COMMUNITY WORKSHOP ON SCIENCE FROM SUBORBITAL VEHICLES
(BALLOONS, AIRCRAFT, ROCKETS)

February 1 and 2, 2007
Toronto

FIRST ANNOUNCEMENT

Introduction

With the Canadian Space Agency currently preparing an Announcement of Opportunity for a new Small Payloads Program, this is an opportune time for a Community Workshop on Science from Suborbital Vehicles. The aim of this workshop is to bring together those in the Canadian science community who have an interest in using balloons, aircraft, rockets, and other unmanned vehicles as platforms for scientific exploration, and to get them dreaming about new ideas.

Such platforms offer a number of advantages that are closely allied to the mission of the Canadian Space Agency. These include:

• Scientific exploration, including atmospheric science, space science, astronomy, and astrophysics
• Technology development, including testing prototypes of satellite instruments
• Validation of satellite missions, such as those making height-resolved atmospheric measurements
• Training of scientific and technical personnel, who will become the next generation of scientists, including our next generation of Principal Investigators

Goals

The goals of this workshop, in anticipation of a new Small Payloads Program, include:

• Raising the profile of balloons, aircraft, and rockets as platforms for scientific investigations
• Stimulating discussion of new approaches and new science questions that can be addressed with such platforms
• Determining the level of interest in these flight opportunities in Canada
• Identifying the infrastructure needed to enable new missions
• Providing a vision for a “program” with regular flight opportunities
• Enhancing and creating new collaborations between Canadian universities, government agencies, and industry

Expected Outcomes

• A ten-year vision
• A game plan for the next year
• A list of potential new missions
• A description of the infrastructure that will be needed for each platform, to allow such missions to be accomplished
• Recommendations for what is needed to maintain continuity
Background

**Balloon platforms** offer excellent opportunities for scientific exploration, particularly for atmospheric observations that look through the atmosphere, and for astrophysical observations from above the atmosphere. They can carry a variety of payloads, including sampling, in situ, and remote sounding instruments, ranging from a few kilograms to several tons. They can fly at altitudes from near the surface to the upper stratosphere, reaching near-space conditions at float altitudes of 40 km. The duration of balloon flights can range from a few hours to several weeks, and they can be designed for special flights to match scientific requirements, such as valve-controlled slow descent, long duration flights, and tethered flights.

The time-scales for balloon missions are relatively short, typically taking from one to five years from concept to flight. Such missions allow testing of new instruments that may have little or no flight heritage in the near-space environment, enabling the assessment of their suitability for satellite missions. Balloon programs are much less expensive than satellite programs, and have many applications, including atmospheric chemistry and dynamics, radiation, weather and climate, and astronomy and astrophysics. Balloons provide observations of detailed atmospheric processes on much finer spatial and temporal scales than is possible from the ground or from satellites.

There have been recent technical advances in a number of ballooning technologies, for example, in trajectory control, super-pressure balloons, UV-resistant balloon materials, power systems, launch techniques, onboard storage, and telemetry, offering opportunities for Canadian industry to develop new strengths and capacities. These advances continue to improve the capabilities and reliability of scientific ballooning, making novel scientific investigations possible. These could include such future Canadian missions as climate change and radiation balance experiments, long-duration Lagrangian (free floater) balloons for in situ chemistry measurements, and stratospheric wind measurements.

Canada has a long history of scientific ballooning, dating back to airglow measurements made in 1960. Early efforts were led by the Canadian Armament Research and Development Establishment, the University of Saskatchewan, and the National Research Council. In the 1970s and 1980s, the Atmospheric Environment Service led the Stratoprobe series of balloon flights, which led to the more recent MANTRA campaigns. Meanwhile, Canada has also been an active participant in a number of high-profile international astronomy balloon missions, such as BOOMERANG and BLAST. We are now at a critical juncture with regard to future ballooning activities in Canada. Environment Canada is reconsidering its support of the launch facility at Vanscoy, Saskatchewan, and much of the existing payload and launch support equipment there dates back 20-30 years. Does Canada wish to maintain its own payload support and launch capability or rely solely on contracting launches to organizations such as NSBF in the USA or CNES in France? Without access to regular flight opportunities, it is difficult to build and maintain these capabilities. There are also questions about the trade-off between flight risk and resources; as currently implemented, ballooning is not supported and managed as a space program in Canada. Moving to a risk avoidance model where all systems are fully flight-tested will require an increase in resources, and is likely to move some development out of universities and reduce student involvement.

**Aircraft platforms** offer high-altitude and long-range capabilities (up to 20 km and 11,000 km, respectively, depending on the aircraft) and provide high-resolution and high-sensitivity measurements using both in situ and remote sensing instruments. High-resolution measurements are
necessary for the study of the complex and small-scale dynamical, chemical, and radiative processes in the lower troposphere (LT) and the upper troposphere/lower stratosphere (UTLS). Both the LT and the UTLS are regions of major interest concerning both climate impact and surface environment. Changes in ozone, water vapour, and cloud properties and coverage in the UTLS have a large impact on surface UV fluxes and temperatures due to the radiative properties and particular temperature structure of this region. Significant ozone trends have been observed globally and further changes in both ozone and water vapour are likely to occur in the future due to a changing climate.

Aircraft measurements and the development of high-sensitivity and high-resolution instrumentation able to cope with low pressures and temperatures has the potential to improve present knowledge of the processes governing the chemical composition and the dynamical structure of the LT and the UTLS, and to monitor future changes. In order to study the UTLS, aircraft campaigns have to be designed to reach altitudes up to 16 or 17 km. On the instrumental side, capabilities should include high resolution and accuracy for in situ measurements of O₃ and CO, different long-lived tracers such as N₂O, CH₄, or SF₆, halogen compounds, water vapour, and total water. A promising and highly valuable technique is offered by lightweight lidars for the vertical profiling of aerosol, ozone, water vapour and wind. Both Canada’s industrial and scientific communities have considerable lidar expertise, offering opportunities for future technological innovation and development, thus providing the prerequisite for scientific progress.

Instrumentation for the measurement of radiation and cloud microphysics is also needed. Although new cloud physics instrumentation has become available over recent years, much characterization is still required to understand the accuracy of the measurements, and the influence of the aircraft itself and the physical instrument configuration on accuracy. Progress in addressing several fundamental issues in cloud physics is still limited by inadequate or poorly understood measurements. Such measurements are required to improve understanding of cloud processes for a variety of applications, such as better cloud treatment in climate change models. Cloud microphysical properties have been shown to strongly affect radiative fluxes.

Aircraft measurements thus present a valuable and indispensable tool to support the development and validation of multi-scale models and of satellite instrumentation. Historically, Canadian instruments have often flown as payloads on American and European aircraft campaigns. In Canada, aircraft measurements have been supported by Environment Canada (EC) and the National Research Council of Canada (NRC). EC and NRC have partnered in approximately 40 cloud physics, air quality and climate studies over the past 13 years with the NRC Convair-580 and Twin Otter aircraft, both of which have been conducted in the LT due to aircraft ceiling limitations. The NRC Convair-580 aircraft (<7 km) has been developed by EC and NRC as a world-class cloud measurement aircraft, and the NRC Twin Otter (<6 km) has been recognized as a world-leading flux measurement aircraft. EC has also developed the NRC Twin Otter as a microwave remote sensing platform as part of its cryospheric studies program. EC also owns and operates its own Convair-580 aircraft, which has been developed mainly for SAR surface remote sensing applications in conjunction with NRCan. Currently, EC and NRC are performing an airborne validation program for CloudSat on the NRC Convair-580 aircraft. The Twin Otter is active in a series of validation programs for AMSR. NRC has recently been developing a T-33 aircraft for higher altitude atmospheric measurements up to a maximum of about 12 km, and also possesses a Falcon-20 aircraft with larger cabin space capable of similar altitudes. However, it must be noted that as yet Canada does not have a well-developed high altitude airborne measurement platform.
Sounding rockets have been essential for developing new instrument concepts and training new instrument PIs in Canada. Going from a high of as many as 70 launches per year from Churchill in the mid-1970’s, Canadian-led sounding rockets have all but disappeared, the last being launched in 2000. For the time being, Canadian scientists continue to receive invitations to provide instruments for rockets flown by other countries, the US and Japan being recent examples. However, it is unclear how long this activity will continue to survive in this “hitch-hiking” mode.

Sounding rockets are used to probe altitudes spanning from the mesosphere to the upper thermosphere/ionosphere, with four-stage Black Brant XII’s reaching as high as 1500 km. The 80-200 km range is effectively inaccessible by any other means. Above 200 km, sounding rockets offer many advantages over satellites: lower cost, short development time, freedom to test newer and riskier ideas, fewer constraints (typically) on mass, power, and telemetry, and ability to choose the precise time and location of the trajectory. The major disadvantage, of course, is that flights last less than 30 minutes, including the ascent and descent.

For decades, Canada has had the distinction of being the world’s foremost producer of civilian motors: the Black Brant and Nihka. Bristol Aerospace also maintained a highly skilled and experienced team of sounding rocket payload specialists. However as time goes by, access to both resources – motors and expertise – becomes more and more uncertain.

Five years ago, Bristol announced that it could sustain a viable sounding rocket support program for something like $1M per launch, provided a launch frequency of two per year could be guaranteed. However, a survey sent to CSA scientific advisory committee members at that time showed insufficient interest, and the idea was dropped. One-off type rocket projects would likely now cost from $1.5-4M, not including scientific instruments. Still, one could argue that this cost is more than offset by the significant reduction in risk for satellite instruments that would otherwise have no flight heritage.

Program Structure

The two-day workshop will include:

- Plenary sessions with invited speakers who will address both the scientific and technical aspects of doing science from balloons, aircraft, and sounding rockets.
- An oral session and a poster session on past projects and case studies as examples of what is possible: what was done, science, results that had significant scientific impact, costs, infrastructure needs.
- Oral session on proposals for future projects, with a focus on the science questions that can be addressed, including a session for graduate students and postdoctoral fellows: “If I Had a Million Dollars…”.
- Poster session on industrial capabilities and interests, including technical applications and how they might use each of the platforms.
- Break-out groups on balloons, aircraft, rockets: to review current capabilities in Canada and abroad, novel technologies and opportunities, the scope for new and exciting projects, logistical issues, etc.
- Final plenary session to bring together reports and recommendations from the break-out groups.
Call for Abstracts

You are invited to submit short abstracts (<1 page) for presentations on the following:
1. Past projects and case studies. The Organizing Committee will assess these and select some for talks and some for poster presentation.
2. Proposals for future projects (talks).
3. Graduate students, postdoctoral fellows, and younger scientists are particularly encouraged to submit proposals for future projects under the theme of “If I Had a Million Dollars…” (talks).
4. Industrial capabilities and interests (posters).

Abstracts should be submitted by 4 PM, Friday, January 12, 2007, preferably using the web-based abstract submission form found at http://www.atmosp.physics.utoronto.ca/~workshop/

In addition, whether or not you are submitting an abstract, if you plan to attend, please register for the Workshop by 4 PM, Friday, January 12, 2007, using the web-based registration form found at http://www.atmosp.physics.utoronto.ca/~workshop/

There will be CSA funds available to provide some support for attendance by graduate students, postdoctoral fellows, and research associates.

Location

The Workshop will be held in the McTaggart-Cowan Auditorium at Environment Canada, 4905 Dufferin Street, Downsview, Ontario.

Organizing Committee

- Kimberly Strong (Committee Chair), Department of Physics, University of Toronto
- Doug Degenstein, Institute of Space and Atmospheric Studies, University of Saskatchewan
- Michaela Hegglin, Department of Physics, University of Toronto
- Dave Knudsen, Department of Physics and Astronomy, University of Calgary
- Tom McElroy, Environment Canada
- Barth Netterfield, Department of Astronomy and Astrophysics, University of Toronto
- Ben Quine, Department of Physics and Astronomy, York University
- Walter Strapp, Environment Canada
- David Tarasick, Environment Canada
- Kaley Walker, Department of Physics, University of Toronto
- Jim Whiteway, Department of Earth and Space Science & Engineering, York University

This announcement and further information about the Workshop will be posted at: http://www.atmosp.physics.utoronto.ca/~workshop/

If you have questions about the Workshop, please send an email to: workshop@atmosp.physics.utoronto.ca