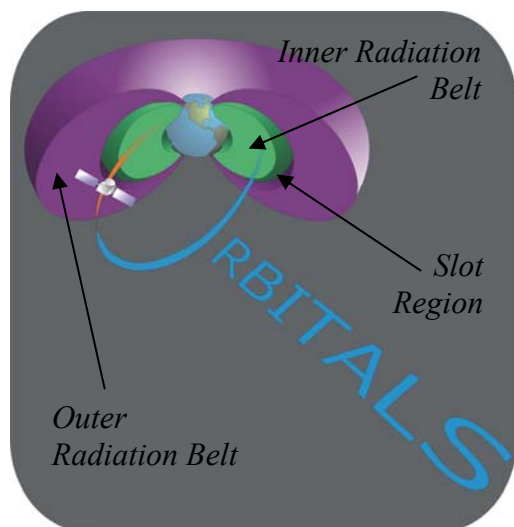


Outer Radiation Belt Injection, Transport, Acceleration and Loss Satellite (ORBITALS)

ORBITALS Mission Goal:

“Understand the acceleration, global distribution, and variability of energetic electrons and ions in the inner magnetosphere”.



PRIMARY Science Objective:

1. Understand the dynamical variation of outer radiation belt electron flux, including determining the dominant acceleration and loss processes.

SECONDARY Science Objectives:

2. Understand the dynamical behavior of inner zone and slot region radiation belt particle fluxes.
3. Understand the structure of global inner magnetospheric electric and magnetic fields.
4. Understand the core ion composition of the outer plasmasphere, plasmopause and plasmatrough regions and its dynamics during storms.
5. Understand the dynamical behavior of the strength, asymmetry, and composition of the ring current in the inner magnetosphere.

Alignment with LWS and ILWS Objectives

- ORBITALS addresses the highest priority LWS Geospace science objective to understand “the dynamics of the near-Earth radiation environment”.
- ORBITALS meets the request from the LWS GMDT for the addition of GTO-like missions in additional petal orbits to partner the LWS Radiation Belt Storm Probes (RBSP).
- ILWS Magnetosphere Task Group gave “high priority” to “an inner magnetospheric fleet of a minimum of 3 satellites on GTO-like orbits” with “different directions of lines of apsides” which operate contemporaneously during ILWS.
- ILWS M-TG report endorsed ORBITALS with RBSP as a “scientifically recommendable solution” to this end.
- As an augment to RBSP, ORBITALS also provides coverage of the dynamically important slot and forms multiple s/c constellations with GEO s/c (e.g., GOES & LANL) at apogee.

Mission Characteristics

- Sun-aligned spinning s/c; 10s nominal spin period.
- Freely drifting orbit following insertion.
- Maximize ground-magnetic conjunctions to Canadian Churchill line (CGSM: CANOPUS magnetometer, NORSTAR optical, riometer, SuperDARN etc) and lower-L extension (e.g., US NSF McMAC array).
- Low inclination (dependent upon launch vehicle; possible kick-motor required for inclination lowering).
- ORBIT Options: A) 1 Re x 5.3 Re altitude (KM to raise perigee): 12 hour period and Churchill line apogee magnetic conjunctions once per day; B) 600km x 5 Re altitude, ~9.6 hr period. Less apogee conjunctions, but adds new scientifically valuable lower-L conjunctions.
- Radiation total dose almost independent of perigee and apogee options. For 7° inclination: 100 krad/yr for 4 mmAl; 10 krad/yr at 8mmAl, and 6 krad/yr at 10mmAl.
- Mission Lifetime: Minimum mission 1yr; Design Lifetime 2 yrs; Extended Mission 3+ yrs.

Science Team

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J.B. Blake	Aerospace	A. Ridley	U. Michigan
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T. Onsager	NOAA	J. Evans	Telesat Canada
R. Rankin	U. Alberta	B. Gordon	Routes AstroEng.

Science Instrument Payload

Fluxgate Magnetometer (FGM) 3-comp. **B**, DC-160 Hz.

Electric Fields and Waves (EFW) 2-comp. **E** in spin plane. 90m tip-to-tip booms. DC-40Hz plus waveform capture burst and Langmuir probe modes upto 500kHz.

Search Coil Magnetometer (SCM) 3-comp. - 40 Hz plus burst modes upto 20kHz (tied to EFW burst modes).

Suprathermal Ion Image (SII) 2D distribution functions; 3D from spin. 0-50 eV ions. Species resolution from s/c ram.

Composition and Distribution Function Analyser (CODIF) H⁺, He⁺, He⁺⁺, and O⁺. 0.02-38 keV/q. 2D distributions; 3D from s/c spin. Cluster flight spare.

Energetic Particle Spectrometer (EPS) Electrons 25keV - 12MeV, Protons 25-4MeV. 2D distribution each spin.

High Energy Proton Telescope (HEPT) Protons and heavy ions 3-100 MeV (2 telescopes). 2D distribution each spin.

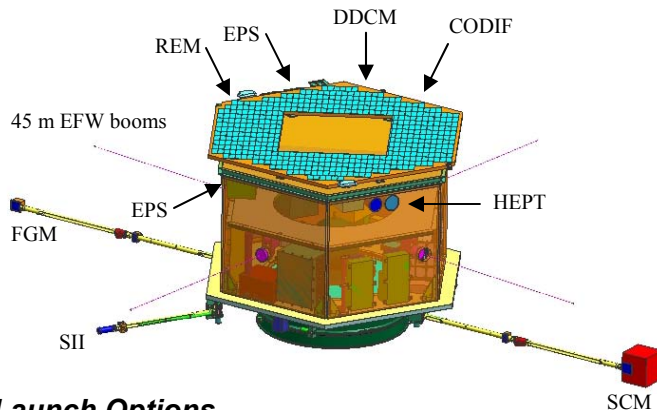
Radiation Effects Monitor (REM) On-orbit total dose and SEU effects on processor chips. STRV heritage.

Deep-Dielectric Charging Monitor (DDCM) On-orbit deep-dielectric charging monitor.

Spacecraft Characteristics

- Small satellite bus developed by Bristol Aerospace Ltd (Magellan Aerospace Corp.). Based on MAC-200 design for CSA Universal Bus.
- 4mm Al equivalent shielding from honeycomb body.
- Additional shielding for electronics and instruments.
- ADCS: Hydrazine or cold gas for initial spin-up and commissioning incl. booms; Magnetic torquers for $\sim 1^\circ$ per day sun re-alignment at perigee (for ORBIT B).
- Data downlinked by redundant 5W S-band-omni transponders during perigee.
- 2GB solid-state on-board storage stores upto 5 days science data (34kbps). EDAC 2-bit error correction.
- Perigee data collection and commanding. Command from CSA St. Hubert; 2 equatorial ground-stations allow perigee downlink with short contact times.
- S/C wet mass (instruments and design contingency included) $\sim 340\text{kg}$.

Payload Accommodation



Launch Options

- Dedicated launch on Taurus (baseline).
- Shared launch (with ILWS s/c, e.g., RBSP) on Delta-II.
- Dedicated/shared launch on Soyuz.
- Commercial piggy-back to GTO.
- Reduced mass (300kg) and diameter (1.5m diameter) option on Ariane 5 ASAP-5 ring; Ariane 5 also has small-sat. capability (cf. NASA Triana launch).
- Sea launch zenit secondary SLSPA ring?

Mission Development Timeframe

- ORBITALS currently undergoing CSA Concept Study for small satellite mission in support of ILWS; concept study to be complete 1st April '05.
- Science team working closely with Bristol Aerospace to develop concept and demonstrate mission feasibility.
- Recent review of ORBITALS concept study progress by CSA Space and Atmospheric Environment Advisory Committee (SAEAC) in Nov. '04.
- SAEAC made resolutions that it "expects that ORBITALS will be ready for Phase-A at the completion of its concept study" and that "the CSA should find the means to continue" the ORBITALS project "in an expeditious manner".

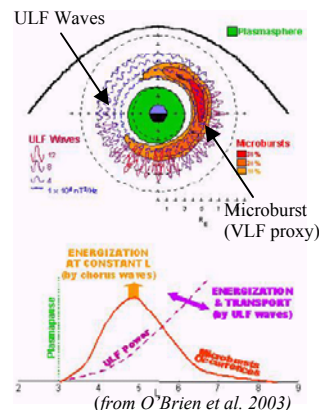
- Optimistic that CSA will release funds for 1-2 year Phase A at the completion of the Concept Study.
- Expected launch $\sim 2012-14$. Target contemporaneous operation with RBSP, and perhaps with proposed Japanese ERG inner magnetosphere mission.

Science Highlights

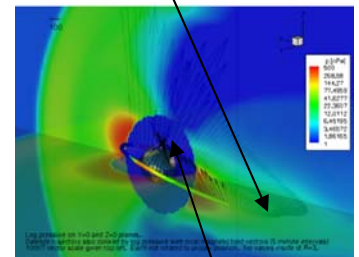
Very successful ORBITALS Science Workshop with ~ 60 international scientists held in Banff 22-24th Sept. '04. The Workshop defined excellent mission scientific focus.



Key mission science issues include: i) The relative importance of ULF vs. VLF waves, ii) Importance of accurate particle PSD; iii) Inner magnetosphere E and B field structure including role of (asymmetric) ring current penetration; iv) The role of cold (plasmaspheric) plasma in energetic particle dynamics; v) The time-dependent competition between acceleration and loss; vi) Slot region creation and dynamics; vii) On-orbit electronics SEU, deep-dielectric charging, and dose effects.



Pressure and B along ORBITALS orbit within BATS-R-US simulation.



Penetration of asymmetric ring current to inner magnetosphere.

CSA-NASA Co-operation Opportunities

- Excellent opportunities for scientific, mission and launch co-operation between ORBITALS and RBSP.
- Strawman payload incorporates instrument provision from world-leading US and Canadian investigators.
- NASA-CSA co-operation would follow the LWS MOWG July '03 recommendation that NASA seek "increased international co-operation".
- Combined RBSP-ORBITALS constellation provides infrastructure required for science closure in the highest priority LWS Geospace objectives.
- Enables voyage of discovery to vastly under-explored, poorly understood inner magnetosphere.
- Would solve the long-standing question of why the magnetosphere, expected to be quiescent astrophysically, is such an efficient accelerator of charged particles to relativistic MeV energies.