DR. D. P. STEELE

NiteOwl Project

NiteOwl is an acronym for “Nightsky Imaging Tomography Experiment to measure Ozone With starLight,” the title of a proposal submitted to the Canadian Space Agency in response to an Announcement of Opportunity (AO) for the Small Payloads Program (SPP). The NiteOwl project logo is shown in Figure N.

The proposal describes a concept for an experiment to measure ozone in the stratosphere and upper troposphere at night by optical means. The concept is to perform a self-calibrating stellar occultation experiment, by flying a slitless imaging spectrograph to 80 km altitude using a small rocket, and measuring the absorption of starlight in the Chappuis bands of ozone (450 - 750 nm wavelengths) as the spectrograph descends beneath a parachute. The payload will include a Global Positioning System (GPS) receiver to determine absolute positions in real time, and an intensified video camera to determine payload attitude, as was done in the GEMINI and OEDIPUS-C missions (Moorhouse, 1995). The proposed 15° field of view will allow the spectra of stars down to magnitude 3.0 to be measured with a signal-to-noise ratio of 100:1. The high SNR is required in order to normalize stellar spectra measured within the ozone layer to those measured above the absorbing layer. Spectral inversion of the normalized spectra will yield column concentrations of ozone, neutral density, and possibly NO_2 and NO_3. Tomographic analysis of these concentrations, measured over a range of azimuths and altitudes as the payload descends while slowly spinning beneath its parachute, will yield the three-dimensional distribution of ozone.

The proposal was submitted by Dr. Steele on behalf of a cross-disciplinary team comprising graduate students and faculty from five departments and three colleges of the University of Saskatchewan, together with senior science, engineering, and management personnel of SCI-TEC Instruments, Inc. of Saskatoon (see Tables A and B). The team, possessing a wide range of applicable knowledge and experience but little prior involvement with space missions, was assembled to pursue a new approach to preparing proposals for space experiments, suggested by Dr. E. J. Llewellyn, which involved graduate students directly in every aspect of the proposal, from concept elaboration and mission planning to locating vendors and writing the actual proposal. For their participation in the preparation of the proposal, the students received credit for special-topics courses in Physics and Engineering Physics or the Commerce MBA program, the latter for the two MBA students who joined the project to prepare the management plan required by the AO. In addition, each of the students gained practical experience in proposing a new experiment and a “three-month interview” with SCI-TEC, as their personnel worked closely with the University members of the NiteOwl team on the science, engineering, management, and cost of the proposed experiment.

The students worked with faculty guidance in eight working groups covering science, optics, electrical and mechanical engineering, data handling on board and on the ground, experiment risk and reliability, and management aspects. Starting in many cases with the proverbial blank sheet of paper, each group first identified the important questions and then tried to answer them using the scientific and industrial literature, design studies, and mathematical modelling. Interactions between various areas required careful trade-offs; e.g., flight dynamics on the parachute (mechanical engineering) constrains the field of view and exposure time of the imager (optics), which in turn limit the sensitivity and achievable signal-to-noise ratio of the data (ground-based data handling). Many aspects of the experiment and payload require fuller study, and will be fully defined during Phase A if the proposal is selected for funding.

A decision on Phase A funding for the proposal is expected in May 1997. Phase A studies would be carried out at the University of Saskatchewan, SCI-TEC Instruments, Inc., and at Bristol Aerospace Limited in Winnipeg, MB, the payload contractor. On successful completion of the Preliminary Design Review, funding would be provided for the execution of the mission. The NiteOwl experiment could fly in January or February of 1999, with Akjuit Aerospace Inc. of Winnipeg providing launch services from SpacePort Canada at Churchill, MB. A follow-on experiment for global ozone monitoring from a microsatellite platform is envisaged, which could provide key environmental data for both scientific and commercial/public use.

Fig. N. NiteOwl project logo.

Table A. Graduate Student Members of the NiteOwl Submission Team

Graduate Team Member	College/Department	Responsibilities
J.K. Chan	Commerce	Work breakdown, budget, management plan
J.E. Giesbrecht	Electrical Engineering	Electronics, detectors, GPS, telemetry
D.P. Harris	Commerce	Work breakdown, budget, management plan
M. Huber	Physics & Engineering Physics	Optical filters and lenses, ozone distribution
E.B. McDougall	Physics & Engineering Physics	Gratings, electronics
J.J. Offiong	Physics & Engineering Physics	Stellar spectra, risk and reliability
J.A. Steele	Mechanical Engineering	Stellar distribution, tomography
M.M. White	Physics & Engineering Physics	Cross-sections, refraction, other species

Table B. The NiteOwl Science Team

Team Member	Responsibility	Level of Effort
D.P. Steele, PEP	Project co-ordination, mission planning and science	160 hr/month
H.S. Caplan, PEP	Project management	5 hr/month
A.V. Koustov, PEP	Instrument calibration and data storage	20 hr/month
A.I. Smolyakov, PEP	Mission simulation	20 hr/month
R.J. Bolton, EE	Electrical/electronics design, risk analysis	25 hr/month
H.C. Wood, EE	Design consultation	5 hr/month
J.D. Bugg, ME	Mechanical and thermal design	15 hr/month
A.T. Dolovich, ME	Development of tomographic analysis technique	15 hr/month
C.E. Soteros, M&S	Inverse problem	15 hr/month
R. Srinivasan, M&S	Data compression, image reconstruction	15 hr/month
E.V. Ivanov, SCI-TEC	Optical instrument fabrication and testing	15 hr/month
J.E. Johnston, SCI-TEC	Optical instrument specification and design	30 hr/month
D.J. Sniezek, SCI-TEC	Management of instrument development	5 hr/month
M.J. Painter, Commerce	Supervision of graduate financial management students	5 hr/month

Polar arc tomography

A collaboration between Dr. Steele and US scientists led to the submission to Geophysical Research Letters of a paper entitled “Tomographic reconstruction of 630.0 nm emission structure for a polar cap arc”, by R.A. Doe, J.D. Kelly, J.L. Semeter, and D.P. Steele. The paper was based on images of a slowly drifting, morphologically stable polar arc, acquired by the Polar Camera at the Environment Canada AStrO Laboratory at Eureka, NWT, and by a similar CCD-based imaging system from the University of Michigan, operated at the US National Science Foundation (NSF) Early Polar Cap Observatory (EPCO) at Resolute Bay, NWT, on February 19, 1996. The tomographically reconstructed vertical emission profiles showed variations in the height and magnitude of peak volume emission rate on a time scale of minutes, which led to the conclusion that such changes were caused by magnetospheric processes such as changes in the precipitating electron energy distribution, rather than thermospheric processes such as neutral heating or plasma diffusion/decay. This collaboration continues, and events from December 5-6, 1996 have been identified for further study, which will be augmented by the expanding instrument complement at Resolute Bay.

Polar Camera

During the spring of 1996 the Polar Camera was returned to Saskatoon for repair, refurbishment, and recalibration. The imaging systems were removed and shipped to Photometrics, Inc. in Tucson, AZ for preventive maintenance, which included pumping and baking the hermetically sealed detector housings. Two little-used filters at 520.0 nm ($N(^2D)$) and 713.5 nm (background) were removed from the filters wheels to facilitate calibration of the eight other filters, and these were remeasured while in the Polar Camera. The results showed that the filters retain the high peak transmissions originally measured four years earlier, and that the passbands have not changed measurably, with the exception of those of the narrow-band filters for 557.7 nm ($O(^1S)$) and 630.0 nm ($O(^1D)$) which have blue-shifted slightly, improving the absolute transmission at the emission wavelengths. The Polar Camera was returned to Eureka for the 1996-97 winter observing season, which will likely span the end of the current solar cycle.