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A Year of Changes

In early 1998 the ISC saw a new Director and a new Senior Seismologist take on responsibility for managing the Centre and maintaining the standards of the Bulletin, while later in the year the Deputy Director retired and a computer system administrator was hired. A third bulletin editor was hired and the aggregate experience of the seismology staff in editing the Bulletin grew from 10 to 35 months during the year.

Analysis was completed for eight issues of the Bulletin, including more earthquakes analysed in a year before 1994, despite the relative inexperience of the staff. New editing procedures reduced inefficient and error-prone transcribing of editing commands. Treatment of data from the EIDC was changed to more comprehensively represent its contribution to global seismic monitoring.

The Centre's new CD included some data products not found in previous CDs; CD sales were robust and further enhancements were planned for future disks. To help users of ISC data, staff members presented results from their analyses of the Bulletin at geophysical conferences and in papers submitted to seismological journals. Interaction with the scientific community provided a payback when artefacts in NEIC data that had previously found their way into the ISC Bulletin were identified with outside help.

The ISC purchased and installed a new set of computers, modified virtually all of its computer programs to run under the new operating system, and established a web site distributing its entire set of published data on the Internet. Plans for a modernisation of the ISC data management were laid, and the first step was undertaken with the purchase of Oracle 8. The NSF committed to supplemental funding during 1999, which should help to continue progress in this area.

Member contributions grew only slightly in the year and several members notified the ISC that they would withdraw. Expenditures were less than budgeted due to delays in hiring, but staffing was nearly completed by year-end. As the result of lower than planned expenditures, the ISC's net assets grew. Because 15% of the member contributions were not received during 1998, however, more of the assets were simply amounts expected from members. As a result, and because of planned capital spending on computers, the Centre's cash reserves fell during the year.

Bulletin Editing

At the start of 1998, no ISC staff member had more than several months experience editing the Bulletin. Nevertheless, the number of data analysed was exceeded in the ISC's history only during 1994–1996. During 1998, ISC staff analysed 46,000 events, represented by 110,000 epicentres and associated with 1.1 million phases.

Month	Analysed	Distributed
1995	Oct	19 Dec 97
	Nov	27 Feb
	Dec	11 Mar
1996	Jan	23 Apr
	Feb	23 Jun
	Mar	24 Jul
	Apr	07 Oct
	May	21 Oct
	Jun	04 Dec
		05 Mar
		21 May
		04 Dec
		02 Feb 99
		02 Feb 99

New procedures were generally deferred in favour of fundamental re-organisation, but two important changes were put in place. First, a system for marking edits on printouts rather than preparing coding sheets was adopted as a standard. Without this change, the staff could not have accomplished the volume of edits actually undertaken. Second, ISC software was modified to exclude "Fake P" arrivals in NEIC data. "Fake P" arrivals are artefacts introduced by NEIC to associate surface wave readings with events in the absence of detectable body waves. Propagation of these artefacts into the Bulletin since the early 1990's was brought to the attention of the ISC by Axel Röhm of Utrecht University.

Editing sped up as the staff gained experience, but even a fully experienced staff of two seismologists could reliably edit no more than ten or eleven months over a year. Planned improvements of the software are expected to help soon, but questions arise about utility of ISC data if publication meanwhile is further delayed. As recommended by the Executive Committee, therefore, the Centre hired an additional seismologist. The ISC's third seismologist has been employed since November, and was still being trained at year-end.

Other Products

The final issue of the Catalogue of 1995 was distributed during 1998. Analysis for the first issue of the Catalogue of 1996 was completed, but printing was still underway at year-end.

Product	Issue	Distributed
Catalogue	1995/B	04 Jun 98
	1996/A	17 Feb 99
Compact Disk	1995	12 May 98

A compact disk with the full set of 1994 and 1995 data was distributed. These two years of Bulletin files fill 90% of the disk, but the remainder was sufficient for Catalogue data files back to 1964, the Bibliography of Seismology, and the International Registry of Stations.

Earthquake Sequences

Several earthquake sequences produced special challenges at the ISC, and are interesting because they provide insight into the need for improved software and because their impact processing and editing.

Event	Notes
Nov 95 Gulf of Aqaba	New editor and large sequence with extensive data problems
Dec 95 Kurils, Ryukyus	Contemporaneous large sequences with many phases per event
17 Feb 96 New Guinea	Largest event analysed this year, Harvard $M_W=8.2$
10 Jun 96 Alentejans	Most readings for one event, 1357 phases from 861 stations

November 1995 included a sequence in the Gulf of Aqaba that was especially challenging because of a highly variable time discrepancy between the seismic networks of Jordan (JSO) and Israel (IPRG), sometimes greater than 90 seconds. In the end, ISC locations for teleseismically recorded events in this sequence were computed without JSO data while regionally recorded events were fixed on the IPRG estimate. Editing this sequence was especially time consuming since the time discrepancy caused the automatic processing to fail to group most corresponding epicentres and their phase data. Thus, both epicentres and phases data had to be re-associated by the editing seismologists.

December 1995 included an unusually high number of phase readings, 30% more than average for other months since January 1995. Large sequences occurred this month in the Kuril Islands (700 events, M_W 7.9 main shock on 3 December) and the Ryukyu Islands (700 events), while the Gulf of Aqaba continued, along with the corresponding problems.

EIDC Data

More comprehensive inclusion of EIDC data expanded the number of events and readings reviewed by ISC seismologists, and also highlighted several long-standing limitations of ISC software.

Inserting phase data directly from the EIDC's REB now avoids the possibility of missing phases, which NEIC reports occasionally fail to include, and incorporates slowness measurements, which are not accommodated in the format used by NEIC. Many of the same readings are unavoidably inserted also from the NEIC files, so the problem of duplicate phase reports has grown significantly. In addition, the EIDC reports IASPEI-91 phases missing from the Jeffreys-Bullen tables, including PKiKP, PKPab, PKKP, SKP, and Pg beyond 8°). With no corresponding phases in the J.-B. tables, ISC software fails to associate them properly and they must all be re-associated by ISC seismologists.

All EIDC epicentres are included in the initial ISC data set for each month from January 1996, eliminating the exclusion of 1995 EIDC epicentres based on three stations. Many of the newly included epicentres differ from NEIC locations for the same events by hundreds of kilometres and tens of seconds. Large mislocations cause two types of problems. First, phases from other earthquakes may be incorrectly associated with a badly mislocated epicentre, while phases from the mislocated earthquake fail to be associated with it. Second, the process that groups epicentres from different agencies for the same event is more likely to fail for larger mislocations. The ISC has dealt with similar problems in the past, e.g., NORSAR array locations, but the extent of difficulties is unprecedented and their treatment is a high priority in the new association and grouping algorithms now being developed.

Property	Impact
EIDC / NEIC partial duplication	Include data from both sources, correct duplication during editing and processing.
EIDC uses IASPEI 91 phases	Phases with no corresponding Jeffreys-Bullen times are routinely misassociated.
Some EIDC events badly mislocated	Routine misassociation of phases and misgrouping of epicentres corrected in editing

Income

Member contributions (black and grey) matched the expectations in the budget from last year's report. Under accruals-basis accounting, this match reflects mainly that no invoices were posted or withdrawn after the budget was prepared and that exchange rate fluctuations did not significantly affect income when expressed in British pounds.

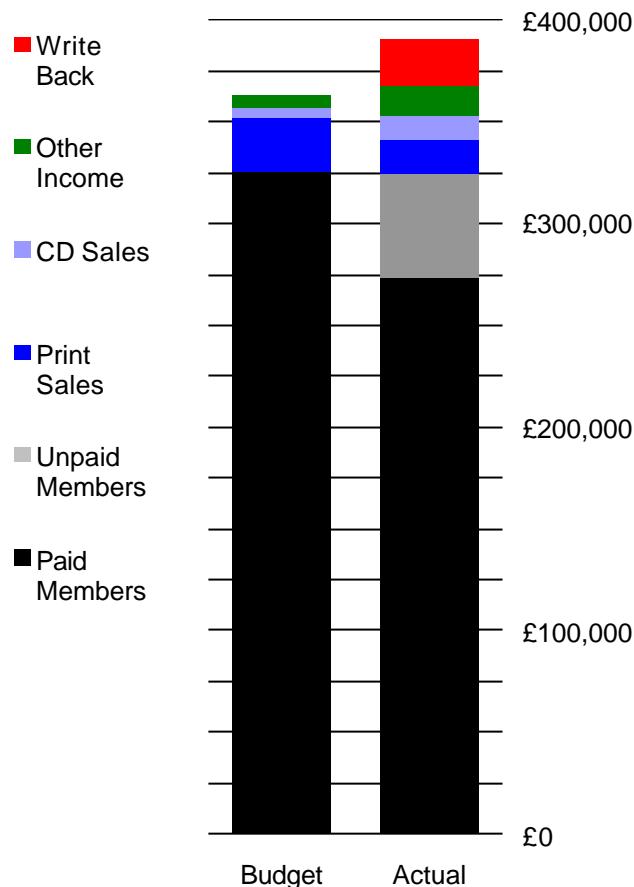
At year-end however, more than 15% of the membership contribution invoices (grey) were unpaid. Nearly half of the unpaid contributions were received before this report was prepared, but delayed payments may require the Centre to pay bank charges maintaining and using a line of credit. Contributions that remain unpaid eventually will be written off, thus appearing as expenditures in future years.

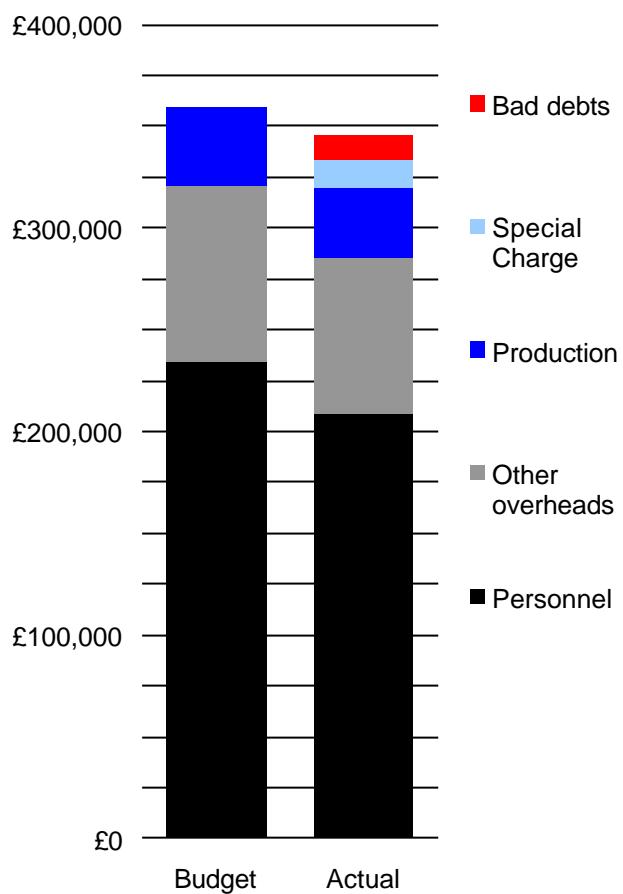
Sales income (blue shades) in total fell only slightly short of the budget, but income from printed products (dark blue) constituted a smaller fraction than expected. This results partly from the delay in production, since it caused invoices for the Catalogue to not be issued during the year. Some of the decline, however, is due to an 11% decline in the number of subscribers to the printed Bulletin, which results partly from cut backs by agencies that formerly held multiple subscriptions. CD sales (pale blue) remained robust; the CDs apparently satisfy a previously unmet demand for computer-readable ISC data. Since income from CD sales is a large multiple of the cost of their production, however, the ISC has implicitly changed its policy from providing data at the cost of reproduction to subsidising operations with sales of data products.

Other income (shown in green) consists principally of interest on bank deposits, with minor amounts from associate member contributions and sales of services. This was larger than expected because excesses of income over expenditures during 1997 and 1998 have resulted in larger average bank balances, so that bank interest income is greater.

The 1997 contribution from the Russian Academy of Science was unpaid at the end of 1997, and written off, consequently appearing as both income and expenditure in the 1997 accounts. The contribution was actually received in early 1999, so it was necessary to write back the contribution into the ISC's accounts. Thus, the 1997 Russian Academy of Sciences (shown in red) contribution appears again as income in the 1998 accounts.

While total income for the year exceeded the budget by 8%, the unpaid member contributions and the written back 1997 contribution represent cash that the ISC gained a reason during 1998 to expect in the future. Cash actually received fell short of anticipated income by 12%.





Expenditures

Personnel costs (black) are comprised of salaries, pension contributions, recruiting and repatriation expenses. Salary and pension expenditures were lower than expected because of the Deputy Director's unanticipated retirement in August and delay in hiring a system analyst from July to November. These savings were partially offset by promotion of a seismologist to senior seismologist, hiring a further seismologist from December, and recruiting costs for unanticipated hires.

Other overheads (grey) include building expenses, computing expenses, travel by the committee and staff, and exchange rate gains or losses. Building expenses consist primarily of mortgage payments, which are uncertain only if Dollar/Sterling exchange rates fluctuate. Computing expenses consist primarily of equipment service contracts and Internet

service fees. The Internet service fees were greater than budgeted because of a change from intermittent service to a leased line early in the year. Travel costs were less than expected because the Director did not make a trip to Japan. Other expenditures not in the budget included production of a new publicity brochure. Exchange rate gains and losses were minimal because the Dollar/Sterling exchange rate was stable and the ISC no longer maintains an account in Thai Baht.

Production costs (blue) are almost entirely for printing and distributing the Bulletin and Catalogue of 1996 events (dark blue), for which subscribers received invoices during 1998. These costs are partly estimated since several issues had not been printed and distributed by the end of 1998. A special charge for production of some Bulletin and Catalogue issues of 1995 events during 1998 (pale blue) is included; an estimate of these costs failed to be included in 1997 expenditures because of an oversight.

Unpaid contributions that are unlikely to be paid within another year are provided for as bad debts (red) and appear as expenditures to remove them from the ISC list of assets. This year, bad debt provisions resulted from the withdrawal of Lithuania, Syria, Chile and Egypt as ISC members. In the case of some of these members, invoiced contributions for several years were being carried as assets by the ISC.

Operating costs are expenditures exclusive of special charges and bad debt provisions. In total, operating costs were 11% less than budgeted, due primarily to the lower than expected personnel costs, which still constituted nearly two-thirds of operating costs.

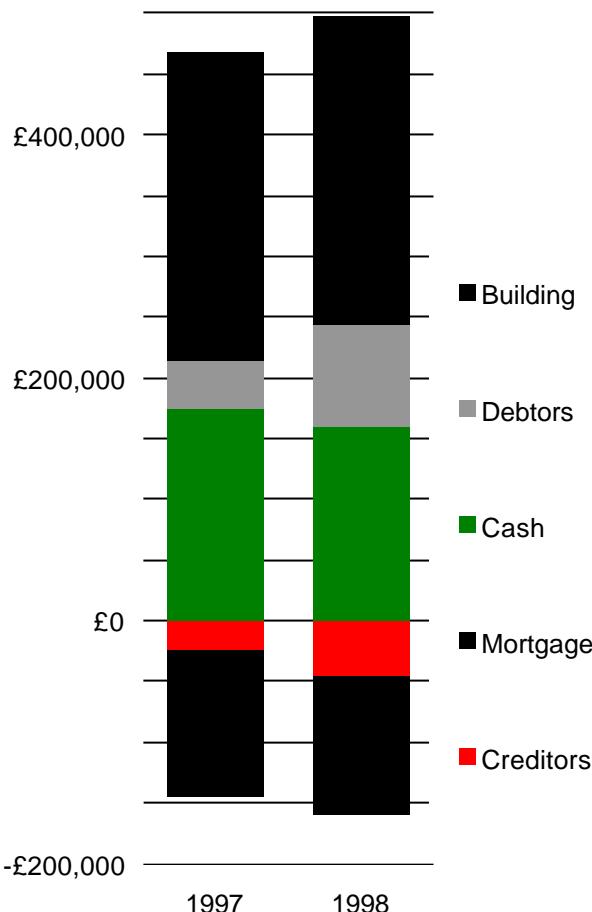
Assets

The net value of the ISC's liquid assets is the difference between cash and creditors, shown in green and red at the right. This includes the bank balances required for the exchange rate stabilisation fund and the computer replacement fund. The net liquid assets of the Centre decreased during 1998 from £150,000 to £113,000. This decrease is due to the large balance of member invoices outstanding at the end of the year and to planned spending from the computer replacement fund. Liquid assets provide the ISC with the cash flow required to operate without drawing on committed reserves. Setting aside the fund balances, at year-end the ISC's unencumbered liquid assets stood at £70,000, sufficient to continue operations for less than three months.

Current debts owed to the ISC, *i.e.* payments expected within one year, are shown in grey. These debts consist almost entirely of unpaid membership invoices that the ISC has not written off. At year-end, this included the 1997 and 1998 Russian invoices, as well as the 1998 French and Italian invoices. The net value of the ISC's current assets is the sum of its liquid assets and current debts, shown in red, green and grey. Net current assets increased during 1998 from £190,000 to £199,000. With these net current assets, the ISC could have continued operating without 1999 contributions for approximately seven months, but only if all contributions due before 31 December were paid and the Executive Committee authorised use of funds balances.

The ISC's net tangible assets are the difference between the assets (above the "0" line) and liabilities (below the "0" line) shown in black in the figure above. The increase in net tangible assets from £133,000 to £140,000 is due primarily a small decrease in the mortgage, on which the ISC paid 4% of the original principal, as set out in the terms of the loan when it was made. Net tangible assets may increase or decrease in the future, partly because the remaining principal on the mortgage, when expressed in Sterling, would change if the Dollar/Sterling exchange rate fluctuates.

The net value of the ISC's total assets, represented by the difference between all assets and liabilities in the figure above, increased from £323,000 to £339,000 during 1998. This level is within British guidelines for assets of charitable organisations, which suggest that net total assets should not normally be much more than twice the annual operating expenditures, approximately £750,000 in the ISC's case.



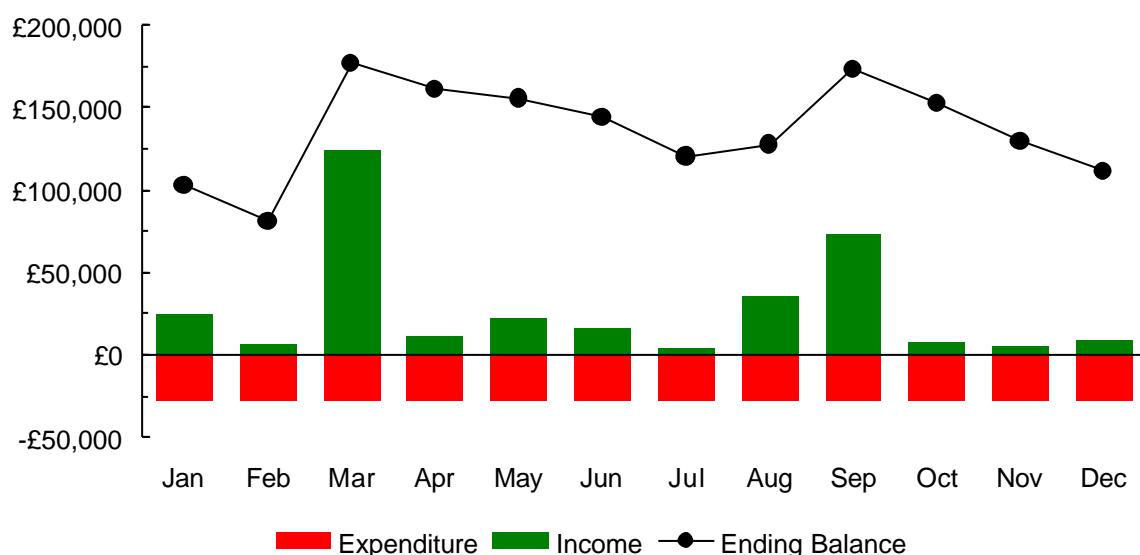
Excess Income and Net Assets

By long-standing policy, the ISC recognises income from capital-purchase grants only when the capital purchases are made. Under this policy, capital-purchase grant income and grant-funded capital expenditures are exactly offsetting. In conformance with generally accepted accounting principals, grant income and capital purchases treated in this way are not shown as income or expenditures, and the value of purchased equipment is not shown as an asset. When such a grant is received, however, the cash from the grant appears temporarily as an asset with no corresponding income. When the capital equipment is purchased, the cash disappears with no corresponding expenditure. If these two events occur in different years, some artificial effects occur in the financial statements.

For example, the ISC received the NSF computer modernisation grant in 1997 and will not finish spending it until 1999. Thus, the not-yet-spent balance of this grant artificially inflates its assets in the 1997 statement and, to a lesser extent, in the 1998 statement. Consequently, the change in the ISC's net total assets does not match the surplus or deficit of income compared with expenditures. During 1997, when the NSF computer modernisation grant was received but mostly not spent, the increase in net total assets exceeded the surplus. During 1998, when the ISC purchased computers using the 1997 grant, the increase in net total assets of £16,000 was well short of the surplus income of £45,000.

Cash Flow

In the cash flow figure below, income is based on the dates when contributions were actually received but expenditures are estimated by distributing them uniformly through the year. This is a reasonable approximation since salaries constitute the bulk of expenditures. Better records are being kept now, and an exact cash flow figure will be given in next year's report. The ending balances exclude cash maintained for the computer replacement and exchange rate stabilisation funds. The figure shows that in 1998 cash on hand never fell to a level that suggested the ISC might need to use its line of credit. This follows, however, a large excess income during 1997, from which the Centre accumulated unusual reserves. If reserves are spent down over the next several years, as planned at this time, timely contributions by the members and a line of credit will again become essential to the continuity of operations.



Computer Modernisation

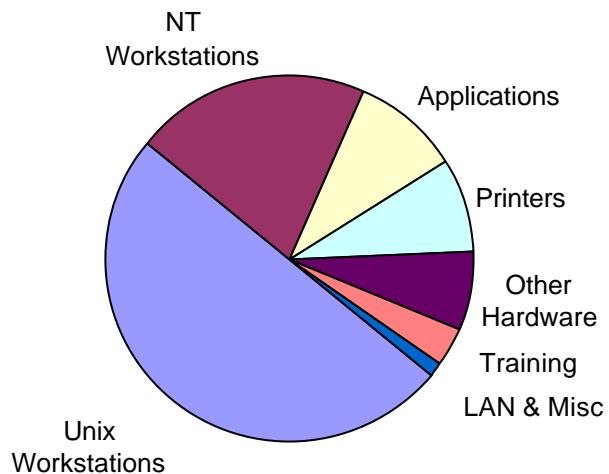
Building on the groundwork laid at the end of 1997, the ISC invested £30,000 modernising its computer systems during 1998, of which £21,000 was for additional workstations. The new workstations included five Sun Ultra 10s running Sun's version of Unix, Solaris, and four Pentium II computers running Windows NT. While the Sun computers are the ISC's principal platform for data processing, computers running Windows NT are more convenient and cost-effective platform for administering finances, entering data, preparing documents and writing compact disks. For now, a workstation with an external disk multipack is used as a file server to share the principal data set among all users. Data storage devices include a DLT drive for backups and archiving, and a DAT drive and CD writer for data exchange.

Apart from software supplied with computers, the principal application purchase was the Oracle 8 relational database management system, with a 5-user license. The ISC's new printers are a laserwriter for administrative purposes, an Ethernet-capable laserwriter for printing Bulletin masters at a continued high standard, and a colour ink-jet printer for viewgraphs and other communications. Other hardware purchases included a 4mm DAT drive, a replacement CD-writer, additional disks, and a scanner.

In April the ISC signed a two-year contract for Internet service from Rutherford-Appleton Laboratory over a 56 kbit/s leased line, which required upgrading its Internet router. Usage of the intermittent ISDN service, including visitors to the ISC web site, had increased sufficiently that a leased line was lower in cost. The contract period is long enough to amortise the installation cost to an acceptable monthly level yet short enough to allow changing reasonably soon to faster service if required or a lower-cost option is available. Internally, the ISC is networked with inexpensive 10 Mbit/s Ethernet hubs and cables, but all of the Centre's new computer devices are equipped 10/100 Ethernet interfaces. If need arose, the ISC could upgrade its network to 100 Mbit/s at relatively low cost.

As planned, the ISC's further commitment of £8,000 to the computer modernisation fund was less than expenditures, decreasing the balance from £39,000 to £17,000. The ISC has spent £48,000 from the fund since receiving the NSF computer modernisation grant in September 1996, leaving it with a commitment to spend £15,000 further during the grant period.

1998 Computer-Related Purchases



ISC Computing Equipment as of January 1999

CPUs:

Microvax, 9-track tape drive (1990 purchase), Compaq service contract expires 04/1999.
2 Sun Ultra 1's (1997) and 5 Sun Ultra 10's (1998), Sun service contract.
4 PCs (1998), no service contract.

Peripherals:

Line printer (1990), Compaq service contract.
PostScript Printers: 2 Ethernet laser printers (199?, 1998); PC laser printer (1998); Ethernet colour ink-jet printer (1998).
Scanner and CD writer for PC (1998).
Sun disk multipack and disks (1997, 1998) and Sun DLT (1997) and DAT (1998) drives, Sun service contract.

Software Development

The most important element of computer program development at the ISC this year was modifying the existing programs running under VMS to run under Unix. This involved re-writing command files as shell scripts or Makefiles, altering input/output modules of Fortran programs, writing programs to transfer certain binary-format files, and creating replacements for some steps previously carried out with VMS utilities.

The US National Science Foundation committed itself to supplemental funding of the ISC to hire a new seismologist dedicated to software development. The intended project is replacing the phase-reading association program. Changing association of a reading with the wrong event or with the wrong phase identification is the most frequent correction that ISC seismologists make while reviewing the preliminary listings for the Bulletin. (Other important edits include selecting from among duplicate readings of the same record, changing grouping of reported hypocentres with events, and constraining depths or epicentres as necessary to obtain a good location.)

The ISC also proposed for support to the UK National Environment Research Council for one additional full-time staff member for a period of three years. The intention was to use the funding, most likely, to continue the NSF-funded staff member, further improving the automatic association and addressing other shortcomings in the automatic processing to further reduce the level of effort required to edit each event.

The ISC implemented a web site, which involved configuring the Sun Web Server that was supplied with the operating system on its new Sun workstations, and writing HTML pages and scripts to search its data in response to user requests. Data are posted to the Internet the day after processing for each month is completed, two to three months more quickly than printed Bulletin is produced.

Personnel

Mr David McGregor retired in August after 34 years with the ISC. Mr McGregor's most important responsibility was developing and maintaining ISC computer programs. He offered to document the programs to help recover data from the archive tapes he wrote for the ISC. At year-end the ISC still sought a qualified replacement.

ISC Staff as of 1 January 1999

Dr Raymond J Willemann, Director
 Dr Dmitry Storchak, Senior Seismologist
 Mrs Maureen Aspinwall, Fin & Admin Officer
 Mrs Anna Surguy, Data Manager
 Mr James Harris, System & DB Administrator
 Mrs Carol Tubby, Data Preparation Assistant
 Ms Alison Bird, Seismologist
 Mr Mamy Andrianirina, Seismologist

Dr Dmitry Storchak accepted an appointment as senior seismologist. Dr Storchak first joined the ISC in 1995 for an INTAS-funded project to consolidate data from regional catalogues. He rejoined the Centre to edit the Bulletin full-time on a two-year appointment from early 1997. Dr Storchak is the longest-serving seismologist now at the Centre, and has benefited from working with Robin Adams, Wayne Richardson, Reinhard Mittag and Anthony Hughes.

Mr James Harris was hired as a system and database administrator in November to help take best advantage of ISC's new computers. Mr Harris holds an honours-level B.Sc. in physics. He has several years of professional experience developing and maintaining computer programs for scientific data analysis, and has progressively become responsible for administering computers running Unix and Windows.

Mr Mamy Andrianirina began a two-year appointment at the ISC in December as a seismologist to help edit the Bulletin. Mr Andrianirina holds university degrees in physics and chemistry and a post-graduate diploma in seismology. He has located regional and teleseismic earthquakes for the Institute and Observatory of Geophysics, Antananarivo, Malagasy Republic, since 1989. He participated recently in the seismology course of the International Institute of Seismology and Earthquake Engineering in Japan.

Scientific Liaisons

Preparing the Bulletin is the principal occupation of ISC staff, and the ISC's mission does not include research. Nevertheless, interaction with other scientists is important for the ISC in order to continue serving the seismological community well. This year, ISC science staff members participated in meetings of the Canadian Geophysical Union, the UK Geophysical Assembly, the European Seismological Commission, and the American Geophysical Union. The ISC continues a subscription to Nature, and staff members subscribe to a variety of geophysical journals. ISC staff members visited the Oxford and Edinburgh Universities and Imperial College, travelled to UNESCO headquarters, and met with CTBT Preparatory Commission chairman Wolfgang Hoffmann.

Visitors to the ISC during 1998

Chris Argent
 David Booth, British Geological Survey
 Chris Browitt, British Geological Survey
 Paul Bryant, Rutherford-Appleton Laboratory
 Yves Caristan, Lab. Det. Geophys.
 Igor Chernobye, CTBT Provisional IDC
 Stephen Cox, The Royal Society
 Adam Dziewonski, Harvard University
 Bruno Feignier, Lab. Det. Geophys.
 Domenico Giardini, Swiss Seismological Service
 Trevor Halsall, Reading University
 Jens Havskov, University of Bergen
 Peter Marshall, Atomic Weapons Establ.
 Aoife O'Mongan, British Geological Survey
 Andrea Morelli, Inst. Nat. Geof.
 Lazo Pekevski, St Cyril and Methodius University
 Debbie Porter, Atomic Weapons Establ.
 David Rendel, Member of Parliament
 Florence Riviere, Lab. Det. Geophys.
 Oleg Starovoit, Russ. Acad. Sci.
 Graham Sutton, Reading University
 Alice Walker, British Geological Survey
 Gordon Woo, EQE Catastrophic Management
 John Woodhouse, Oxford University
 John Young, Atomic Weapons Establ.

ISC staff members regularly analyse the Bulletin in order to help users take full advantage of ISC data, and to help plan, implement or evaluate improvements to the Bulletin. Analyses of broad interest are presented at conferences or published in peer-reviewed journals. The results during 1998 are tabulated at right.

The ISC has only a limited knowledge of how its data are used. Users usually do not inform the ISC when they publish research that uses of ISC data. Compiling the Bibliography of Seismology offered only a very limited view of uses of ISC data, but even this has not occurred for more than two years now. Unfortunately, therefore, the list below of papers using ISC data is incomplete.

ISC Staff 1998 Publications

McGregor, Fake P readings from the USNSN in the ISC Bulletin, *ISC web site*.

Storchak et al, What is the best source of data for studies of global seismology? (abs.), *Euro. Seis. Comm. 1998 Gen. Assem.*

Willemann, Regional thresholds of the ISC Bulletin (abs.), *Euro. Seis. Comm. 1998 Gen. Assem.*

Willemann, Network Amplitude Biases in the ISC Bulletin (abs.), *Am. Geophys. U. 1998 Fall Mtg.*

Willemann, Body-wave magnitude thresholds of the ISC Bulletin, *Seis. Res. Lett. (in press)*.

Storchak et al, Discrepancies in earthquake location between ISC and other agencies, *J. Seis. (submitted)*.

Citations of ISC Data in 1997

A. Barka and R. Reilinger. Active tectonics of the Easter Mediterranean region: deduced from GPS, neotectonic and seismicity data. *Ann. Geof.*, 40, 587-610.

E. A. Bergman. Systematic relocation of mid-ocean ridge earthquake. *IASPEI 29th Gen. Assem. Abs.*, 133.

D. Bowers and D. A. McCormack. The mechanisms of shallow earthquakes and the monitoring of a comprehensive test ban. *Geophys. J. Int.*, 128, 701-707.

N. V. Kondorskaya, Y. A. Khrometskaya and I. V. Fedorova. The analysis of ISC Bulletins and Catalogues as compared to those compiled in the former USSR. *IASPEI 29th Gen. Assem. Abs.*, 134.

A. Rhöm, J Trampert and R. K. Snieder. Stochastic analysis of ISC travel times in terms of correlation function of mantle structure. *IASPEI 29th Gen. Assem. Abs.*, 135.

H. N. Srisatava. Application of ISC data for seismological research in India. *IASPEI 29th Gen. Assem. Abs.*, 132.

J. G. Tanner, and J. B. Shepherd. Instituto Panamericano de Geografia y Historia Final Report on Seismic Hazard in Latin America and the Caribbean.

R. D. van der Hilst, S. Widiyantoro and E. R. Engdahl. Evidence for deep mantle circulation from global tomography. *Nature*, 386, 578-584.

S. Widiyantoro and R. van der Hilst. Mantle structure beneath Indonesia inferred from high-resolution tomographic imaging. *Geophys. J. Int.*, 130, 167-182.

J. B. Young, A. Douglas and P. D. Marshall. Estimating the detection thresholds of P for seismological stations contributing observations to the Bulletins of the ISC. *IASPEI 29th Gen. Assem. Abs.*, 133.

Citations of ISC Data in 1998

- H. Bijwaard, W. Spakman and E. R. Engdahl. Closing the gap between regional and global travel time tomography. *J Geophys. Res.*, 103, 30,055-30,078.
- A. N. Foster and J. A. Jackson. Source parameters of large African earthquakes: implications for crustal rheology and regional kinematics. *Geophys. J. Int.*, 134, 422-448.
- J. Gauden, R. G. North and I. Bondar. Comparison of ISC, NEIC, and PIDC (REB) bulletins for January-June, 1995, in "Evaluation and Tuning Studies at the Prototype IDC July-December 1997", Technical Report CMR-98/02.
- H. Kao, S. J. Shen and K.-F. Ma. Transition from oblique subduction to collision: earthquakes in the southernmost Ryukyu arc-Taiwan region. *J. Geophys. Res.*, 103, 7211-7229.
- B. L. N. Kennett, S. Widjayanatoro and R. D. van der Hilst. Constraints on seismic velocities in the Earth from traveltimes. *Geophys. J. Int.*, 122, 108-124.
- E. A. Okal, and S. H. Kirby. Deep earthquake beneath the Fiji Basin, SW Pacific: Earth's most intense deep seismicity in stagnant slabs.. *Phys. Earth Planet. Int.*, 109, 25-63.
- G. Pegler and S. Das. An enhanced image of the Pamir-Hindu Kush seismic zone from relocated earthquake hypocentres. *Geophys. J. Int.*, 134, 573-595.
- C. Piromallo and A. Morelli. P-wave propagation heterogeneity and earthquake location in the Mediterranean region. *Geophys. J. Int.*, 135, 232-254.
- C. Piromallo and A. Morelli. Imaging the Mediterranean upper mantle by P-wave travel time tomography. *Ann. Geof.*, 40, 963-979.
- J. Plomerova, V. Babuska and R. Scarpa. Teleseismic P-residual study in the Italian region - Inferences on large scale anisotropic structure of the subcrustal lithosphere. *Ann. Geof.*, 41, 33-48.
- M. Rezapour and R. G. Pearce. Bias in surface-wave magnitude MS due to inadequate distance corrections. *Bull. Seis. Soc. Amer.*, 88, 43-61.

Status of Earlier Plans

The table at right, adapted from the 1997 Director's report, shows that the ISC achieved a broad range of ambitious goals. Posting the entire 30-year Bulletin to the Internet went well beyond one important goal, and a web-based selection program satisfied the needs of many users. The port to Unix was substantially completed and the data archive was duplicated but for a few troublesome tapes. An outstanding system analyst was hired to administer the ISC computer systems and British seismologists have responded favourably to the Royal Society's solicitation for comments on the ISC.

JAN 1998 STATUS	PLANS FOR 1998	JAN 1999 STATUS
<i>Data Analysis</i>		
<ul style="list-style-type: none"> • Four months behind • Inexperienced editors 	<ul style="list-style-type: none"> • Part-time seismologist • Keep pace • Sacrifice completeness 	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <ul style="list-style-type: none"> • Seven months behind • Experienced editors • Third full-time editor
<i>Data Exchange</i>		
<ul style="list-style-type: none"> • CDs through 1994 • iscbul 	<ul style="list-style-type: none"> • Release 1995 Bull. CD • Post recent on the Internet • Prototype new selection 	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <ul style="list-style-type: none"> • All data on Internet • New select on Internet
<i>Computing</i>		
<ul style="list-style-type: none"> • VMS batch processing • Frequent problems • Workstations delivered 	<ul style="list-style-type: none"> • Port applications to Unix • Copy data archive to DLT • Released Bull. to RDBMS 	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <ul style="list-style-type: none"> • NSF-funded developer • Oracle being installed
<i>Finances</i>		
<ul style="list-style-type: none"> • Surplus from 1997 • Salaries redirected 	<ul style="list-style-type: none"> • Hire system analyst • Campaign for support • Seek Japan STA grant 	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <ul style="list-style-type: none"> • Even larger reserve

It is unsurprising that there were a few departures from such ambitious goals:

Keep pace: The most important shortcoming was failure to produce 12 full months of the Bulletin. Keeping pace became impossible after deciding, with the advice of the Executive Committee, not to sacrifice completeness. Given the large data volume and small, relatively inexperienced editing staff, the goal may have been over-optimistic in any case. Editing did speed up through the year as the editors gained experience and a third editor was taken on in December to further improve the rate of production.

Relational Database: The relational database anticipated at the start of the year was not implemented during 1998. This resulted partly from the unanticipated retirement of the Mr McGregor, who had led software maintenance and development. In addition, the system analyst was hired several months later than anticipated as a result of difficulty finding a well-qualified candidate.

STA Grant: Little was done during 1998 regarding a grant from the Science and Technology Agency, based on advice from Japanese colleagues. A more disconcerting financial development was that the ISC ran a significant surplus for a second consecutive year. This resulted from the temporary understaffing that also delayed software development. Plans in this report show how the ISC intends to spend from its reserves during the next three years to produce the best and most timely Bulletin possible.

Plans for Bulletin Content

In the mid-1960's, the global distribution of seismic stations was sparse almost everywhere and global travel-time and attenuation were fairly uncertain. Nevertheless, based partly on the then-new WWSSN, the ISC was organised to begin compiling a comprehensive global catalogue of the record readings and earthquake parameters.

Developments since then include tremendous growth in the number of seismic data available, greatly improved accuracy of earth models, and widespread digital recording of broadband seismic waveforms. While unquestionably beneficial to seismology, these changes pose challenges to the ISC as it currently functions. All of these developments are ongoing, but with the near-completion of the GSN and the general acceptance of earthquake parameters by Engdahl et al. using a new earth model, the time may be ripe to adopt a new standard for the Bulletin. In order to make changes that meet the needs of seismologists as well as possible, the ISC is planning a workshop on the future content of the Bulletin. Topics to be addressed include the types of data that should be included in record readings, whether or not a uniform policy on thresholds should be established, and the earth model that should be used in computing earthquake parameters.

Plans for Data Analysis

The ISC editing staff continues to gain experience. The senior seismologist, Dr Dmitry Storchak, now has an indefinite appointment with the ISC and we have applied for an extension of his permit to work in the UK. Ms Alison Bird holds a British passport and may continue with the ISC beyond the end of her current appointment in November 1999. Provided that funding is sufficient, the ISC is likely to offer Ms Bird an extension and she has indicated that she would likely accept an offer. Mr Mamy Andrianirina is contracted to work at the ISC through November 2000, and is legally permitted to work in the UK for the ISC through November 2001.

With more experience, the staff can produce a large Bulletin more quickly while maintaining high standards for reliability and consistency. In the last few months of 1998 the editors came close to a pace that would produce 14 months of Bulletin during 1999, anticipating a full contribution from Mr Andrianirina. Projecting to 2000 is less certain because of questions about the staff and software development. If both Ms Bird and Mr Andrianirina continue with the ISC, however, it may be possible to produce as much as 16 months of Bulletin during 2000. This would leave the ISC only one or two months behind its target schedule for distribution of the printed Bulletin.

With the arrival of a third seismologist, a backlog of edit keying developed, and the situation will grow worse as Mr Andrianirina comes up to full speed. The problem has been partly addressed in the short-term by increasing the data preparation assistant, Ms Carol Tubby, from 4 days per week to 5 for a period of six months. Beyond that, a prototype interface for on-line editing is being developed. In the first instance, the primary objective of on-line editing will be to automatically write the edit files now keyed by hand. The system may be useful at first primarily for early editing passes, which result in the largest number of rapidly produced edits, and the largest fraction of simple edits. Interactive capabilities, such as re-computing residuals based on new locations could be added gradually to this interface.

Plans for Data Exchange

Wide adoption of a standard format would benefit the ISC directly. Data will probably continue to be offered to the ISC by a variety of means, including e-mail, ftp and computer tapes and disks. Regardless of the means, however, if the data were supplied to the ISC in a standard format the ISC's data collection system could be simplified. The CTBT International Data Centre will certainly adopt a variant of the GSE 2.1 format, and the NEIC has committed to supporting the same format. This format is used by AutoDRM sites around the world and is supported by regional agencies such as EMSC. GSE 2.1 also has the advantage of including data types that are, in some cases, not reported to the ISC only because they are excluded from current formats, and the ISC is working with the IDC and NEIC to encourage modifications required for further types of earthquake data. If we succeed, the three most widely distributed global seismicity bulletins could all be available in a common format, encouraging seismologists everywhere to adopt it.

It now seems premature to release a DVD during 1999, so the ISC plans to release only a standard compact disk released of 1996 events and readings, probably near midyear. The new disk is planned to include a PDF version of the printed Bulletin and some of the HTML pages presently used in the ISC's web site, as well as the Bulletin files in the 96-column fixed-format on the earlier CDs. The disk of 1997 events and readings released during 2000 is planned to include a search program written in Java, allowing users with a wide variety of computers to easily select from the data. The program is planned to provide users with options for output in a variety formats, at least including 96-column and IMS.

More immediately, during 1999 the ISC plans to modify data selection on the ISC web site to allow queries spanning multiple calendar months. Access to the data by ftp is problematical because files as large as the ISC's month-long Bulletin files may fail to be transferred unacceptably often. Breaking the Bulletin into daily files would result in a very high overhead since either the headers providing keys to station and agency codes would have to be repeated for each day, or users would have the burden of re-assembling monthly files.

Data that have been collected by the ISC but not yet analysed are planned to be released on the Internet during 2000. The critical step is implementation of a single system for managing all of the ISC's data to replace the current system of varied formats, so that the same data tools will support access to all data.

There are several systems available for implementing an AutoDRM interface. The systems available are designed to launch a data query, wait for the result, and dispatch a reply message. Thus, these systems assume a separate system for satisfying data queries, which are likely to vary greatly from one centre to another. The ISC plans to investigate AutoDRM systems as the organisation of its new data management system becomes better defined, and expects to implement one during 2000.

The availability of ISC data on-line makes it more useful to correct errors discovered after publication, incorporate additional data, or occasionally re-compute locations with an updated earth model. Updates would have the widest benefit if users select from the data at the ISC as required for each project, rather than duplicating the database at their own sites. The ISC can encourage this practice by providing tools to make access easier. We may offer source code for functions to select ISC data using http, which users could use in their own programs.

Plans for Computing

The ISC plans to purchase a server computer during 1999, using the MicroVAX in part exchange. With this purchase, the ISC's needs for computer hardware will have essentially been met while spending most of the commitment to spend \$105,000 during the period of the NSF computer modernisation grant. Any further spending would be for purchasing software and development tools, and for training to enable ISC staff to efficiently implement new applications.

A new system for managing data is required to completely record data collected by the ISC, provide an efficient interface to access all of the ISC's data, and support simultaneous updates by several editors. The Oracle database management system purchased in 1998 will make implementing a new system significantly easier, and modifying ISC applications to use the new system will be an important task in the upcoming years. After designing the table formats early in 1999, the first things implemented will be collection of data to the database and copying from it to the format now used for association and location processing. After data are stored in the Oracle database, running data distribution from the database will be a high priority. We hope to have an Internet-interface to the database by mid-1999.

Employing a third seismologist has increased the requirement of edit keying, making development of an on-line editing more urgent. Initially, on-line editing is planned to simply write the edit command files without the need for manual editing. Because of the new urgency in this area, it is now planned to develop an initial capability in this area before modifying the location program to work more directly with the database.

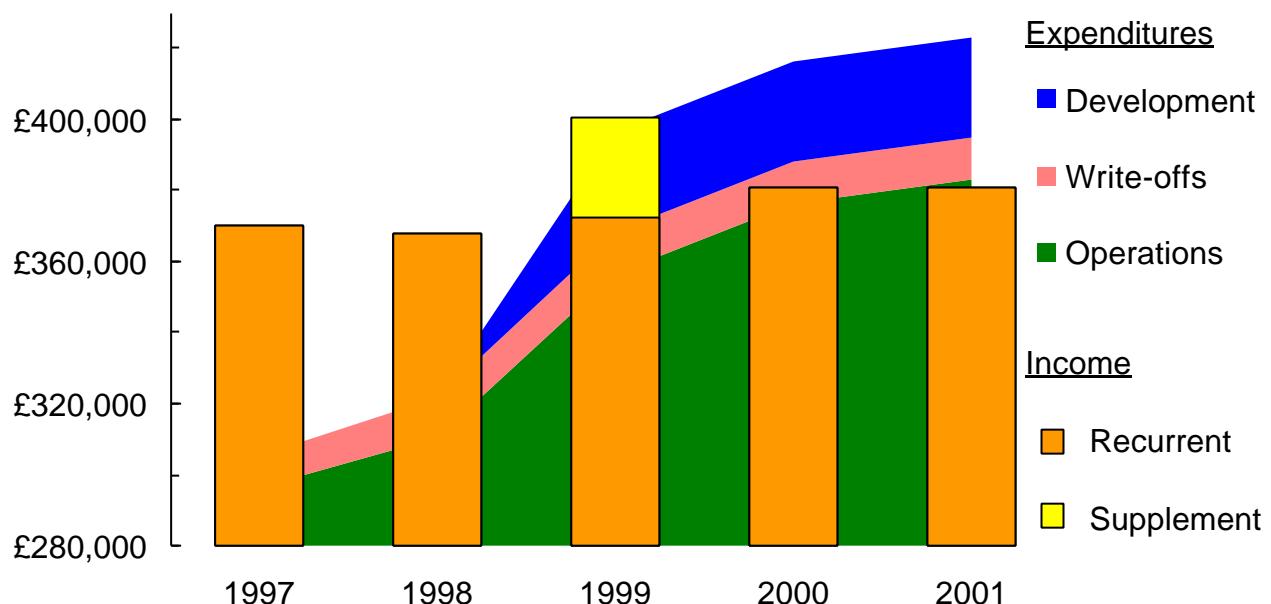
Thanks to NSF funding, the ISC has hired a seismologist dedicated to improving automatic association. The new association program will depend on updating of the ISC's management of data within the ISC, since it is planned to use reported associations, which are not currently stored by the ISC. Flexibility will be required, so that the program can be re-configured in the future. Progress in testing an algorithm is expected by mid-1999, and we hope to put a new program into operation by the end of 1999, although it is likely that the configuration would be refined later. If funding is obtained to continue, effort during 2000 might best be directed towards improving automatic identification of duplicate readings.

The table at right is adapted from the 1998-2002 Development Plan. Because of the lack of a programmer during late 1998, some of these goals will be reached later than anticipated. Employing an extra seismologist for development may help us to recover the original schedule by the end of 1999, but the need to reduce the requirement for edit keying will cause us to postpone direct update of the database when relocating earthquakes in favour on-line editing.

Target	Objective
1999 Mar	Collect data to the relational database
1999 Jun	Use agency-supplied phase associations
1999 Sep	Revision of event locations updates the database
1999 Dec	Editing utilities with less keying, more useful output
2000 Mar	Further improved automatic processing
2000 Sep	Eliminate WTF files

Plans for Finances

The budget projection figure below illustrates the evolution of the ISC's income and expenditures over the last two years and projected for this year and the next two years. Grant-funded capital spending is excluded. Write-offs are estimated at £12,000 annually for 1999–2001 and exclude special treatment of Russian contributions in 1997 and 1998. The provisional membership rate for 2000 agreed by the Governing Council in 1997 is used for both 2000 and 2001.



The figure shows significant surpluses during 1997 and 1998 that resulted from delays in hiring. The ISC is now fully staffed, including a third seismologist to help cut the publication delay and an extra seismologist/programmer to accelerate development. Supplementary funding was obtained for 1999 to support this level of effort, and further funding is being sought for the future. The accumulated reserves have facilitated development, since they allowed the ISC to sign two-year employment contracts before funding is certain.

The projected budget shows recurrent income climbing slowly despite annual indexing of member contributions. This is partly because some contributions are later or smaller than expected. The Governing Council has noted the situation of the Russian Academy of Sciences, and its contributions continue to cause uncertainty in future income. In addition,

- The UK Royal Society declined to index its contribution for 1998 and 1999, and is reviewing the level of its support to the ISC.
- The British pound has strengthened significantly over time with respect to the French Franc, Deutsche Mark and Canadian Dollar, where members are invoiced in their native currencies.
- While five organisations have joined the ISC since January 1997 and April 1999, six single-unit members withdrew during the same period.
- The numbers of subscriptions to the printed publications are declining, but cuts in production runs might not be cost-effective.

Since salaries constitute two-thirds of operating costs, the greatest pressure on expenditures is the need to continue raising salaries in-line with UK inflation. The ISC is located in the “Silicon Valley” of Great Britain, with the world’s largest mobile communications company headquartered a few miles away in Newbury and important European-region offices of Microsoft, Oracle and other information technology companies in Reading and other nearby cities. Oxford and Reading Universities, Rutherford-Appleton Laboratory, the British Research Councils in Swindon, and meteorological data centres are all within commuting distance. Thanks to good train and motorway service, Thatcham is even home to London workers. As a result, housing costs continue rising in the area and there are many alternative opportunities for potential ISC employees. Unemployment in Berkshire is very low and the ISC must continue paying competitive wages in order to employ people with the skills required for the ISC to thrive. As shown in the budget projection, even without an extra staff member for development, deficits of £7,000 in 2000 and £14,000 in 2001 are projected.

With deficits in 2000 and 2001, there is a projected cumulative excess income from 1997 to 2001 is £37,000. Nevertheless, if important contributions continue to be paid very late or without indexing, or if no supplementary funding is secured, in 2000 it may be necessary to re-evaluate the Centre’s ability to support a staff member dedicated to development in 2001.

The ISC will continue to seek grants for development projects, but it is important that funding for operations does not decline in real terms. Even development projects undertaken by staff hired with supplementary funding require time from both the Director and the Senior Seismologist, who are necessarily involved in projects with the potential to impact the standards of the Bulletin. As shown at right, the ISC has applied or intends to apply for special grants from agencies of the governments of the US, the UK, the European Union and Japan. If all were successful, the ISC would be challenged to implement each of them with full effect. It is more likely, however, that at least some of them will be successful only if resubmitted in future years.

In the face of financial challenges in the past, the ISC purchased land and constructed its own facility, and the ISC’s financial security now benefits from equity in its building and property. Despite medium-term financial concerns, investments are planned to keep the existing building in good repair and up to date. During 1998–1999, the ISC performed minor exterior repairs, re-organised the warehouse, re-fitted the computer room, and accommodated a larger staff. Further investment in 2000 should include modernisation of the electrical and air handling systems, to extend the life of computer workstations and improve the comfort and productivity of the staff.

ISC Supplementary Proposals

NSF: Successfully applied in 1997 for partial funding to purchase new computer equipment.

NSF: Applied in 1997 for an extra staff member for 3 years to modernise processing. Intend to apply in 1999 to broaden data in the Bulletin.

NSF: Successfully applied in 1998 for a supplement to support a development seismologist for 1 year.

RS: ISC invited to request one-off grant to be spent by 31 Mar 99. Decision on supplement to computer modernisation still pending on 1 Feb.

RS: CSB suggested Dr Chen Qi-fu as an applicant for a one-year RS fellowship at ISC. Decision expected in mid-1999.

NERC: Applied in 1998 for support an extra staff member for 3 years to implement the ‘98–’02 plan. Intend to re-apply in 1999.

EC: Fifth framework beginning in 1999 includes support for infrastructure. The ISC intends to apply jointly with other Euro agencies in mid-1999.

INTAS: Propose in mid-1999 on location algorithms jointly with CEME, ING and Crimea to EC-funded programme supporting work in former FSU states.

STA: Request for ¥100,000,000 over five years to support development of new products is pending, but not expected for several years.