration and testing of instruments with the IDPU, based on his experience in a similar role on the Alaska 99 rocket, where he was also the overall program manager; **S. Mende** will be responsible for developing the auroral ground imagers, based on his development of the AGO network; **T. D. Phan** an experienced magnetopause and magnetotail researcher (current experience: CLUSTERII), will also be responsible for analysis software development based on his similar role on Equator-S; while **M. A. Temerin** will lead the analysis of radiation belt data analysis efforts based on his 20 years of experience in radiation belt physics and wave-particle interactions.

At UCLA, **K. K. Khurana** will conduct FGM inter-calibration and data analysis (similar to his Galileo and CLUSTERII roles), **M. G. Kivelson** will study plasmoid/flux rope and sources of modulated flows based on her experience on Galileo and Geotail, **J. Raeder** will perform event-based MHD modeling deriving from his ISTP mission support and **C. T. Russell** will be responsible for ground magnetometer development and for space/ground correlative substorm studies. At CU, **R. Ergun** will design the IDPU fields processing, stemming from his experience on FAST, and **X. Li** will conduct event-based analysis and particle tracing for radiation belt physics as on CRRES and POLAR. At no cost to NASA foreign co-Is will participate in THEMIS data analysis geared towards various aspects of substorm physics phenomenology (**Baumjohann, Nakamura, Jacquey, Roux, Sergeev**), theory (**LeQueau, LeContel, Voronkov**) data analyses correlative with ground pulsations (**Glassmeier, Samson, Schwingenschuh**) and images (**Donovan**). Canadian co-Is will advise on development and support deployment of the ground stations. In addition to (and in conjunction with) Raeder's MHD simulations, co-Is **Buechner** and **Fujimoto** will conduct data-model comparisons using kinetic or hybrid simulations, based on their recent successful practices on Interball and Geotail respectively. Un-funded collaborator **Singer** will advise the team on space weather issues and

Goes data usage.

	THEMIS Team Member	Institution	NASA Mission Management	FGM	ESA	SST	SCM	EFI	Common IDPU	I&T, Operations and In-flight	Tail Science	Radiation Belt Science	Magnetopause Science	Theory/ Modeling	Ground Correlations	Most Recent Demonstrated Experience
NASA FUNDED																
PI	V. Angelopoulos	UCB	★								✔★				✔★	ISEE, IRM&CCE, Geotail
NASA funded co-Is/co-Es	C. W. Carlson		✔☆		✔★				✔★	✔★	✔★				✔★	FAST PI; CLUSTERII/CIS
	G. T. Delory							✔★	✔★	✔★						FAST, Alaska 99: PM
	R. P. Lin		✔☆		✔	✔★				✔☆	✔					HESSI, WIND/3DP: PI
	S. Mende														✔★	AGOs, IMAGE/FUV:PI
	F. S. Mozer		✔☆				✔☆	✔★		✔☆	✔★		✔★			S3-3, POLAR/EFI: PI
	G. Parks														✔★	Geotail; Polar; ClusterII
	T. D. Phan										✔★		✔★			Equator-S, ISTP
	M. A. Temerin										✔★	✔★		✔★		S3-3, POLAR, FAST
	K. K. Khurana	UCLA		✔						✔★	✔★			✔★		Galileo/MAG; Cluster/FGM
	M. G. Kivelson			✔							✔★		✔★	✔★		Galileo/MAG; Cluster/FGM
	J. Raeder										✔★		✔★	✔★		ISTP; MHD Codes
	C. T. Russell			✔☆						✔★	✔★		✔★	✔★	✔★	ISTP; MEASURE; SMALL
	R. E. Ergun	CU					✔☆	✔☆	✔★	✔	✔					Rockets, FAST waves: co-I
	X. Li											✔★		✔★		IRM; CRRES; SAMPEX; Polar
	A. T. Y. Lui	JHU/ APL									✔★			✔★	✔★	ISIS, CCE, Geotail,
	D. Sibeck										✔★		✔★			AMPTE/CCE, GOES, ISEE3
Instrument key persons	R.D. Campbell	UCB				✔★				✔★						ISEE1,2,3; WIND/3DP; Equator-S
	D.W. Curtis (EE)				✔★	✔★			✔★	✔★						IRM, WIND/3DP, Cluster, FAST IDPU
	P.R. Harvey (EE)						✔★	✔★	✔★	✔★						Cluster, POLAR, FAST
	D. Pankow(ME)				✔★	✔★	✔★	✔★		✔★						LP, POLAR, FAST, HESSI
NON-NASA FUNDED																
	U. Auster	TUBS		✔★						✔★			✔★			MIR, Equator-S, Rosetta
	K.-H. Glassmeier										✔★		✔★		✔★	Freja, CLUSTERII, Rosetta
Foreign co-Is	W. Baumjohann	IWF									✔★	✔★	✔		✔★	IRM, Equator-S, Geotail
	R. Nakamura										✔★	✔			✔★	Equator-S, Geotail, Sampex
	K. Schwingenschuh			✔★						✔★						Equator-S, Rosetta/ROMAP
	J. Buechner	MPAe									✔★		✔	✔★		Equator-S, Interball; PIC Codes
	O. Le Contel	CETP									✔★			✔★		CLUSTERII, GEOTAIL
	A. Roux						✔★			✔★	✔★			✔★	✔★	GEOS,CRRES, CLUSTERII
	E. Donovan	UC									✔★				✔★	NORSTAR(PI), CLUSTERII
	P. Escoubet	ESTEC				✔★				✔☆						WIND/3DP, CLUSTERII
	H. Laakso										✔★					POLAR/EFW, CLUSTERII/EFI
	M. Fujimoto	TITech									✔★		✔★	✔★		Geotail; Hybrid Codes
	C. J. Jacquey	CESR									✔★			✔★	✔	ISEE, Geotail, Interball
	D. LeQueau										✔★		✔★	✔★	✔	ISTP theory, CLUSTERII
	J. Samson	UA									✔★			✔★	✔★	ISTP-Canopus
	I. Voronkov										✔★			✔★	✔★	
	V. Sergeev	USP									✔★			✔★	✔★	Interball; ISTP; ClusterII
†	H. J. Singer	NOAA		✔		✔				✔	✔☆	☆				ISTP on Space Weather

†Unfunded Collaborator ✔Demonstrated experience ★Primary Function(s) ☆Advisory Role(s)

Table D-7 *Member roles and experience*