Report on the 1997 Grants Competition: Awards, Policy Matters, and a Five Year Spending Plan for Subatomic Physics

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1 Overview and Present Status

The GSC found itself in an extremely difficult situation at the start of the 1997 competition. The situation arose from the need to fund major capital expenditures on the three highest priority subatomic physics projects: SNO, ISAC and ATLAS, while at the same time maintaining a balanced research program in the discipline. The problem was exacerbated by the significant reductions that have been imposed on the subatomic physics envelope since 1995 arising from the federal budget cuts to NSERC and the first Reallocations Exercise.

Funds available for allocation in the 1997 competition totalled \$7.3M out of an approved envelope of \$17.3M. Funding requests for SNO, ISAC and ATLAS alone, the community's top priority projects, totalled \$9.8M, while the sum of all grant requests was \$16.8M. Given that the GSC is charged to maintain a reasonable level of diversity in the program while providing adequate funding to its highest priority initiatives, the committee could find no solution to the 1997 awards dilemma that was consistent with the previously approved subatomic physics GSC budget.

The committee met with Dr. Brzustowski and Dr. Lloyd during the competition week and informed them of the critical need to advance approximately \$2M to the 1997 competition from future year budgets in order to bridge the immediate funding gap. It was left to the GSC to propose a financial model within a constraint of this magnitude and to explore the implications for subsequent years in much greater detail than had been done previously.

In response, the GSC undertook a financial modelling exercise that was carried out with unprecedented thoroughness within the time available in the several weeks following the grants competition. The aim of the exercise was to establish realistic spending guidelines for the total capital and operating components of the envelope to determine how the initial 1997 debt of \$2M could be repaid while providing adequate support to the research program over the next few years.

The implications of awards recommended in 1997 were tracked over a 10 year period. It was concluded that the necessary capital investments in SNO, ISAC and ATLAS implied starting with a debt of \$2M in 1997 that would grow to \$3M by 1999. 10% of the debt is to be repaid in the year 2000, with the remaining 90% of the debt to be eliminated in 2001. By the end of this five year period, the GSC concluded that it would be in a position to restore a healthier balance between operating and capital components of the budget and to contemplate additional new initiatives.

A detailed report proposing a five year spending plan for subatomic physics, together with the 1997 award recommendations, was submitted to the President of NSERC on March 17, 1997. The recommendations and the spending plan were considered together by the President and the Executive Committee of NSERC Council in a teleconference that took place on March 27th. As a result of this teleconference, the spending plan was conditionally approved.

All award recommendations for 1997 were approved with the exception of funding for one new experiment at TRIUMF: 'Precision Measurement of Muon Decay Parameters', E614;

this decision was delayed until the June meeting of NSERC Council. E614 was delayed because it was identified as the only major new initiative with long term financial implications recommended this year besides ATLAS and ISAC, the latter having been widely recognized as the community's highest priority new projects since the Fenton planning report of 1995. The condition that must be met by the June Council meeting for the E614 award to be approved is that the GSC must provide another detailed report addressing the issues of contingency over the five year planning period, making the case that this project can be supported at the recommended levels even in the event of an unsuccessful outcome for subatomic physics resulting from the 1998 Reallocations Exercise, or in the event of cost overruns in SNO, ISAC or ATLAS construction projects.

A necessary condition for approval of this financial plan is the GSC's firm commitment to repay the capital loans on schedule, even in the event of a negative reallocation result for our discipline. The GSC has made this commitment. A contingency report is currently in preparation.

The remainder of this document contains a section on policy matters followed by an edited version of the original report proposing the five year spending plan that was sent to the President of NSERC on March 17th. This version is as complete as possible for public release, within the constraints imposed by the Privacy Act which precludes the disclosure of information relating to applications that were not successful in the funding competition. The original report to the President contained a section discussing the many very excellent research initiatives that could not be recommended for funding this year because of the severely constrained resources available to the GSC. Notably, all GSC's were specifically asked to report on this topic in 1997 with the aim of establishing an information data base for NSERC to be used in 'Identifying the Shortfall in Research Grants' as arguments for increasing the funds allocated to NSERC in subsequent federal budgets.

2 Policy Matters

2.1 Funding Priorities

In the committee's view, the success of the Canadian program in subatomic physics relies heavily on the success of three very important, high profile scientific projects that were identified in the Fenton plan as being of highest priority: SNO, ISAC and ATLAS. The GSC set as a very high priority that these three projects should be funded adequately to enable their physics goals to be met. Applied to the 1997 grants competition, this principle translated into an average success ratio of 69% ($ Awarded/ $ Requested) for these three projects alone; $7.3M out of $9.3M allocated this year went to SNO, ISAC and ATLAS[1], representing 38% of the total expenditures on subatomic physics in 1997.

As a second high priority, the GSC is committed to supporting a variety of excellent physics initiatives across the spectrum of nuclear and particle physics in order to ensure a balanced research program for Canada. This year, the pressures of the funding situation led to allocation of only $2M out of $6.8M requested outside of SNO, ISAC and ATLAS, translating to a success ratio[2] of only 31% for applications in this category. Theory requests were funded at a success ratio of 48%; the total expenditure on theory in 1997 is consistent with the Fenton planning recommendation. This year, other experimental support outside the top three initiatives could only be funded at 28% of the grant dollars requested; this anomalously low success ratio resulted from the need to fund SNO, ISAC and ATLAS adequately coupled with the very firm maximum borrowing limit of $2M set by NSERC for 1997 during the competition week.

Needless to say, the competition for funds was exceptionally severe, and the committee had to make some very difficult decisions in allocating its budget for 1997. Only the highest ranked applications were considered for funding. The committee could only meet its financial boundary conditions by not funding the majority of the new initiatives beyond SNO, ISAC and ATLAS, particularly initiatives with significant capital needs over the period of the five year spending plan, and by cutting operating support to 'minimum survival' levels for existing programs. In this context, any applicants receiving continued operating support at or near the level held previously, even in the case where the need for funds would imply a significantly larger award, should interpret this signal as a strong endorsement of the applicant and the proposed research program.

2.2 MFA Awards

The Major Facilities Access program, introduced for the 1996 grants competition, is intended to support access to major regional, national or international research facilities. Subatomic physics is the only discipline for which the MFA budget allocation is under the GSC's control – in all other cases, MFA applications are judged by a multidisciplinary awards committee.

[1]This figure includes an additional capital contribution of $0.45M to SNO which was advanced by NSERC as part of the 1996 construction overrun package.

[2]The 'success ratio' is defined in this report as the ratio of funds awarded to funds requested.

The GSC has developed eligibility guidelines for MFA support in subatomic physics. Technical personnel who work on several projects which are multi-institutional in nature and aimed at experiments at national or international facilities are eligible; computer systems managers are generally not eligible, as they tend to support primarily the needs of the local research group. MFA awards are not intended to support personnel that are more appropriately funded via Project Grants due to the focus of their work; while the GSC is sympathetic to the urgent need for increased infrastructure support across the entire program, it cannot recommend the use of MFA funds to compensate for previous cutbacks in other operating grants which were necessitated by the very constrained financial situation that has persisted for the past few years.

Competition for MFA/Infrastructure support was very severe; this year 4 out of 6 requests were supported for a total of $0.9M, or 56% of the requested funds. The largest awards in this category are in support of IPP ($590k) and HEPNET ($123k), both very important elements of the subatomic physics infrastructure in Canada. The major fraction of the IPP award is in support of the salaries of its Research Scientists. Last year, the complement was reduced from 8 to 7 positions through attrition. This year, the very severe financial pressures led the GSC to allocate a 'bare bones' operating grant to IPP, sufficient to just cover salaries and administration costs with very little available for other purposes. The IPP has an arrangement with NSERC to seek approval for any new appointments prior to initiating a job search in the event that an existing position is vacated; this arrangement will continue, and the GSC would be consulted in such an event and would consider the replacement position in light of the financial situation and funding priorities at the time. For both IPP and HEPNET, the GSC is committed to continuing support of these important components of the research infrastructure, within constraints of the overall funding for subatomic physics. In the case of HEPNET, the cost to the GSC of supporting this resource is forecast to grow by almost 60% next year; it is hoped that avenues for securing additional non-NSERC support for this valuable resource can be explored with some success prior to the next competition to ease the financial burden on the GSC.

2.3 Individual versus Team Support of Experimental Programs

With the steadily increasing strain on the subatomic physics envelope, it has become critically important for the GSC to be able to assess the total support available to any given project in order to follow up the implications of its award decisions. To this end, over the past few years the GSC has developed a policy of consolidating support of collaborative research activities into a single Team or Project Grant for each distinct effort. In several instances, applicants requesting individual support for closely related collaborative research projects have been given one year awards and explicitly advised by the GSC to reapply in the next competition as part of a Team.

The GSC continued to apply this policy in the 1997 competition. Discontinuation of a formerly-held Individual Research Grant award as a result of this policy bears no relation to the committee's assessment of the quality of the individual and his/her research program and should not be interpreted as such. While Individual Research Grant awards are still appropriate for experimentalists in some cases, the number of Individual Research grant awards in experimental subatomic physics is steadily decreasing. This policy has helped to alleviate some of the difficulties associated with phasing out of the former Infrastructure Grants Program, as a number of groups are now supporting Research Associates via Team Grants since they do not qualify for MFA support, and NSERC rules stipulate that no researcher can hold an Individual and a Team Grant at the same time. By contrast, Individual Research Grants are the dominant mode of support for researchers in subatomic theory, and this trend is expected to continue.

2.4 Capital Support for New Projects

As discussed in section 3 of this report, the GSC in its financial planning exercise has budgeted as carefully as it reasonably can within the constraints of what is known at present for future capital needs of SNO, ISAC and ATLAS. It has also recommended a MIG award for a new experiment at TRIUMF, E614, as discussed above. Beyond these areas, capital investments in new projects over the period of the five year plan will have to be made from funds that are currently allocated to operating budgets, ie. funds that are spent in 1997 between Individual, Team, MFA and Project Grant programs. It should be noted that at the present time, a non-negligible fraction of Project Grant budgets is spent on equipment items, so that modest investments in new projects will be possible as ongoing projects are completed.

One area that has received relatively little NSERC capital investment in recent years is the offshore program in intermediate energy physics (IEP), where many examples can be cited of equipment funds provided by offshore laboratories or foreign funding agencies to make up for shortfall in funds available from NSERC. This problem was remarked on in the Fenton report (1995): '*The Committee would prefer to see a smaller number of projects funded adequately by Canada than a larger number funded inadequately, as is currently the case.*'. The GSC was in agreement with the spirit of this comment from the Fenton report, but was not able to find a way of substantially increasing the support of research in this area in the present competition. The GSC did not recommend any new long-term commitments to this part of the program in 1997. The total expenditure on the IEP offshore program in 1997 is \$542k of which \$200k was allocated this year; the total is anticipated to increase gradually by about 50% over the period of the five year financial plan, through redirection of existing support as other projects are completed.

An increase to the subatomic physics envelope that might result either from a successful outcome of the next Reallocations Exercise or from an increase to the overall NSERC budget could of course improve the forecast for availability of capital funds across the entire program, while further reductions to the subatomic physics envelope would exacerbate the already very difficult situation.

2.5 Communications

In recent years, the GSC has set a high priority on improving communications with the subatomic physics research community. Following the 1997 competition, all applicants will have received an individual written comment from the committee; the intention of these comments is to explain as clearly as possible the reasons for the GSC's decisions in each case. In almost every case, expert referee reports on individual proposals were received prior to the competition and were considered as part of the committee's assessment of the applications. These referee reports are sent to applicants together with the GSC comments by NSERC. There are many examples of proposals which could not be recommended for funding on primarily financial grounds – it was simply not possible to fund a number of very excellent requests this year, as noted previously.

This year, for the first time, the committee voted unanimously to release the Chair's report to the community at large – you are reading it now. It is anticipated that this policy will continue. As well, the Chair welcomes any invitations to speak to the community and answer questions about the competition; it is anticipated that the tradition of an oral presentation to the DNP and IPP meetings at the annual CAP Congress will be repeated this year.

2.6 Advice to Applicants

With the ever increasing competition for diminishing research funds, the written material submitted to NSERC is crucial to the success of each application. This includes both the grant application and the Personal Data Form. Note that it is a very firm policy of NSERC that each application must be considered **only** on the basis of the written application and supporting documents. Too often, the GSC finds that some important information has not been provided in the application package. Some common items of concern are noted below. With funding so tight at present, the committee cannot afford to give applicants the benefit of the doubt when such important information is missing:

- **Budget Years:** The introduction of generic grant application forms has led to confusion in the interpretation of the calendar years associated with the grant years on the cover page of the application form. It would be helpful to the committee if applicants would label each box (1...5) with the calendar year (19xx-19yy) to which it refers.

- **Students:** Each application requesting support for graduate students should specify the names of existing or to-be-accepted students where possible, and should indicate their status in the program, including anticipated dates of completion. Funds requested should be the actual cost to the grant, which varies widely due to differences in local institutional support.

- **Travel:** Unfortunately, travel budgets sometimes appear to be inflated, and the committee tends to be conservative in its estimates of travel expenses where inadequate details are provided in the application. For travel to research laboratories, applicants should itemize the expected number of trips per year and the number of persons travelling on each trip. Experimentalists should indicate, if known, the amount of beamtime scheduled at each laboratory for their program during the grant period.

- **Previous Year Expenses:** For ongoing programs supported by Project Grants, it is important for the committee to understand the actual operating costs based on previous years' experience. This part of the form should be filled in accurately and explained in the text; a good job of this part of the application is very important in justifying the new grant request, particularly if an increase is needed. The temptation to account for large sums in the 'Miscellaneous' category should be avoided unless details of major items are provided.

- **Technical Support:** The GSC is fully aware of the recent sharp decline in infrastructure and technical support that is available to researchers in subatomic physics. Technical personnel are primarily funded through the MFA program, though in some cases Team or Project Grants also support such personnel. In the present financial climate, technical support can only be maintained if it is demonstrated clearly in the grant application that this support is essential to the success of the highest priority elements of the research program.

- **Personal Data Forms:** These forms are very important to the committee's understanding of each individual researcher's contributions to the program of research he/she is engaged in. It is essential for these forms to be updated each year, and for the applicant's role and responsibility in each collaborative project to be clearly explained. Supervision of students and training of highly qualified personnel should be documented here as well. In many cases, these important elements were either missing or inadequately addressed in the Personal Data Forms submitted to the 1997 competition.

- **Computer Equipment Requests:** Competition for funds in this category is very severe; approximately 20% of requested support (excluding SNO) for computer equipment was granted this year, which is in keeping with past competitions. The equipment requested should be described and clearly justified in the context of existing equipment available to the applicant. The computing power requested should be justified by explaining the demands of the research applications to be carried out. A valid manufacturer's price quotation enhances the credibility of the proposal even if it is not strictly required by NSERC rules for items under $25k.

2.7 Reallocations Exercise

As everyone should be aware, preparations for the next NSERC Reallocations Exercise are already underway in the form of the Review of Physics that has been facilitated by the CAP and NSERC. Detailed information about the Reallocations Exercise has been provided in past issues of Contact and is available on the NSERC web site. The Reallocation report for subatomic physics will be written by a small steering committee whose membership is expected to be finalized by the time of the CAP meeting this June. The report making the case for increased funding of subatomic physics in the next Reallocations Exercise is due at NSERC on January 2, 1998. Results of the exercise will be announced in July or August, 1998 and will first apply to the 1999 competition. Subatomic physics will contribute approximately 6.8% of its envelope budget[3] to a common pool to be redistributed amongst the various discipline-specific GSC's. Changes recommended by the Reallocations Committee will be phased in over the 4 year period beginning in 1999, at which time a further Reallocations Exercise is anticipated.

[3]This fraction is calculated as 10% of the envelope excluding MFA and Equipment Grant awards, and is the same fraction attributed to subatomic physics in the previous Reallocations Exercise.

3 Five Year Spending Plan for Subatomic Physics

This is an edited version of the original report proposing a five year spending plan for subatomic physics that was submitted to the President of NSERC on March 17 1997, as explained in section 1.

3.1 Executive Summary

The Subatomic Physics Grants Selection Committee faces an unprecedented financial crisis. The situation has arisen from the need to fund major capital expenditures on the three highest priority projects: SNO, ISAC and ATLAS, while at the same time maintaining a balanced research program in the discipline. These priorities have been widely endorsed by the subatomic physics community, by the 1995 GSC Advisory Committee chaired by B. Fenton, and by NSERC Council in its acceptance of the Fenton planning report. The timescales for funding these projects have been set by factors which are beyond the GSC's control: SNO is late, ISAC is on time, and ATLAS is earlier than expected. The 'collision course' of these major capital needs has proved impossible to navigate with a constant funding envelope without causing irreparable damage to the rest of the program.

The situation has changed dramatically since 1996, when Council approved a 3 year spending plan to permit an orderly phaseout of support to the Saskatchewan Accelerator Laboratory and to finance an unanticipated capital contribution to SNO. In response to these changes, the GSC has undertaken a new financial modelling exercise with unprecedented thoroughness. The implications of awards recommended in 1997 have been tracked over a 10 year period; the first 5 years are needed to repay forward borrowing for major capital expenditures. By the end of the 5 year period, the GSC will be in a position to restore a healthier balance between operating and capital components of the budget and to contemplate new initiatives.

Figure 1 shows how the proposed GSC expenditures evolve during the five year period that is needed to finance the major capital contributions to ATLAS, ISAC and SNO. Because the timescale for the urgent capital investments is so short, adjustments to operating expenditures cannot be made quickly enough to manage within a constant annual budget of \$17.3M. This results in a borrowing profile that tracks the capital spending profile. The plan begins with a deficit of \$2.0M in the first year and a cumulative debt that peaks at \$3.0M in the third year. The debt is eliminated in the fifth year when the capital expenditures are once again reduced to a level comparable with the beginning of the period.

In preparing this plan, the GSC has attempted to avoid systematically underestimating future program needs in order to ensure that the financial bottom line is realistic. It is recommended that a similarly detailed modelling exercise be carried out on an annual basis by the GSC, building on the data base that was prepared this year. With this approach, we are confident that future GSC's will be able to support the highest priority projects in subatomic physics and to maintain reasonable balance in the program.

The remainder of this document describes the 1997 grants competition, the major program elements, and the proposed financial plan in greater detail. The report begins with a summary of recent events leading to the present financial impasse and then shows that the GSC's plan defines a responsible and conservative solution. The consequences of significantly reduced flexibility over the five year period are also explored; the committee believes that such a scenario would have a long term negative scientific impact and should be avoided if at all possible.

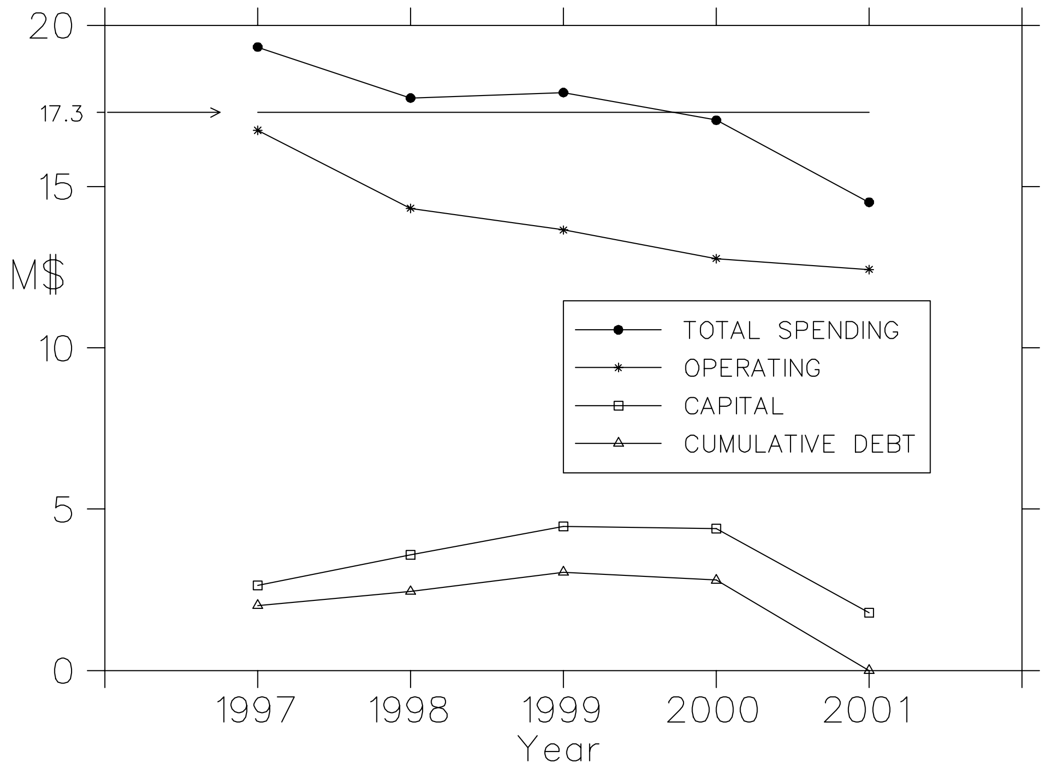

Figure 1: *Proposed 5 year spending profile – operating and capital contributions*

Table 1: Summary of the Five Year Spending Plan (k$)

Category	**1997-8**	**1998-9**	**1999-0**	**2000-1**	**2001-2**	**5 yr Σ**
CAPITAL	2631	3588	4467	4392	1796	16874
OPERATING	16740	14325	13652	12767	12427	69375
TOTAL SPENDING	19321	17740	17910	17055	14509	86535
ENVELOPE	17307	17307	17307	17307	17307	86535
ANNUAL DEFICIT	2014	433	603	0	0	
CUMULATIVE DEBT	2014	2447	3050	2798	0	

3.2 Introduction

Subatomic physics has been funded via an envelope system since 1991. This system places all expenditures on operations and equipment under the purview of a single GSC. With stable, multi-year budgets and a long range scientific plan, the GSC can provide for periodic major capital needs by forward planning and careful management of its operating expenditures. This situation prevailed during the first four years of the envelope system, when the annual subatomic physics GSC budget was \$19.6M.

Several key events took place during 1994-96 which influenced the course and funding of subatomic physics research into the next decade:

1. The Sudbury Neutrino Observatory, which had been under construction since 1990, experienced its first significant delay and cost overrun, \$3M of which was provided by NSERC and taxed back to the GSC envelope at a rate of \$1M per year from 1994-96. In January 1996, an additional capital funding package was arranged for SNO, and a further \$0.9M was provided by NSERC to be repaid from the GSC envelope by 1998.

2. A 14% federal budget cut to NSERC was announced just after the GSC competition week in February, 1995. This, together with the first NSERC Reallocations exercise, resulted in a rapid decline of the subatomic physics envelope from \$19.6M in 1994 to \$17.3M in 1997. Coupled with the additional funds lost to SNO cost overruns, these events put the research program under tremendous financial pressure. A one year additional contribution of \$1M from NSERC helped to offset this problem in 1995, but was not repeated in subsequent years.

3. A new Five Year Plan was approved for TRIUMF in 1995, incorporating an expanded scientific and technical mandate for the laboratory. TRIUMF undertook to build and operate a new radioactive beams facility (ISAC), to maintain a strong science program based on the existing cyclotron, to provide a significant contribution to construction of the LHC accelerator at CERN, and to provide infrastructure support to subatomic physics on a national basis.

In response to these events, a community based long range planning exercise was undertaken in 1995, with the assistance of NSERC. Under the chairmanship of Brock Fenton, the GSC Advisory Committee reviewed the entire subatomic physics program, established priorities and recommended a GSC spending plan which would accomplish the community's main research objectives. Fenton identified SNO, ISAC and ATLAS as the three highest priority projects in subatomic physics; to ensure adequate funding from a constant GSC envelope and maintain a reasonable amount of balance in the rest of the discipline, his committee reluctantly concluded that it would be necessary to phase out or reduce the scope of many promising research activities even before their originally targeted goals had been met.

3.2.1 The 1996 Competition

The Fenton report was endorsed by NSERC Council early in 1996 and provided valuable advice to the 1996 GSC. Expert reviews were conducted of major program elements for which funding was requested in that competition. The 1996 GSC followed Fenton's advice in most respects, notably:

- Despite the demonstrated excellence of its physics program on an international scale, operating support to the Saskatchewan Accelerator Laboratory (SAL), which had been steady at \$3.0M per year, was phased out over two years with a funding profile to permit the highest priority experiments to be completed[4].
- Total funding allocated in the broad categories of nuclear physics (DNP), particle physics (IPP), SNO, and theory was very close to the levels recommended by Fenton for 1996, once several corrections were taken into account[5]. Within the IPP physics program, operating budgets of most ongoing projects were significantly reduced in order to provide increased support to the growing Canadian ATLAS collaboration.

However, there were several differences between the 1996 GSC awards and the Fenton budget recommendations, notably:

- A proposal to proceed with the BaBar project, at a significantly reduced scale compared to what was considered by Fenton, was approved. The GSC considered that a modest capital investment together with infrastructure support from TRIUMF would make it possible for a highly-rated Canadian group to participate in this important new physics initiative.
- An additional SNO capital contribution of \$0.9M, which Fenton had not foreseen, was made by NSERC at the end of 1995 and charged to the GSC for repayment between 1996 and 1998.

Despite a significant reduction of operating expenses in 1996, it was not possible for the GSC to balance its budget in light of the additional SNO capital requirement and long term commitments to international collaborative projects. The GSC sought and obtained permission from NSERC to 'front load' its expenditures in the first two years for SAL and pay the additional 1996 SNO capital contribution in the third year of a 3-year funding cycle. At the end of the 1996 competition, the GSC prepared a financial plan for 1996-98 to meet these boundary conditions, in light of Fenton's recommendations and projected developments of SNO, ISAC and ATLAS at that time. The 1996 spending plan is summarized in Table 2. Note that the total debt owed by the GSC to NSERC in 1996 was \$1.9M for the first two SNO capital shortfalls and was to be repaid in the first and last years of the plan[6].

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[4] The SAL operations phase-out total of \$4.0M recommended by Fenton was allocated by the GSC over two years rather than three in order to maximize the scientific output during this period.

[5] Funding of Offshore intermediate energy physics programs, and the operating funds to individual researchers working at SAL, were each underestimated by approximately \$200k in the Fenton budget tables for 1995.

[6] The approved budget line for 1996 in this table includes a \$105k unspent carryover from 1995.

Table 2: 1996 GSC Three Year Spending Plan (k$)

	1996	**1997**	**1998**	**3 yr sum**
Research Grants	17470	17900	15335	50705
SNO Capital	758	0	1142	1900
Approved Budget	18228	17307	17100	52635

3.2.2 Developments Leading to the 1997 Competition

After the 1996 funding competition, several events took place which had major implications for subatomic physics and wreaked havoc with the GSC's three year funding model:

- The SNO project, now nearing completion, encountered further delays in the construction of the acrylic heavy water vessel. A site review in August concluded that in addition to cost-saving measures implemented by SNO management, an additional \$200k would be required to complete the construction project. The GSC recommended release of this amount from a portion of the 1996 MFA award which had been reserved to cover D_2O insurance payments that were not yet necessary.

- AECL withdrew its support of the SNO project, valued at \$500k per year in salary and infrastructure contributions, effective June 30, 1996. After considerable discussion, AECL agreed to provide transition funds of \$300k for salaries of key personnel through March, 1997. These costs were transferred to the SNO NSERC grant requests starting in 1997.

- AECL announced withdrawal of support for the TASCC accelerator, effective 31 March, 1997. Attempts to secure alternative funding were not successful. Canadian researchers are now in the process of re-establishing their programs at offshore facilities, at least in the short term.

- CERN Council approved the LHC construction schedule in December, 1996, for completion by mid-2005 and endorsed the ATLAS Technical Design Report. While the construction period for the LHC is extended by one year with respect to the schedule at the time of the Fenton plan, the timescale for delivery of Canadian components of the ATLAS detector is shorter than initially assumed because they must be installed early in the ATLAS assembly schedule.

- A GSC site review committee visited SNO at the end of January, 1997. It concluded that an additional delay of several months in the completion of the construction project was most likely, with an associated additional cost overrun of \$2.0M. Existing construction funds were projected to be fully spent by May, 1997.

3.3 The 1997 Competition

As a result of the above developments, all of which were beyond the GSC's control, the committee found itself in an extremely difficult situation at the start of the 1997 competition. Funds available for allocation totalled \$7.3M out of an approved envelope of \$17.3M, assuming that the remaining SNO capital debt from 1996 was to be paid in two equal installments in 1997 and 1998.

Funding requests for SNO, ISAC and ATLAS alone totalled \$9.8M, while the sum of all grant requests was \$16.8M. Since the fraction of Canadian grant-eligible researchers (full-time equivalents) working on SNO, ISAC and ATLAS is only 1/3 of the total at the present time, awarding all of the available funds to these three projects was not a viable option. The size of the SNO collaboration is relatively stable at 10% of the total, with the ISAC and ATLAS groups of comparable size and expected to roughly double in size by the end of the decade. Given that the GSC is charged to maintain a reasonable level of diversity in the program while providing adequate funding to its highest priority initiatives, the committee could find no solution to the 1997 awards dilemma that was consistent with the 1996 three year spending plan.

The committee met with Dr. Brzustowski and Dr. Lloyd during the competition week and informed them of the critical need to advance approximately \$2M to the 1997 competition from future year budgets in order to bridge the immediate funding gap. It was left to the GSC to propose a model within a constraint of this magnitude and to explore the out-year implications in much greater detail than had been done previously.

The committee then proceeded to rank the 1997 applications on a 7 point scale from A+ to C, according to the criteria established by NSERC: scientific excellence of the researcher(s), merit of the proposed research, need for funds, and contribution to training of highly qualified personnel. The committee discussed and established an appropriate level of funding for each proposal. Six detailed site visit reports were input to the deliberations, along with 2-3 external referee reports per application. Each application was reviewed initially on its own merits; in subsequent deliberations, applications and their interrelationships were also considered in the context of the program as a whole, in light of the scientific priorities and detailed budget recommendations set out in the Fenton plan. By the end of the third round of deliberations, only applications ranking A- or higher were recommended for funding, and several excellent applications with ratings in the A to A+ range could not be recommended for funding due to the financial situation.

3.3.1 Summary of Recommendations for 1997

The GSC recommends funding of 55 awards out of 90 applications received in the 1997 competition. Total spending exceeds the approved budget for 1997 by \$2.0M. Capital expenditures, including \$0.45M towards the 1996 SNO construction debt, total \$2.6M, while operating expenditures are at \$16.7M. Recommended awards to SNO, ISAC and ATLAS are \$7.3M, or 40% of the total.

The recommendations made by the GSC represent a consolidation of research efforts in both nuclear and particle physics. Only the highest ranked projects in each category were considered for support, and some very highly ranked projects were recommended for only partial support, or no support at all, on financial rather than scientific grounds. It was necessary to make significant reductions to operating support of a number of ongoing programs of high quality. Operating funds have been reduced to a 'minimum survival' level in most cases in order to release capital funding needed for the community's top projects, SNO, ISAC and ATLAS. Once the immediate capital needs of these projects have been met, it will be vitally important to restore operating funds to the discipline at a significantly higher level, or even the very best Canadian research teams will lose their international competitiveness in subatomic physics. Highlights of the 1997 award recommendations are discussed below:

SNO: The Sudbury Neutrino Observatory remains the highest priority subatomic physics project in Canada. It is expected to begin data taking as the detector is filled with heavy water late in 1997; no other neutrino detector in the world either working now or planned will have the sensitivity that SNO will have because of the unique choice of heavy water as a detection medium. The GSC considered the 1997 funding requests for SNO very carefully in view of the difficult financial situation and concluded that support to SNO operations could be reduced slightly with respect to the site review committee's recommendation due to the later start of the heavy water fill. The recommended awards for 1997 are \$2250k for the site MFA grant, of which \$300k is required as a payment for heavy water insurance[7], and \$1360k for the Project grant. An award totalling \$258k over two years is recommended for purchase of computer equipment for the SNO site and participating institutions. The total recommended support to SNO in 1997 is \$3747k, very close to the Fenton plan and 1996 GSC plan figures.

ISAC: ISAC is a unique accelerated radioactive beams facility, currently under construction at TRIUMF. The research community that will use ISAC, Canada's highest priority project in nuclear physics, is steadily growing. Low energy beams will be available in 1999, and the first accelerated beams in 2000, serving a variety of experiments in nuclear physics, astrophysics, and studies of fundamental interactions. Experiments currently supported by the GSC are in progress at a low intensity test facility 'TISOL' at TRIUMF, and will move to ISAC as the new facilities become available. With the closure of TASCC by AECL in 1997, two state-of-the-art instruments for nuclear physics research funded by NSERC will move temporarily to U.S. laboratories, but are eventually expected to return to Canada and be sited at ISAC. These are the Canadian Penning Trap Mass Spectrometer (CPTMS), only recently commissioned at Chalk River, which will move to Argonne National Laboratory, and the 8π spectrometer, which will move to Lawrence Berkeley National Laboratory in the fall. The CPTMS would ideally make use of low energy beams from ISAC, while the 8π could be used for nuclear reaction studies at the high energy area.

The GSC anticipates making significant capital investments in research instrumentation for ISAC, beginning this year. The nuclear astrophysics program will require a precision electromagnetic spectrometer, the 'Recoil Products Detection Facility' (RPDF), coupled to a windowless gas target for low energy reaction studies. The gas target technology is straightforward; funding is recommended at \$322k spread over two years. The RPDF is much more

[7]The insurance payments for 1998 and beyond are expected to be \$440k per year.

challenging. An award in support of the final design study is recommended this year ($103k); a MIG request in the $2M range and cost-shared with TRIUMF is anticipated next year. Operating funds for the TISOL/ISAC program are recommended at $702k this year and equipment at $269k for a total of $971k, intermediate between the Fenton plan and the 1996 GSC 3-year plan figures.

ATLAS: Participation in the ATLAS physics program at the CERN Large Hadron Collider (LHC), the world's highest energy accelerator due to begin delivering beams to experiments by mid-2005, is the highest priority project in Canada's particle physics program. It is also the largest and longest-term new construction project contemplated by the GSC. The main goal of ATLAS at the LHC is to detect the long-sought Higgs particle, which is expected to give rise to the origin of mass in the Standard Model. Canadian groups have been working on R&D for ATLAS detector components and on computer simulations of the detector response to signals of the Higgs particle formation for a number of years. Their designs for two critical detector elements, the 'HCAL' and 'FCAL' calorimeter devices, are innovative and have been accepted by the international ATLAS collaboration.

In 1996, TRIUMF signed an agreement with CERN to provide a contribution valued at $30M to the LHC accelerator construction over the 5 year period from 1996 through 2000. NSERC also signed an Interim Memorandum of Understanding with CERN signifying Canada's intention to make a contribution to the ATLAS detector commensurate with the size of the ATLAS-Canada group in comparison to the full ATLAS collaboration, subject to availability of funds. This implies an intended contribution of approximately 3% to ATLAS, or about $14M in equipment funding, plus operating support to the Canadian research groups involved in the project. In December 1996, CERN Council approved the LHC construction schedule for completion by mid-2005, and endorsed the ATLAS Technical Design Report, which specifies the detailed design and cost of all major detector components as well as the construction and installation schedule.

In January 1997, a GSC site visit committee reviewed the NSERC grant requests of the ATLAS Canada collaboration. The committee was charged to consider various funding scenarios, including the Fenton plan '$20M over 7 years' recommendation, which the ATLAS Canada collaboration had been requested to address by the GSC in 1996 – the latter is considered equivalent to '$22.5M over 8 years' in view of the extended construction time of the LHC accelerator and the projected annual operating grant expenditures at the end of this period. The committee examined the budgets in detail and identified some areas in which cost savings could be achieved on the capital side, as well as significant savings in the operating funds. The committee described three funding scenarios for ATLAS[8]:

I. $20M over 7 years, or $22.5M over the 8 year construction period, consisting of $12M capital plus $10.5M operating (8 yrs);

II. $27.4M over 8 years consisting of $15.4M capital plus $12M operating;

III. $32.8M over 8 years consisting of $20.8M capital plus $12M operating.

[8] All of these scenarios include the required fraction of common fund/common project capital contributions as part of the MIG budget.

The third scenario corresponded to the committee's estimate of what the ATLAS Canada collaboration would need to accomplish the goals set out in their proposals; the second scenario corresponded to their strongly recommended choice as a reasonable compromise for ATLAS in the present financial context; the first scenario corresponded to what the committee considered to be a last resort for supporting ATLAS if insufficient funds were available. In all three cases, significant reliance on TRIUMF infrastructure support is necessary to meet the construction goals, and operating support is considered to be uncomfortably low by both the site visit committee and the GSC. In the first scenario, there is concern that the capital contribution may not be considered large enough by CERN to support a Canadian collaboration of the intended size at the LHC.

The GSC would have preferred to recommend the scenario II funding level for ATLAS. The difference between scenarios I and II is not appreciable in the first two years of the construction schedule, since in any case 'module 0' prototypes have to be built and tested at CERN, and the main cost saving between scenarios I and II is in the number of production modules supplied to the final detector.[9] However, in evaluating the implications of scenario II in the present financial context, the GSC regrettably concluded that scenario I is the only option that it could recommend. The total MIG award recommended is \$12.22M, over a period of 8 years. Most of this capital funding is required by 2001, with the peak years being 1999 and 2000 at \$3.2M each. The 1997 installment of the ATLAS MIG is recommended at \$1.38M; the GSC recommends a one-year Project grant award of \$800k for 1997.

Contingency is not included in the MIG award, but is estimated to be approximately \$0.5M, based on varying market costs of the raw materials for the calorimeter construction (tungsten and copper). The committee considers that in the event of significant increases in its construction costs, the ATLAS Canada collaboration should be able to respond by reducing manpower costs, making use of scientific manpower to assist with the assembly of the detector. The contingency situation for ATLAS detector components is completely different from that for SNO; ATLAS costs are based on detailed prototyping which was not possible for the SNO detector, and with the exception of fluctuations in commodity prices noted above, they are unlikely to exceed current estimates by a significant amount.

The total funds recommended for ATLAS in 1997 are \$700k higher than anticipated in the 1996 3-year GSC plan, and are closer to Fenton's recommendation. Costs are driven by the need to construct prototypes of the FCAL and HCAL units on a timescale that is earlier than the GSC had previously envisioned.

Other Particle Physics: In addition to ATLAS, the Canadian particle physics program consists of a variety of international collaborative projects. Operations funding for the largest program elements – the OPAL experiment at CERN and the ZEUS experiment at HERA, as well as for the HERMES experiment at HERA and BaBar at SLAC, was established for 2 years during the 1996 competition. A brief summary of recommendations from the 1997 competition is given below:

[9] In scenario II, ATLAS Canada builds tungsten 'FCAL' detector elements for both ends of the (symmetric) ATLAS detector, whereas in scenario I, only one end, or half the total modules, is supplied.

- **E787:** A Canadian team, led by a group from TRIUMF, plays a key role in the Rare Kaon decay experiment E787 at Brookhaven National Laboratory. After major effort and investments spanning over 10 years, the experiment has reached an unprecedented sensitivity in the branching ratio for the decay $K^+ \to \pi^+ \nu \bar{\nu}$ which would enable for the first time a real signal of this extremely rare and important process to be observed. After considering the advice of an expert site review committee, the GSC recommended a project grant award of $550k for two years to complete datataking for E787. The award for E787 is consistent with the 1996 GSC's three year plan.

- **IPP Infrastructure:** The major elements of this infrastructure consist of a Project grant which supports the salaries of 7 IPP Research Scientists; an MFA grant which supports HEPNET, providing computer communications links, software and technical support to the Canadian subatomic physics community; and a variety of smaller MFA awards supporting technical personnel in universities who in turn support the IPP research program and SNO. In view of the very tight financial situation this year, only 4 out of 8 requests were funded totalling $1436k, with all awards at the 'minimum survival' level. These awards are consistent with the 1996 three year plan and the Fenton recommendations.

Other Nuclear Physics: In addition to ISAC, the Canadian nuclear physics program consists of a variety of elements. These can be grouped into three main subject areas, namely the TRIUMF non-ISAC program, Intermediate Energy Physics Offshore, and a collection of other activities including completion of the highest priority projects in the SAL experimental program, loosely referred to as 'DNP Other'. Highlights of the 1997 recommendations in these areas are as follows:

- **TRIUMF Non-ISAC:** The GSC has set a high priority on supporting the best elements of the science program based on the TRIUMF cyclotron, in accordance with the new five year plan for TRIUMF. During the next two years, a number of smaller, ongoing experiments will be completed; the GSC sees this as an opportunity to consolidate the efforts in the TRIUMF base program.

  The GSC recommends support of an important experiment to achieve an order of magnitude higher precision measurement of the fundamental muon decay spectrum, TRIUMF experiment E614. The GSC concurred with a site review committee and recommended funding a MIG application for E614 totalling $536k over 4 years. The committee was convinced that the experiment, while extremely challenging, should be feasible with the novel high-precision wire chambers proposed and the strong team that has been assembled to carry out the measurements. This is a very important experiment for TRIUMF, and is strongly supported by the laboratory. It should be noted that the MIG award is a highly leveraged investment of NSERC capital funds, with an additional $500k committed by TRIUMF, an in-kind contribution of detectors valued at $500k from the Russian collaborators, and $500k of electronics to be provided by the U.S. The recommendation is contingent on all elements of the capital support being confirmed, and the MIG profile starts with a $50k award in 1997. An additional $50k Project grant award is recommended for 1997.

Total funding recommended in the TRIUMF non-ISAC category for 1997 is \$704k, consistent with the Fenton recommendation and higher than the 1996 three year plan. Most elements of the program were given one-year operational support, with a review planned for 1998 to enable adjustments to be made in light of developments with E614.

- **IEP Offshore Projects:** The GSC supports a small number of high priority projects at offshore facilities in Intermediate Energy Physics (IEP). Four out of seven requests were recommended for funding this year, totalling \$200k. The largest single item is a Project grant in support of the University of Regina group's program at Jefferson Laboratory (JLAB, formerly CEBAF) in the U.S. A one-year award of \$35k to support participation of a second group in the 'G0' parity violation experiment at JLAB is recommended this year; the decision on a longer term commitment to this program will be made in 1998. Total funding recommended in the Offshore category for 1997 is \$542k, slightly lower than the 1996 three year plan.

- **DNP Other Projects:** This category includes support for completion of the experimental program at SAL, for support of university researchers formerly working at TASCC, and for a variety of smaller projects in nuclear physics that do not fall into the above categories. The major awards recommended this year included a \$200k project grant award for continuation of the physics program of the 8π spectrometer group, and a \$48k equipment award for purchases necessary to complete a high priority experiment at SAL. Total support in this category for 1997 is \$922k, higher than Fenton's recommendation and lower than the 1996 three year plan.

Computing: The recommended awards totalling \$100k for computer equipment, in addition to the HEPNET grant and SNO computer awards, are consistent with allocations in previous years. This represents funding of 4 out of 10 applications, at 20% of the requested funding levels.

Theory: Recommended support to 15 individual researchers in subatomic theory totals \$338k in the 1997 competition; total allocations come to \$1741k, very close to the 1996 three year plan estimate, and slightly lower than in the Fenton plan.

SNO Capital Shortfall: Included in this year's budget is half of the outstanding payment on the 1996 capital shortfall of SNO, \$451k. In the three year model made by the 1996 GSC, this payment was deferred until 1998.

Table 3 summarizes the 1997 award recommendations in comparison to Fenton's plan for 1997 and the 1996 GSC's three year plan for 1997. The only significant increases with respect to the 1996 plan are in two areas: ATLAS (\$684k) and SNO capital (\$451k). In addition, spending is slightly higher on ISAC, and the third installment of the BaBar MIG has been advanced from 1998 to 1997. These four contributions account for the increased spending of \$1.4M in 1997 with respect to the plan made at the end of the 1996 competition.

Table 3: Summary of 1997 Award Recommendations

Category	Fenton Plan	3 yr Plan	GSC 1997
SNO OPERATIONS	3700	3700	3747
ISAC	1120	800	971
ATLAS	2000	1500	2184
BABAR		485	600
CDF	193	218	218
CLEO phaseout			20
RARE KAON DECAY	450	550	550
OPAL	1900	1750	1750
ZEUS	800	900	900
HERMES	400	440	485
IPP INFRA.	1400	1400	1436
SAL OPERATIONS	1200	2000	2000
TRIUMF NON-ISAC	700	500	704
IEP OFFSHORE	300	600	542
DNP OTHER	800	1257	922
COMPUTING			100
THEORY	1850	1800	1741
NEW INITIATIVES	487		
SNO CAPITAL			451
TOTAL SPENDING	17300	17900	19321
ENVELOPE	17300	17307	17307
DEFICIT	0	593	2014

Note that the total Fenton plan recommendation of \$4.0M for phaseout of SAL operations was also recommended by the 1996 GSC but was awarded over a two year rather than a three year funding cycle. The Fenton plan did not report a separate budget line for computer equipment, which was accounted for in the DNP, IPP and SNO operating figures; this line is introduced as a convenience for awards analysis and planning purposes by the 1997 GSC.

3.4 Five Year Spending Plan

3.4.1 Starting Point

As noted in the previous sections, the financial situation has changed dramatically since 1996, when Council approved a three year spending plan to permit an orderly phaseout of support to SAL and to finance an unanticipated capital contribution to SNO. It is now clear that during 1997 and 1998, the GSC will need to spend a total of \$2.3M more on ATLAS and ISAC than was forecast in 1996, and an additional capital contribution to SNO will also be necessary.

In response to these changes, the GSC has undertaken a new financial modelling exercise that is an order of magnitude more detailed than the one conducted last year. The goals of the exercise were as follows:

- to assess the implications of the 1997 recommendations with realistic assumptions about future capital and operating requirements for the various program elements;
- to ensure that sufficient operations and capital funds are included for the three highest priority projects – SNO, ISAC and ATLAS;
- to ensure that adequate funds are available to maintain a reasonably balanced research program of high quality in nuclear and particle physics in addition to SNO, ISAC and ATLAS;
- to include a reasonable contribution to the latest SNO construction overrun in the financial plan;
- to propose a responsible spending plan which future GSC's can adhere to while the front-loaded capital investments are paid back in future years;
- within the above constraints, to minimize the forward borrowing and pay back debts to NSERC as quickly as possible, working with the assumption of a constant GSC envelope of $17.3M.

3.4.2 Methodology

The GSC carried out detailed assessments of the operating and capital needs of all subatomic physics projects in the three weeks following the 1997 grants competition. Independent estimates were made of the requirements for each project by at least two committee members in most cases. Results of a 'bottom up' estimate of minimum operating requirements for each project were compared with analyses of current funding levels, and with funding of other projects in the discipline. For major program elements, project spokespersons were consulted for input, adding confidence to the GSC estimates.

In preparing this model, the GSC reduced operating estimates to the 'minimum survival' level in most cases. While the operating budgets are very lean, the GSC has attempted to avoid systematically underestimating future program needs in order to ensure that the financial bottom line is realistic.

3.4.3 Financial Plan

The implications of awards recommended in 1997 have been tracked over a ten year period; the first five years are needed to repay forward borrowing for major capital expenditures. Operating support to the subatomic physics program decreases steadily by a total of 25% during the first five years, even though operations support to the highest priority program elements grows significantly.[10] By the end of this period, the GSC will be in a position to

[10]Half of the decrease in operating support is accounted for by the phaseout of NSERC support for SAL operations, currently at $2M for 1997-98.

restore a healthier balance between operating and capital components of the budget and to contemplate new initiatives.

The conclusion that follows from this exercise is that a five year time period is required to finance the major capital contributions to ATLAS, ISAC and SNO, with an annual deficit of \$2.0M in the first year and a cumulative debt that peaks at \$3.0M in the third year and is repaid in the fifth year of the plan. The long timescales for phasing out operating funds to major international collaborative projects, as compared to the very short timescales for the capital requirements of the program, result in a mismatch between the funds required and the funds available in a constant budget scenario, driving the spending plan into a deficit mode for the first 3 years and a surplus in the last two years which is used to repay the debt.

Figure 1 shows how the capital and operating components of the GSC expenditures evolve during the five year period[11]. Because the timescale for the urgent capital investments is so short, adjustments to operating expenditures cannot be made quickly enough to manage within a constant annual budget. This results in a debt profile that tracks the capital spending profile. The cumulative debt is eliminated in the fifth year when the capital expenditures are once again reduced to a level comparable with the beginning of the period.

Figure 2 illustrates the capital funding profile of the five year spending plan, and its constituent elements. The total annual capital expenditures follow the ATLAS MIG spending profile, its dominant contribution. There is some flexibility, and indeed some uncertainty in the capital funding and optimum profile for ISAC equipment investments, the next largest contribution. Included in the estimated ISAC capital expenditures are the RPDF MIG, spread over three years beginning in 1998 and cost-shared with TRIUMF; the gas target for ISAC, costed at \$0.3M and allocated during 1997 and 1998; expenditures to relocate the CPTMS to ISAC during 1998-99, and a modest allocation of \$200k per year of miscellaneous detection equipment needed to equip the new facility.

The plan assumes that the GSC will pay the same fraction of the latest SNO construction overrun as it has been assigned in two previous instances, namely 1/5 of the total. This amounts to an additional \$0.4M for SNO construction, which is spread equally over 1999 and 2000. Other smaller contributions to the capital spending profile include the final payment on the BaBar MIG award in 1997, the E614 MIG award over four years from 1997 to 2000, and an allocation for computer equipment discussed previously.

While there is some flexibility in profiling capital investments for SNO and ISAC during the five year plan, the total capital spending proposal is relatively firm, major additional SNO capital shortfalls excluded. By the end of the period, the NSERC capital investments in SNO, ISAC, BaBar and E614 will be completed and these projects will be taking data. ATLAS will still be under construction; smaller investments including RHIC and efforts at Jefferson Laboratory will also result in physics data taking at relatively new offshore facilities. Capital investments in large subatomic physics experiments are generally driven by new facilities, and there are very few of these during the five year time horizon which are not already considered in the plan.

[11] Details are provided in Tables 4 - 6 at the end of this document; see also section 3.5.1.

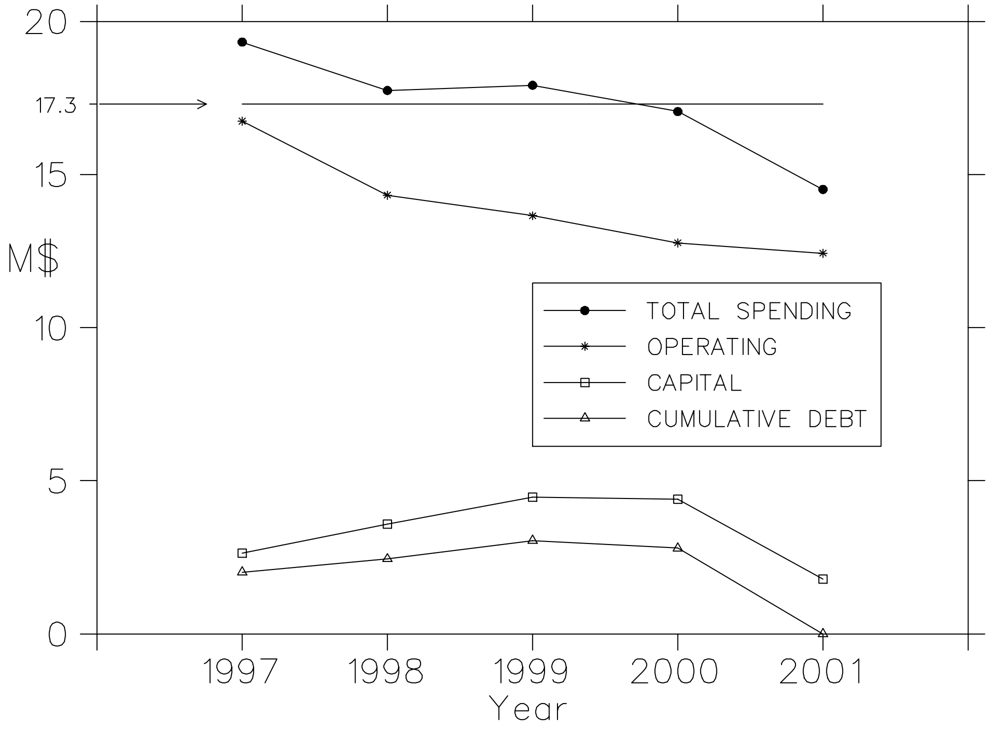

Figure 1: *Proposed 5 year spending profile – operating and capital contributions*

In order to keep to this spending plan, it is recommended that a similarly detailed modelling exercise be carried out on an annual basis by the GSC, building on the data base that was prepared this year. For the sake of continuity, it is proposed that the past chair participate in the final stages of competition week discussions in future years, acting as a financial consultant and advisor on policies established in previous years.

3.4.4 Alternative Models

After completing the detailed modelling exercise described above, the committee examined the impact of funding levels significantly lower than those recommended here, and considered how it could meet such a reduction. It was clear from the foregoing discussion that this would be an extremely difficult task. In such a scenario, the financial boundary conditions will limit the possible solutions, and these must be clearly defined for the committee to be able to reach a meaningful conclusion. With alternative boundary conditions undefined, including the extent of the latest SNO cost overrun that will be taxed to the envelope, the GSC was not able to reach a consensus recommendation in the time available, although several options were raised for possible consideration.

Options to reduce the forward borrowing requirements, which are driven by the short term capital needs of the program, are severely limited if it is assumed that SNO, ISAC and ATLAS are to be adequately supported and that a reasonably balanced program is to be maintained in the rest of the discipline. The GSC is of the opinion that the latter condition is extremely important, in view of the present fraction of scientific manpower currently engaged in these (1/3) and other (2/3) projects in subatomic physics.

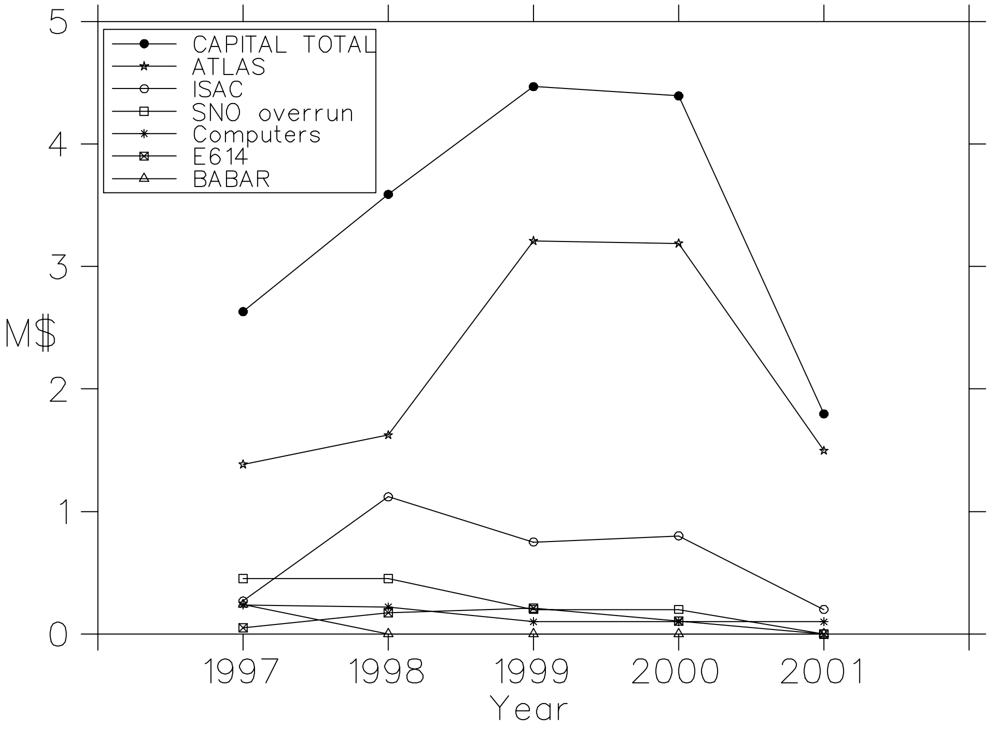

Figure 2: *Capital costs included in the five year spending plan*

The GSC discussed a possible tax on prior year installments as a method to reduce spending in the first year; budget savings in 1997 amount to $70k per % reduction of taxable installments[12]. The GSC concluded that it could only recommend a tax as a 'last resort' and would be reluctant to recommend a tax in excess of 5% even in the worst case scenario.

Another option includes an across-the-board freeze on new projects, the muon decay initiative at TRIUMF recommended this year as one example. In each case, the issue of program balance would need to be reexamined in light of such a decision; support to other projects which was reduced in order to make way for smaller new initiatives might need to be restored to ensure a balanced program.

Another option includes a catastrophic retreat from one or more major ongoing projects in the DNP or IPP programs. Here again, the difficult issue of balance between DNP and IPP operating funds would need to be carefully addressed, as well as the issue of prior commitments to international collaborative projects. While no consensus was reached on which project or projects should be targeted in this case, it should be noted that most major program elements will be reviewed in the 1998 competition, and such a retreat could be identified at that time in response to the detailed proposals submitted to the committee.

Finally, there is an option to globally reduce the operating budgets included in the plan, which were arrived at following a very thorough exercise in which the GSC evaluated the

[12]SAL operations, the IPP salary grant, and the final installment of the BaBar MIG were excluded from the tax in arriving at this figure.

minimum operating needs of all major program elements. This exercise convinced the committee that significantly faster reductions in operating funds would have disastrous effects on Canadian subatomic physics in the near and long term. The committee cannot recommend an option to impose a global cut on operating budgets beyond what is already accounted for in the five year spending plan. The committee notes that the danger of underestimating minimum requirements for key elements of the program is that it could lead to a future crisis in the management of operating funds, which is to be avoided in any scenario.

In the event of further reductions to the subatomic physics envelope which could possibly result from the next NSERC Reallocations Exercise and would take effect in 1999, the GSC would have to respond by extending the capital payback schedule or by reducing operating expenditures, or a combination of both, since long term commitments to ISAC and ATLAS capital projects would be well underway by that time. The severity of the approach would depend on the size of the reduction and the timescale over which it was applied. All of the options described above would naturally be considered in such a case.

3.5 Conclusion

As stated earlier, the Subatomic Physics Grants Selection Committee faces an unprecedented financial crisis. The 'collision course' of the major capital needs of SNO, ISAC and ATLAS has proved impossible to navigate with a constant funding envelope. The proposed solution is a five year spending plan that is higher in the first three years and lower in the last two years than the present envelope of $17.3M. The plan is based on a detailed modelling exercise carried out by the GSC during several weeks following the competition in Ottawa. Inputs to the model have been carefully considered. Operating funds to existing programs are reduced significantly to make room for future needs of the highest priority projects. The GSC is confident that the spending plan is realistic and that future committees will be able to support the highest priority projects in subatomic physics and maintain a reasonable level of balance in the rest of the program with the proposed five year spending plan. We strongly urge NSERC to adopt this strategy as a solution to the present financial crisis.

Membership of the Committee:[13]
Shelley A. Page, Chair (*University of Manitoba*)
Jean-Eudes Augustin (*Institut de Physique Nucléaire de Lyon*)
Sam M. Austin (*Michigan State University*)
Walter F. Henning (*Argonne National Laboratory*)
Barry R. Holstein (*University of Massachusetts*)
Stanley Kowalski (*Bates Linear Accelerator Center, MIT*)
Vera G. Luth (*Stanford Linear Accelerator Center*)
William Marciano (*Brookhaven National Laboratory*)
Pekka K. Sinervo (*University of Toronto*)
Douglas G. Stairs (*McGill University*)
Michel C. Vetterli (*TRIUMF*)
Nathan Weiss (*University of British Columbia*)

[13]The listed members constitute the Subatomic Physics Grants Selection Committee for 1997, and have endorsed this report to NSERC.

3.5.1 Note to the Subatomic Physics Community

The budget tables on the next page formed the basis of the spending plan submitted to the President of NSERC on March 17th and conditionally approved on March 27th by the Council Executive Committee. Only a small fraction of the total funds shown in the tables has actually been allocated by the GSC beyond 1997. In general, the individual table entries should **not** be interpreted as funds that are in any sense preallocated to certain projects or subdiscipline areas and thus usurping the decision making powers of future GSC's. The entries listed for project awards are estimates only, not commitments; actual awards will be decided in response to grant applications submitted to NSERC and reviewed by future GSC's. The one major exception to this statement is ATLAS, for which an 8 year MIG commitment was made this year, along with the definition of an 8 year package for capital and operating funds as described in section 3.3.1.

The GSC considers that the operating funds in this financial model are very frugal for all projects, but that the community should be able to manage under these conditions for a few years while the necessary major capital investments are made for its highest priority projects; without making this type of sacrifice, the major capital investments would not be possible. While future GSC's will have some flexibility to decide the allocation of operating funds amongst the various subdisciplines, as well as the breakdown of ISAC capital funds, the bottom line is absolutely firm; however the components fall into place in future competitions, the cumulative debt will not be allowed to exceed the values shown year by year in Table 4.

As mentioned earlier, the GSC is now preparing a supplementary report to NSERC on contingency and must address the issue of how to meet the debt repayments implied by this financial model even in the event of cost overruns on capital projects or a loss to the envelope resulting from the next Reallocations Exercise. The actual cost to the GSC of the 1997 SNO construction overrun affects the spending plan and will be determined soon; the needed $2M capital package is in the final stages of negotiation. The contingency report will be submitted to NSERC in early June, 1997.

Table 4: Summary of the 5 Year Spending Plan (k$)

Category	1997-8	1998-9	1999-0	2000-1	2001-2	5 yr Σ
CAPITAL	2631	3588	4467	4392	1796	16874
OPERATING	16740	14325	13652	12767	12427	69375
TOTAL SPENDING	19321	17740	17910	17055	14509	86535
ENVELOPE	17307	17307	17307	17307	17307	86535
ANNUAL DEFICIT	2014	433	603	0	0	
CUMULATIVE DEBT	2014	2447	3050	2798	0	

Table 5: Capital Funding Components of the Spending Plan (k$)

Category	1997-8	1998-9	1999-0	2000-1	2001-2	5 yr Σ
SNO CAPITAL	451	451	200	200	0	1302
COMP. (incl. SNO)	237	221	100	100	100	758
BABAR	240	0	0	0	0	240
ISAC	269	1120	750	800	200	3139
ATLAS	1384	1623	3208	3188	1496	10899
E614	50	173	209	104	0	536
CAPITAL TOTAL	2631	3588	4467	4392	1796	16874

Table 6: Operating Funding Components of the Spending Plan (k$)

Category	1997-8	1998-9	1999-0	2000-1	2001-2	5 yr Σ
SAL MFA	2000	0	0	0	0	2000
SNO	3610	3630	3440	3390	3300	17370
ISAC	702	800	900	1100	1200	4702
OTHER DNP	2118	1977	1691	1416	1390	8592
ATLAS	800	800	1200	1200	1500	5500
OTHER IPP	5719	5265	4532	3877	3357	22750
THEORY	1741	1680	1680	1680	1680	8461
TOTAL	16740	14325	13652	12767	12427	69375