

Introduction

<i>Operations</i>	1
<i>Finances</i>	4
<i>Other Activities</i>	8
<i>Plans for Upcoming Years</i>	14

Extending Recent Progress

This year the ISC built on recent improvements and also prepared for further improvements in the near future. Data collection advanced further ahead of the schedule that the ISC has followed in the past, which is essential for improving the timeliness of the *Bulletin*. The ISC's collection of data from temporary deployments, aftershock studies, and other special projects grew to many times its former size and discussions were undertaken with instrument programmes and journal publishers about encouraging individual investigators to use the ISC's archiving and re-distribution services. Processing to organise data and prepare for analysis continued to be run promptly when data are inserted in the ISC database. This processing complements improvements in the timeliness of data contributions to make the preliminary part of the on-line *Bulletin* quicker and more comprehensive. Modifications to the ISC's hypocentral location program culminated in the use of *S* arrival times in computing the Centre's own hypocentres, which significantly improves results for some small earthquakes. The reliability of the prompt processing also made it possible to select events for manual review using a broader set of criteria, facilitating efficient analysis despite growth in the volume of data collected. ISC seismologists began using a system to record their analysis digitally, which immediately cut the risk of errors in manually keying edit files and laid the basis of integrating graphics and decision support tools into the analysis system.

The annual *Bulletin* CD included data for more events than ever before. The *Catalogue* CD included even recently contributed data for earthquakes that occurred in any year, a copy of all of the data in the most modern format, and a program with a graphical user interface to manipulate data from the modern format files. The web site provided data in response to more requests from more users than before, and also began to offer a variety of graphics to aid users. Computing infrastructure was improved to support further development, including security measures that are essential for continuing to use the Internet for both collection and distribution of data. Thanks partly to stability and flexibility in the data management system that was implemented in recent years new software at the ISC is modular, which makes maintenance easier and more reliable, yet fully integrates its results with other data and processing results at the ISC. Thus, it was straightforward to begin developing software that could further improve ISC hypocentres or magnitudes by taking advantage of better travel time or attenuation models, and that could further improve data collection by taking advantage of the wide availability of digital waveforms in the 21st century.

Data Collection

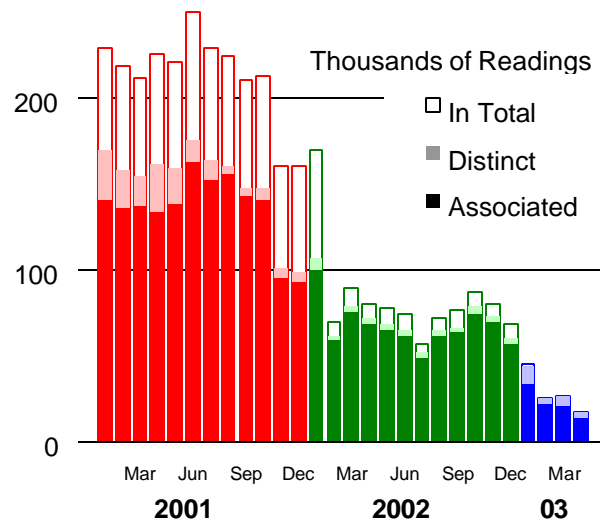
The ISC worked with many agencies to advance data contribution schedules, in some cases by six months or more. These advances were important to limit the effort required to parse last minute contributions, which have grown more numerous as the *Bulletin* is published with a progressively shorter delay. All regular contributors sent data in time for 13 deadlines during 2002 for a further month of data, in accordance with the schedule for a timelier *Bulletin*. But a few agencies indicated that they would be challenged to contribute 13 months of data again during 2003. The ISC began collecting preliminary bulletins, which could be used if a contributor's final bulletin is not available until after the ISC's own analysis, and amended data management to more fully integrate data that are collected after the ISC's manual analysis. Thus far, however, it has not been necessary to use a preliminary bulletin or to integrate data from a regular contributor after the ISC's analysis.

The ISC's collection of data from special projects grew considerably. Special project data incorporated into the ISC database include bulletins from temporary deployments to record aftershocks, such as Bhuj and Biak Island, and to improve knowledge of seismicity and earth structure in otherwise sparsely monitored regions, such as the PASSCAL projects SPASE and SAPSE. Special project collections also include re-analyses of existing data sets, such as the EHB phase identifications, which now accompany the EHB hypocentres inserted during 2001, and further source parameters for events in the *Bulletin*, such as moment tensors from regional waveforms prepared by INGV (Rome), ETH (Zurich) and ASIENS (Taipei).

Data Processing

An important change in ISC processing during 2002 was use time of *S* arrival times in computing hypocentres. This was implemented with only minor disruption thanks to months of collective effort spent modifying ISC location software and testing the effects on ISC hypocentres. Use of *S* arrival times causes only insignificant changes to hypocentres that are well-determined by *P* times alone, which constitute a large majority of hypocentres computed by the ISC. But *S* times help to stabilise inversions for marginally constrained hypocentres, which reduces the number of divergent solutions that must be reviewed by ISC seismologists and probably reduces the chance of including very poor hypocentres in the *Bulletin*.

The ISC automatically groups hypocentres into events and associates arrivals with primary hypocentres as each of them is collected. The data and processing results are the preliminary *Bulletin* that is available from the ISC's Internet servers. The figure at right shows the status of phase readings in 2003 April, after the database was updated with results analysing 2001 June. Status for 2001 July – 2003 April shows results from automatic processing. The database then held data from NEIC's PDE through the end of 2002 January and from IDC's REB through all of 2002.



Although there are variations from month to month, the figure suggests that typically

- Fewer than 30% of expected distinct phase readings are collected in the first several months after the events.
- Only a few of the phases from the REB duplicate those already collected by the ISC, and almost all other phases collected in the first year after the events are distinct.
- The ISC first collects about 20% of distinct phases from NEIC's PDE, even though most phases from NEIC's PDE duplicate readings that the ISC has already collected.
- The ISC collects about 35% of distinct phase readings just months before its final analysis, including fewer than 5% of distinct phase readings in the last few weeks. Almost all of these phases are distinct from others, including phases from the PDE.
- Nearly all distinct phases are associated with an event by ISC's automatic processing, but about 10% of them are disassociated in ISC's manual analysis.

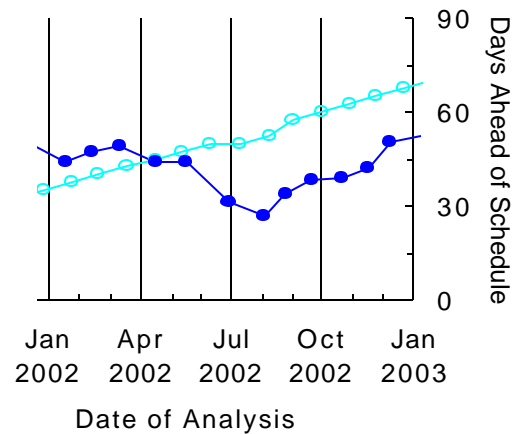
Bulletin Editing

During 2002 ISC seismologists editing the *Bulletin* began considering the effect of *S* arrival times on hypocentres, started using a new editing system, analysed a major earthquake swarm, and were joined by a new seismologist. Minor disruptions from each change accumulated to a significant delay. An editor who had planned to leave in October was retained through the end of the year, which partially recovered the delay.

With the new editing system, ISC seismologists still use paper listings to work efficiently with so many data, but they record decisions digitally. This seemingly simple change has transformed the way that editing is done, since seismologists now interact with their workstations almost continuously. The program that facilitates their interaction could be enhanced to run further programs with additional capabilities, if such development seems likely to help seismologists edit more quickly or with fewer errors.

ISC seismologists reviewed results for almost every event of year 2000 with a reported magnitude of 3 or more, with reported information from two or more agencies, or with a reported arrival at a station at least 5° from the epicentre. With several selection criteria, we could use the same thresholds for all regions while re-analysing fewer small events that were recorded by only one network. The magnitude threshold was raised to 3.5 for events reported only by the JMA during July – September 2000, when a great swarm of earthquakes occurred in the Izu islands. For the events of 2001, to handle a growing number of reported data, the magnitude threshold was set at 3.5 and the distance threshold was set at 10° for all agencies.

Apart from time lost to disruptions, editing the ISC nearly met its goal of requiring just 32 “experienced seismologist days” to analyse each month. Compared to 40 days per month required in the past, this is an improvement that is due to changes in the automatic processing implemented during 2001 and 2002, and use of the new selection criteria.



Contributors responded to the ISC's request for progressively more timely data. ISC's analysis paced its traditional schedule.

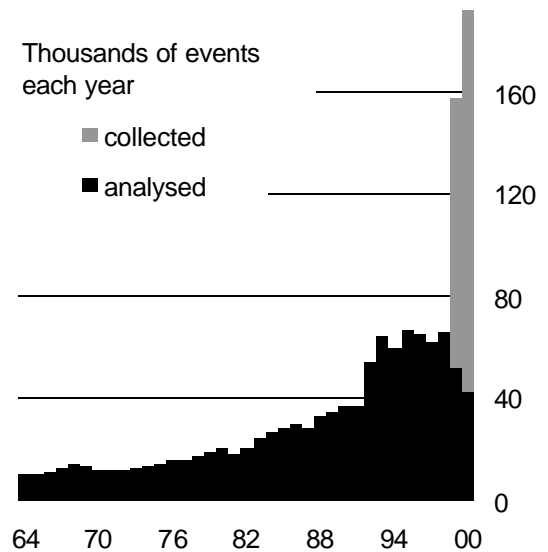
Production and Distribution

In 2002 the ISC distributed six bimonthly issues of the *Bulletin* averaging 210 pages per month. The two semi-annual issues of the *Regional Catalogue* for the events of 2000 each comprised about 760 pages. The time between despatching master copies and receiving products from the printer varied between 5 and 6 weeks. Print runs were held at 350 for the *Bulletin* and 200 for the *Catalogue*. The 2000 *Bulletin* and *Catalogue* CDs were distributed within a few weeks of completing analysis for the year.

Product	Issue	Distributed
Bulletin	Jan/Feb	31 Jan
	Mar/Apr	11 May
	May/June	10 Jun
	Jul/Aug	30 Aug
	Sep/Oct	10 Oct
	Nov/Dec	20 Dec
Catalogue	CD-ROM	26 Nov
	1999/B	04 Jan
	2000/A	01 Aug
	2000/B	03 Jan 2003
	CD-ROM	26 Nov

Data for all events, even those below the analysis thresholds, were included in the ISF and FFB files on the CDs. As shown at right, the number of events for which *Bulletin* data were available from the CD grew substantially even beyond the extraordinary increase for 1999. As for 1999, on the CDs for 2000 included the data in IASPEI Seismic Format (ISF) along with FFB and PDF formats. The CDs distributed in 2002 included a version of WizMapII, which the BGS modified to read and write ISF files, making it useful as a GUI for ISC data on the CD.

Distinct users of the ISC web site grew modestly to 2000-2600 per month during 2002, compared with 1900-2500 during 2001 and 1400-1900 per month during 2000. These users outnumber CDs distributed and vastly outnumber AutoDRM e-mails. Selections from the On-line *Bulletin* continue to be the most frequently used part of the ISC web site, and in 2002 such selections were made even more often than the ISC's home page was reloaded. The total volume of data downloaded grew to 11.3 GB in total during 2002, from 8.5 GB during 2001 and 8.1GB during 2000. The increase is due partly to the addition of graphics among the text data. The total number of selections of data from the database through the web site grew to 95,000 during 2002, compared with 26,000 in 2001 and 62,000 in 2000. The fluctuation reflects heavy usage by very few users, but demonstrates that the ISC can act as a reliable on-line database so that users need not download the entire set of data. Despite lack of resources to update the *Bibliography*, web site users searched the *Bibliography* 3600 times during 2002, compared with 2800 times during 2001 and 5800 times during 2000. No static information page about analysis or products at the ISC has ever been downloaded as often as 2000 times in a single year, and most have never been read more than a few hundred times. Fewer people read the on-line version of the quarterly newsletter, for example, than receive the printed newsletter.

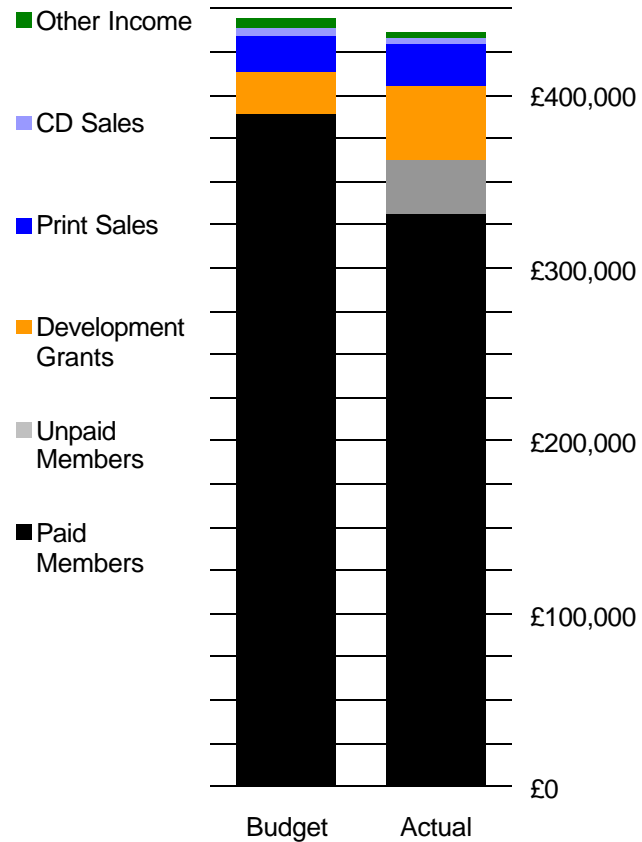


For the events of 2000, ISC data volume grew dramatically once again.

Income

Member contributions (black and grey) fell short of expectations in the budget from last year's report. The difference arose because the rate for exchanging US Dollars to British Pounds fell significantly over the course of the year. Member invoices are almost all in US Dollars and had a lower value when expressed in British Pounds at the end of year rate. In fact, expressed in British Pounds, actual contributions from institutional members fell 3.5% from 2002 to 2001 despite the increase in the unit rate of membership.

At year-end, only 9% of 2002 membership contribution invoices were unpaid (grey), which is less than half of the proportion unpaid at the end of 2001 and 2000. This improvement helped the Centre to avoid bank charges from using a line of credit despite the fall in income.

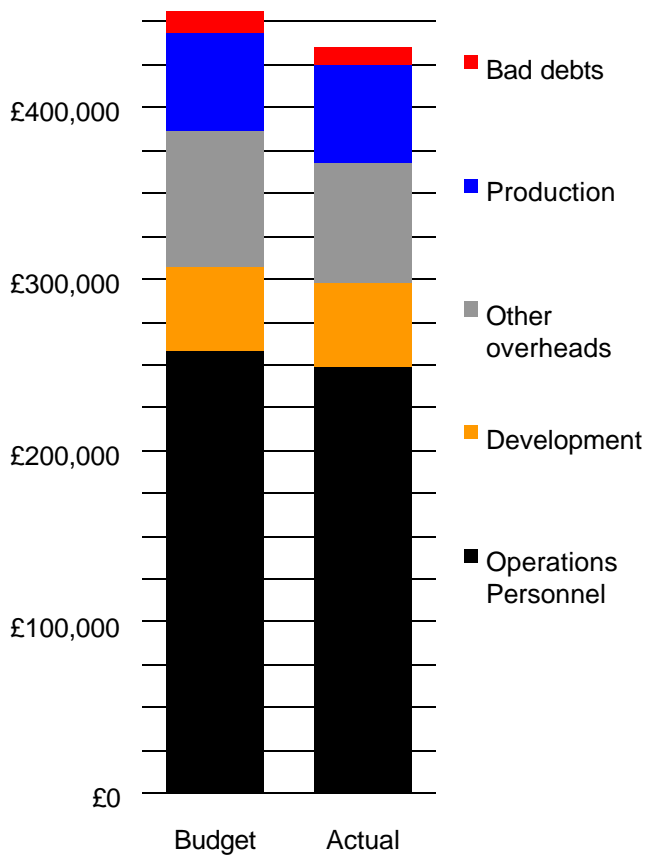


The expected support for development consisted principally of contributions from the UK Department of Trade and Industry and the US National Science Foundation. Additional support for development beyond the budget came out of the new grant from the US National Science Foundation. The expected and actual development support also include a small contribution to support ISC participation in the EPSI project, but as in every year since 1997 development support for the ISC continues to come almost exclusively from the United States and the United Kingdom.

Income from printed products (dark blue) and CD sales (light blue) were close to the budget. This departs from the outcome in recent years, when income from print sales fell short of expectations due to cancelled subscriptions and income from CD sales exceeded expectations thanks to selling a growing number of CDs. Print sales did not rebound; the budget was adjusted to reflect the smaller number of subscriptions, but CD sales did fall.

Other income (green) consists of interest on bank deposits, associate member contributions and sales of services. This income was less than expected because interest rates on many types of small business bank accounts in the UK have fallen to virtually nil.

Total income for the year fell only slightly short of expectations. Greater disappointment was avoided only because the effect of exchange rates on contributions from institutional members was counter-balanced by development support that was uncertain at the start of the year and so not included in the budget.



Expenditures

Personnel expenditures (black and orange) are comprised of salaries, pension contributions, recruiting and repatriation expenses. These costs were 3% less than budgeted because hiring and repatriation costs were less than expected and because salary rises were smaller and later in the year than budgeted. The ISC continues to follow UK academic salary scales as a guide. As in other recent years, the rise in these scales was close to consumer price inflation but short of the general rise of salaries in Britain.

Other overheads (grey) include costs for the ISC building, computing expenses, travel by the committee and staff, and costs of consumables. Expenses for the building were £6,000 less than budgeted thanks to a decrease in the interest rate on the mortgage. Committee travel cost £3,000 less than budgeted because some

committee members did not ask the ISC to reimburse expenses related to participating in the Executive Committee meeting at the ISC. Costs for staff travel, including participation by ISC seismologists in EGS and AGU annual meetings and the ESC bi-annual assembly, were in line with the budget. Costs for computing and consumables were very close to the budget.

Production costs (blue) are almost entirely to print and post the *Bulletin* and *Catalogue* of 2000 events, for which subscribers received invoices during 2002. These costs were almost exactly as expected. These costs were not significantly greater than during 2001 when they are expressed in UK Pounds, but only because the exchange rate for Thai Baht has fallen.

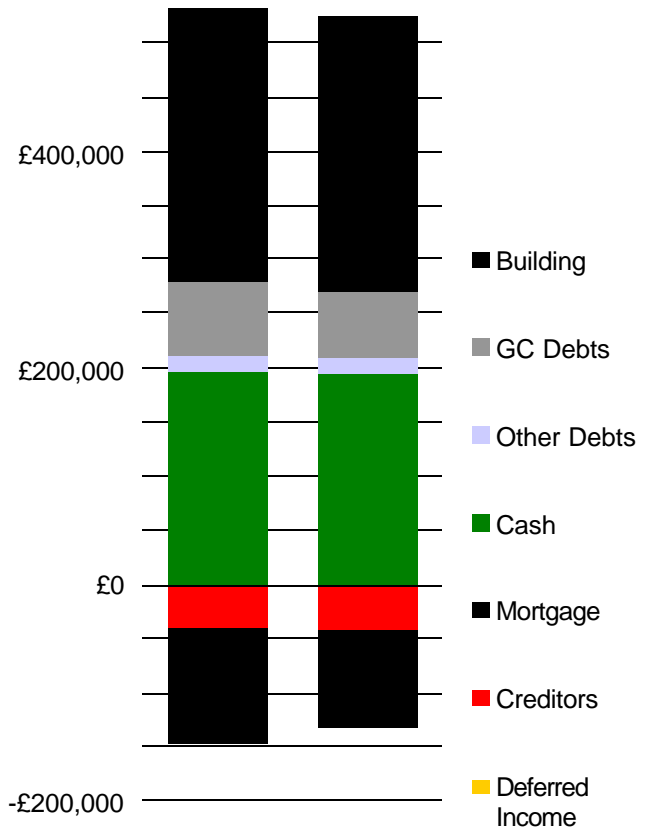
NRIAG (Cairo, Egypt) and KSU (Riyadh, Saudi Arabia) have each failed to pay their membership invoices for years 2000, 2001 and 2002. In conformance to past practice when institutional members do not pay for 3 consecutive years, these invoices were written off as bad debts (red). Thus the total of these invoices for three years appear as expenditures in the accounts for this year and they are removed from the ISC list of assets. Neither NRIAG nor KSU notified that they intend withdraw from the ISC, and this accounting action does not preclude either organisation from paying the invoices to re-activate its membership.

Operating costs are expenditures exclusive of bad debt provisions and special charges, of which there were none this year. Operating costs were 4% less than budgeted, primarily because lower than expected overhead costs, but also from smaller savings in personnel 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 bank balances required for the exchange rate and computer replacement funds. Net liquid assets decreased during 2002 from £157,000 to £154,000, reflecting a near balance of cash received and spent. Liquid assets are the cash required to operate while not drawing on reserves. Apart from balances of the reserved funds, at year-end unencumbered liquid assets stood at £75,000, which is sufficient to continue operations for less than 3 months.

Current debts owed to ISC (grey and blue) are mostly unpaid membership invoices. At year-end, CEPREDENAC (Central America) and INMG (Portugal) each owed ISC for 2 years of one-unit membership while SRC (Australia), NGRI (India) and MEMR (Jordan) each owed the ISC for one year. ISC has not received \$85,200 from the Russian Academy of Sciences for its 2001 and 2002 membership. Despite a large amount anticipated from the Russian Academy, debts owed to the ISC were less at the end of 2002 than in other recent years thanks to payment of other member invoices.



The net value of the ISC’s current assets is the sum of its liquid assets and current debts owed to the ISC, which are shown in colours other than black. Net current assets declined during 2002 from £239,000 to £230,000. The difference between the changes in liquid assets and current assets reflects the decline in debts owed by institutional members, which are not liquid assets because the ISC cannot convert them to cash on short notice. With these net current assets, the ISC could have continued operating without 2003 contributions for approximately six months, but only if the Russian Academy contributions for 2001 and 2002 were paid and the Executive Committee authorised use of funds that are normally reserved.

The net value of ISC’s tangible assets is the difference between the assets (above the “0” line) and liabilities (below the “0” line) shown in black. Net tangible assets increased from £147,000 to £164,000 due to a decline in the amount owed on the mortgage for the ISC’s building. The ISC paid 4% of the original principal, as set out in the terms of the loan. In addition, because the loan is denominated in US Dollars, the amount owed expressed in UK Pounds fell with the exchange rate. The ISC plans to continue paying down the mortgage, leading to long-term growth of net tangible assets. But in the short-term net tangible assets may grow quickly, slowly, or even temporarily decline if exchange rates fluctuate.

The net value of ISC’s total assets, which is the difference between all assets and liabilities, increased from £386,000 to £394,000 during 2001. This is well within British guidelines for charitable organisations, which suggest that net total assets should not normally be much more than twice the annual operating expenditures, or nearly £900,000 in the ISC’s case.

Excess Income and Reserves

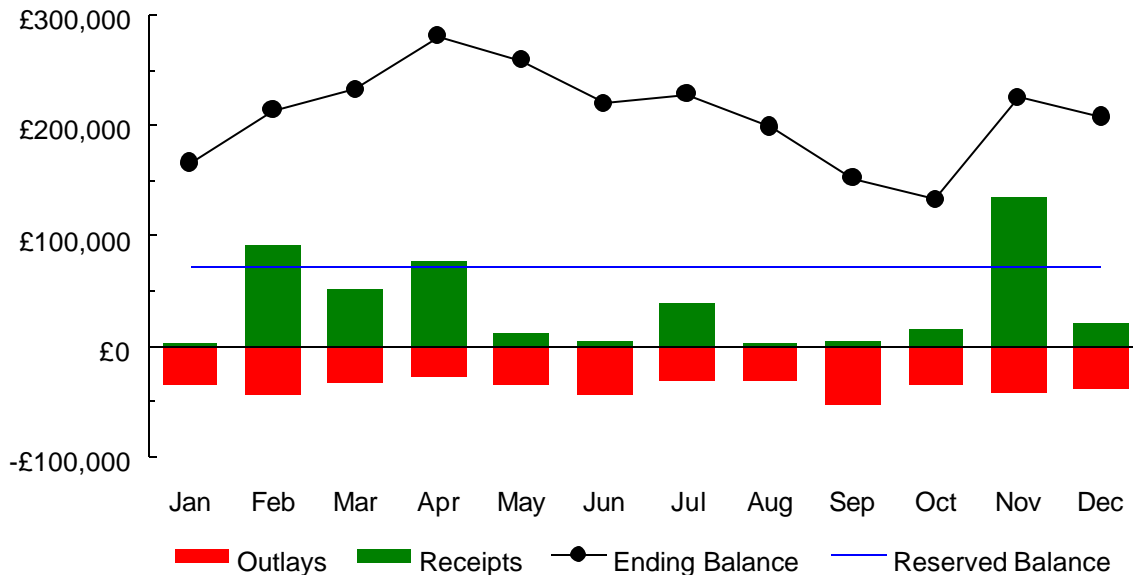
The ISC recognises income from capital-purchase grants only when purchases are made, so that grant income and grant-funded capital expenditures are exactly offsetting. In conformance with international accounting standards, such grants and purchases are not shown as income or expenditures, and the value of such capital equipment is not shown as an asset.

During 2002, interest of £700 earned on one of the ISC's bank accounts was attributed directly to the computer replacement fund rather than being treated as income. Consequently, the surplus income of £7,700 does not fully reflect the increase of £8,400 in total reserves.

As previously recommended by the Governing Council, the ISC transferred £5,000 from the general reserve to the computer replacement fund. Consequently, the increase of £2,700 in the general reserve is less than the surplus income of £7,700.

Cash Flow

The cash flow figure below shows receipts and outlays using dates when transactions were recorded at the bank, and bank balances with US Dollars converted to UK Pounds using the exchange rate as of 1 January 2003. Cash flow excludes credit extended to the ISC, debts owed to the ISC, and commitment of assets, such as the exchange rate and computer funds.



Receipts were large in February, March and April when the Royal Society and many other members contributed soon after receiving invoices. Receipts were large in November when the NSF and CSB made contributions, which included development support from the NSF. Modest fluctuations in expenditures resulted from various quarterly payments and payment of invoices to print the *Bulletin* and *Catalogue* at irregular intervals.

Since contributions were concentrated near the beginning and end of 2002, the unreserved sum of ISC bank balances fell by 70% from late April to early November. If it had not been for the contributions received in November, then to pay salaries and meet other obligations the ISC may have needed to draw on its £20,000 line of credit or to ask the Governing Council chairman for authorisation to use the exchange rate or computer replacement funds.

Computing Infrastructure

The ISC purchased a “firewall”, which comprises a Pentium-based computer with software for protecting other computers from Internet attacks. As a further precaution against increasingly frequent attacks, more secure web and e-mail server programs were installed and protocols for encrypting passwords exchanged between ISC computers were implemented. Further intrusions have been averted but to keep ISC computers secure it may be necessary soon to update the firewall configuration, to install a further independent firewall, and to run services for external users on dedicated computers that are outside of an inner firewall.

The ISC purchased a new line printer to print bar codes efficiently in listings of results from automatic processing and early passes of editing. The new printer was required for the new editing system and the purchase was partially subsidised by the grant supporting development of the new editing system. The old line printer was retained but its service contract was terminated. A service contract for the new printer will be advisable after its warranty period expires, but is expected to be cheaper than the cost of servicing the old line printer.

The ISC purchased a “Blade 100”, which is an inexpensive workstation in a new line of computers from Sun Microsystems. The new workstation allows the ISC to dedicate one of the Sun Ultra 1’s purchased in 1997 exclusively to servicing ISC web site users and provides a platform for testing ISC programs with newer versions of Sun’s operating system.

The University of Leeds purchased a further Sun Blade 100 installed at the ISC with funds from the NERC grant supporting development of an automated system to measure *SKS* splitting. This Blade 100 is used exclusively for development and provisional operation of the *SKS* splitting measurement system, but since it has full access to the ISC database and file servers it had to be configured at the ISC to maintain the security of other ISC computers.

Newly collected data and results from processing and analysis reduced free space in database files from 38% to 33%. A service contract for the Sun 250 that functions as ISC’s database and file server was extended. Inexpensive operating system upgrade contracts for Sun workstations were renewed. The contract with Rutherford-Appleton Laboratory for Internet service and a BT 64 kbit/s line and the Oracle 8 license were each renewed for one year with little change.

The new line printer, which cost the ISC £5,000, replaced the ISC’s last essential IT hardware from before the 1997-1999 modernisation programme. Otherwise, new computer hardware and software required purchases of only £3,400. Thus the ISC could commit £5,000 to the computer modernisation fund in addition to interest of £700 earned on the bank account for its computer and exchange rate funds. At the end of 2002 the computer fund balance was £48,100.

Computing Equipment at the ISC as of 1 January 2002

CPUs:

Sun 250 (1999); internal disks (1999, 2001).
2 Sun Ultra 1 (1997); 5 Sun Ultra 10 (1998).
2 Sun Blade 100 (2002, one to U. Leeds).
Desktop PCs (4 from 1998, 1 from 2001).
1 laptop PC (1999).

Peripherals:

High-speed line printer (2002).
Line printer (1990).
PostScript Printers: 2 Ethernet laser printers (1995, 1998); PC laser printer (1998);
Ethernet colour ink-jet printer (1998).
Scanner (1998) and CD writer for PC (1999).
Sun disk multipack and disks (1997, 1998, 1999); Sun DLT (1997) & DAT (1998) drives.

Proposals

Royal Society of London: In response to an enquiry with a list of specific questions, the ISC submitted a substantial report to the Royal Society in support of its review of the ISC, which is intended to determine the Society's level of support for the next several years. The review extended beyond the end of 2002 and in early 2003 the Royal Society made a contribution comparable to its support for the ISC in other recent years.

Software Development

Major Software Development Completed

Identification of Regional S: During 2002 the ISC completed modifications of the program used to compute hypocentres for the *Bulletin* so that *S* arrival times can be used. The specific change during 2002 was to stop mis-identifying *S* phases at local and regional distances from hypocentres in the lower crust. But this followed other changes that allowed use of additional travel time tables, use of multiple phases at a single station, different weighting of different phases, and extensive testing to demonstrate consistency with the original version of the program when only *P* arrival times are used. As a result of these changes, hypocentres in the *Bulletin* for small events with marginal station distributions are now much more well constrained if regional network operators report *S* arrival times to the ISC.

Digitally recorded editing: The project that was carried out jointly with the Computer Science Department at the University of Reading to modernise *Bulletin* editing was completed during 2002. The new system includes programs to print bar codes on listings of prior processing results, to record bar code scanning by seismologists editing the prior results, to translate the scanning records to edit command files similar to those now that are now keyed manually, and to generate reports of changes can be used readily during further editing. As a result of this development, from late 2002 editing commands by ISC seismologists were no longer manually keyed, which eliminates the risk of keying errors and saves staff time.

Merged data extraction: The programs used to write "FFB" files for ISC CDs, to write "ISF" files for the CDs, and to write data in "GSE2.0" or "ISF" for the On-line Bulletin were merged. A Perl version of the library of ISF routines distributed by the ISC was implemented and used in the merged program. This development was critical during 2002 because:

- All FFB files for the 1904-2000 *Catalogue* CD were re-written to incorporate data and corrections added to the database after publication of the *Bulletin*.
- ISF files for 1904-2000 were included on the *Catalogue* CD and tested with the program *WizMapII*, which was contributed by BGS this year.

As a result of this development the accuracy and consistency of data in the various formats and in the database has been re-checked and it will be more straightforward to assure that further types of data added in the future are written consistently to all formats.

Improved on-line services: Improvements to services available on-line include

- Association of readings contributed after the *Bulletin* is published with the prime hypocentre in the *Bulletin*. This allows users more readily to integrate data in their own analyses that were made available too late for use by the ISC.

- “Beach ball” images of focal mechanisms that were contributed to the ISC as moment tensors or fault plane solutions. This allows users to more readily compare focal mechanisms for different events or from different authors.
- Maps of epicentres that satisfy a user’s selection criteria, with an ability to zoom, pan and to show topography, magnitudes, and depths. This allows users to get an overall view quickly of the events that they have selected.
- Subscriptions to e-mail versions of the *Catalogue* and to selections from the *Bulletin*. Users send AutoDRM subscription messages to select the data that will be e-mailed to them when the ISC finishes analysis of each month.

Other Significant Computer-Related Projects

New location program: During 2002 the ISC started writing a new program to compute hypocentres and magnitudes. The new program is designed to be more well documented and commented and to be more easily modified and tested. Although intended in the first instance to replicate the behaviour of the program used in current operations, it is anticipated that the greatest benefit to the ISC from implementing a new program will come if the ISC changes to using a model that more accurately represents real travel times in the Earth.

Measurement of SKS splitting: The ISC started a joint programme with the University of Leeds to develop a program that automatically measures splitting of *S* waves, which results from anisotropy in the Earth. Measurements from programs operated by the University of Leeds for the duration of the programme will be inserted in the ISC database, just as any other contributed phase measurements are. But the system is being developed to work readily in the ISC computing environment so that the ISC might carry on making measurements after the Leeds programme concludes.

Improved station registry: Significant progress was made in improving the readily accessible documentation on station information, including opening and closing dates, re-surveys and re-locations. Inconsistencies had developed over several tens of years when station codes were re-used or alternative codes came to be used as primary codes for some stations. The ISC anticipates agreement with NEIC on the preferred code and the best available record of information updates during early 2003. Close co-ordination between ISC and NEIC is intended to prevent the development of new inconsistencies.

Personnel

Ms Esmeralda Banganan returned to the Philippines in January 2002, at the end of her appointment as a seismologist editing the *Bulletin*. Mr Mamy Andrianirina agreed to a brief further extension beyond October as a seismologist editing the *Bulletin*, and left the ISC in January 2003. Mr Tom Bayliss, a University of Reading employee working at the ISC to carry out most

of the development for the new *Bulletin* editing system, concluded work on his project in October and enrolled at the University of East Anglia, to study for a Ph.D. in seismology.

Working at ISC as of January 2002

Dr Raymond J Willemann, Director
 Dr Dmitry Storchak, Senior Seismologist
 Mrs Maureen Aspinwall, Fin & Admin Officer
 Mr James Harris, System & DB Administrator
 Mr Mamy Andrianirina, Seismologist
 Dr Nurcan Meral Özel, Seismologist
 Dr Peter Dawson, Applications Manager
 Dr Richard Lockett, Applications Developer
 Mr Cliff Allen, Data Preparation Assistant
 Mr Matthew Evans, Leeds Univ Associate

Dr Nurcan Meral Özel joined the ISC in August as a seismologist helping to edit the *Bulletin*. Dr Özel is on leave from the Kandilli Seismic Observatory and ERI, Bogazici University, Istanbul and plans to work at the ISC for two years. She started at Kandilli in 1984, earned her MSc there with a thesis on earthquake risk models, and gained extensive experience at Kandilli helping to prepare its seismic bulletin for all of Turkey. Dr Özel earned her PhD at the Univ. of Hokkaido with Prof. Hiroshi Okada. In collaboration with Takeo Moriya and Tsutomu Sasatani at Hokkaido, she used local and regional data to determine earthquake source mechanisms, and then to compute regional stress patterns. After returning to Turkey, Dr Özel joined in Kandilli Observatory's intensive work that followed major earthquakes in 1999 near Izmit and Düzce.

Mr Matthew Evans, a University of Leeds employee and Ph.D. student, started working at the ISC in July to develop the *SKS* splitting measurement system. While earning an MSc in geophysics at the University of Leeds, Mr Evans spent one year studying at U.C. Los Angeles, where he participated in the LARSE project, and one summer working at the ISC. During that summer at ISC, Mr Evans developed software to retrieve waveform segments at the expected times of phases from selected earthquakes, which is now planned to be part of the splitting measurement system. Mr Evans plans to work principally at the ISC for two years developing and operating this system, and to conclude his PhD in residence at Leeds during a third year when he will analyse selected splitting measurements to study anisotropy in the upper mantle.

Scientific Liaisons

ISC staff members analyse the *Bulletin* in order to plan or evaluate improvements to the *Bulletin*, and to help users take full advantage of ISC data. Analyses of broad interest are presented in conferences or seminars, and sometimes published in journals. The status of papers by ISC staff that were published in or submitted to journals during 2002 is tabulated at right.

During 2002 ISC staff made 8 presentations with published abstracts at conferences of the European Seismological Commission, the European Geophysical Society, and the American Geophysical Union. We attended seminars at the University of Oxford, and participated in London meetings of the Royal Society, the Royal Astronomical Society, and the Society of Earthquake and Civil Engineering Dynamics. We participated in the final two meetings of EPSI, a project to develop an integrated European bulletin. ISC staff members continue subscriptions to *Nature*, the *Journal of Geophysical Research*, *Geophysical Journal International*, the *Bulletin of the Seismological Society of America* and *Seismological Research Letters*.

Peer-Reviewed Publications by ISC Staff

R J Willemann (2003). Evaluating the fit of alternative hypocentres to arrival times, *Bull. Seis. Soc. Amer.*, 93, 519-525.

2002 Visitors to ISC

James Anderson, U. Reading
 Robert Blandford, U.S. Air Force
 David Bowers, AWE Blacknest
 Chris Browitt, Brit. Geol. Survey
 Fan Changqing, Shanghai Seis. Bur.
 Paul Denton, Univ. Leicester
 Adam Dziewonski, Harvard Univ.
 Paul Earle, U.S. Geol. Survey
 E. Robert Engdahl, Univ. Colorado
 Huo Enjie, Shanghai Seismol. Bur.
 Gary Gibson, Seis Res Corp, Adelaide
 Michael Kendall, U. Leeds
 Keith McLaughlin, Ctr. Monitoring Res.
 Avi Shapira, Geophys. Inst. Israel
 Paul Naylor, Teaching Co. Direc.
 Oleg Starovoit, Russian Acad. Sci.
 William Walter, Law.-Liv. Nat. Lab.
 John Woodhouse, Univ. Oxford
 Cedric Wright, Univ. Witwatersrand
 Akio Yoshida, Japan Met. Agcy.
 John Young, AWE Blacknest
 Zhu Yuanqing, Shanghai Seismol. Bur.

Citations of ISC Data in 2002

Users often do not inform the ISC when they publish research that uses of ISC data. Unfortunately, therefore, the list below of papers using ISC data is incomplete.

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Status of 2002 Plans

The table at right, derived from the 2001 Director's report, shows that the ISC carried out nearly all of its plans for 2002. One new editor was hired and an alternative editing system was implemented. The *Catalogue* CD has files that include recently contributed data and a Graphical User Interface to manipulate them. Agencies that contributed data during 2001 continued, including the IDC. On the Internet, the ISC provides additional data, some data graphics, and alternative access. Upgrades to computing infrastructure went beyond plans and data processing was improved in several ways. Spending matched income and we made progress in securing Royal Society funding.

JAN 2002 STATUS	PLANS FOR 2002	JAN 2003 STATUS
<i>Data Analysis</i>		
• One month ahead	• Edit 13 months	✗ • Edits trail collection
• 2 editors continuing	• Replace one editor	✓ • 2 editors continuing
• Edits require data entry	• Implement an alternative	✓ • New system in use
<i>Data Exchange</i>		
• CD <i>Catalogue</i> original	• Re-write from database	✓ • New data on new CD
• CDs lack GUI	• Use BGS's WizMapII	✓ • WizMapII on new CD
• REB to 2001 Dec	• Encourage further release	✓ • REB to 2002 Dec
• Gaps in some regions	• Encourage contributions	✗ • Most gaps continue
<i>Internet Data Services</i>		
• No on-line data graphics	• Add beach balls	✓ • Maps also on-line
• No e-subscriptions	• AutoDRM subscriptions	✓ • Few subscrips taken
• Late reads not in events	• Assoc process improved	✓ • All reads associated
<i>Computing</i>		
• Parts of LAN slow	• Upgrade UPS & LAN	✓ • No network problems.
• Hypocentres on <i>P</i> only	• Implement use of <i>S</i>	✓ • Local <i>S</i> times helpful
• Poor hypos mis-group	• Assoc using all hypos	✓ • Poor hypos excluded
• Use JB travel times	• Start new program	✓ • Program nearly done
<i>Finances</i>		
• Surplus from 1997-2000	• Spend current income	✓ • General reserve stable
• RS plans review	• Respond to RS enquiry	✓ • RS decision pending
• US, UK support dev	• Seek other sources	✗ • US, UK support dev

We had hoped to achieve all of these goals, but we were frustrated in some cases:

Edit 13 months: Disruption encountered in the course of improving the ISC's software delayed analysis by several weeks. The rate of editing expected in the near future declined because of expansion in data collection starting from 2001 and because, in practice, the new editing system has somewhat increased the time required to analyse each month.

Secure further data contributions: Attempts to convince network operators to resume lapsed data contributions were mostly fruitless even when they make some of their data freely available on the Internet. Some operators are reluctant to contribute an imperfect catalogue and others regard contributions for the ISC as a burden for which they are not rewarded.

Development support apart from the US and UK: To support further development, the ISC invited several Governing Council members to discuss in-kind or cash contributions or a secondment at any level. Only one member of the Governing Council from outside of the US and UK responded to the request, and even in that case a no contribution could be secured.

Plans for Data Collection

Collection of data from print publications has ceased. The ISC no longer employs a data entry clerk, who formerly divided time between keying data from a few printed bulletins and keying edits by ISC seismologists. A few agencies continue contribute data only in print, and the ISC periodically encourages them to make electronic contributions.

The ISC continues attempting to fill gaps among contributors of complete regional bulletins from several seismically active areas in South America, the Middle East, and central Asia. Collecting data from special studies, such as hypocentres from temporary aftershock networks or arrival times from tomography experiments is planned to continue. The ISC continues to remind non-contributors that we would be pleased to archive their data, to delay re-distribution if necessary, and to include their data in the *Bulletin*.

The ISC's database can be extended readily to accommodate further types of data, and the ISC remains prepared to accept further data types, such as parameters of rupture extent or directivity and phase measurements that might relate to earth properties that depart from linear, isotropic elasticity. The ISC has not implemented database structures for relative event locations or relative arrival times, but seeks contribution of such data sets with permission to re-distribute them.

We plan to consult with the Governing Council about the possibility of collecting *SKS* measurements by continuing to measure *SKS* splitting at the ISC after the joint project with the University of Leeds is concluded. This would mark a significantly more pro-active approach to collecting parametric data, since to date the ISC has relied upon network operators and other agencies to make measurements from waveform data.

Plans for Data Processing

The most important part of data processing development will be to complete development of the ISC's new program for computing hypocentres and magnitudes. The initial version of this program, with the ISC's existing algorithm, travel times and attenuation models, will be publicly released. We plan to present results from tests alternative travel time models to the Governing Council in 2003, after which further development might be concentrated on implementing efficient use and extensive evaluation of results through late 2003 and 2004.

We plan to consult with the Governing Council about using the new program to compute hypocentres based on results from automatic association. This would allow us to include ISC hypocentres in the preliminary *Bulletin*, even though they would be less reliable than those from ISC's final analysis, and could be a step towards more interactive analysis.

Otherwise, we plan to improve automatic identification of regional *S* phases and to continue grouping hypocentres, identifying duplicate phase readings and associating the readings with hypocentres as they are received. Developer time continues to be required for incrementally improving grouping and association when seismologists editing the *Bulletin* realise that they make the same type of edits many times each month.

Plans for Data Analysis

The ISC plans to analyse 13 months of events during each of the next few years, which will move the ISC's final analysis progressively closer to the time of the events. Dr Nurcan Meral Özel, who joined the ISC in mid-2002, is one of only two seismologists who planned to continue editing at the ISC beyond early 2003. Despite raising the thresholds for analysis to $M=3.5$ and $D=10^\circ$, two seismologists experienced in editing the *Bulletin* are proving to be sufficient to review automatic processing of only 12 months of data each year.

To overcome this insufficiency and prepare for the possibility that Dr Özel may return to Kandilli in 2004 July at the end of her initial employment contract, a new seismologist will be recruited to join the editors in late 2003 or early 2004. The resulting period of several months during which 3 seismologists would be editing the *Bulletin* should advance ISC's analysis to meet its target of producing a progressively timelier *Bulletin*.

Further development of the editing system is planned no sooner than after the CD of 2001 events is produced. This further development is yet to be planned in detail, but could involve generating an image, such as a map of stations with associated arrivals, that would be used occasionally to resolve a particular difficulty in computing a reliable hypocenter.

Plans for Data Distribution

As a result of the Governing Council's decision to advance the data collection schedule, we plan to distribute the 2001 *Bulletin* and *Catalogue* CDs in October 2003 and the 2002 CDs in September 2004. The CDs are planned to include the data in ISF files, FFB files, and PDF documents, although we plan to compress the FFB files. As in 2002, further CDs are planned include files in ISF. We plan to re-write files for *Catalogue* CD each year to include data added to the ISC database after publication of the *Bulletin*.

The CDs are planned to continue including the ISF version of the BGS's "Wizmap II", which is a graphical user interface that runs under Microsoft Windows to interactively display maps and other graphical representations of an earthquake catalogue and to select subsets of events from a catalogue for further analysis.

By mid-2003 we plan to supplement AutoDRM e-mail subscriptions to selections from the *Bulletin* with the complete set of data for each month from an anonymous ftp server with a fast Internet connection. We plan to improve our facility for user-defined requests for waveforms during 2003. Our previous plan to offer on-line re-computation of hypocentres may be deferred if the Governing Council agrees that the ISC should, instead, focus on computing hypocentres for the *Bulletin* using more modern travel times.

We plan not to print the *Catalogue* for events of 2001 at least until after consulting with the Governing Council in July 2003. We plan to publish the printed *Bulletin* for events of 2001 in the same format as for other recent years, but to consult with the Governing Council in July 2003 about the format of the printed *Bulletin* for events from 2002 onward.

Plans for Computing Infrastructure

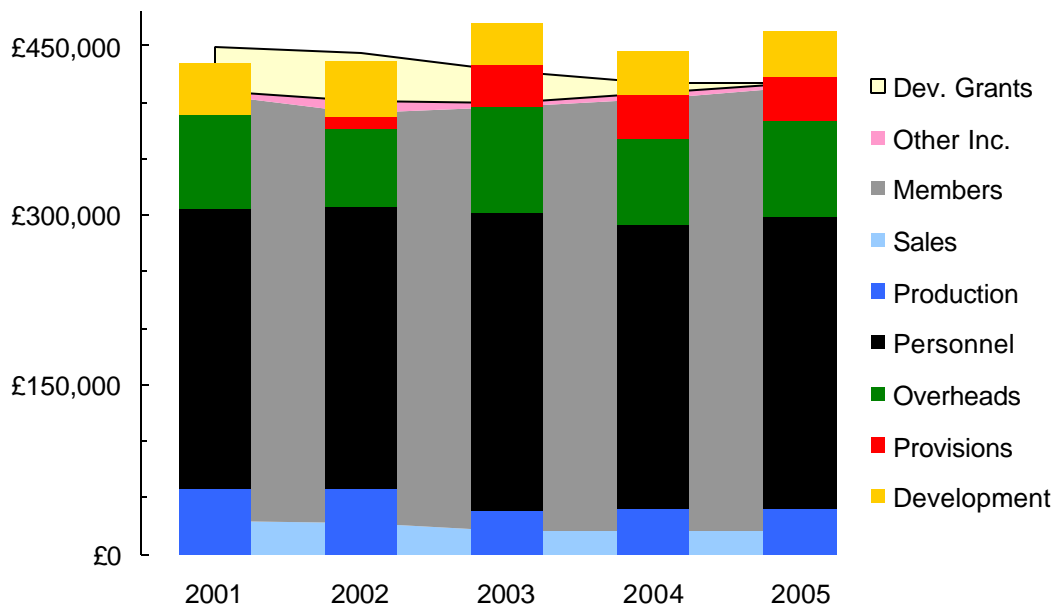
The load on the ISC database server grows as processing is rewritten to update the database directly and as late collection of data creates a desire to re-write data files annually for the *Catalogue CD*. The load will grow further as more processing is done that way, as new types of processing are undertaken, and if manual analysis changes to directly update the database.

The ISC's database server is a Sun 250 in which the hardware has already been upgraded as much as possible. During 2003 a new Pentium-based file server will be installed, removing that load from the Sun 250. A consultant will advise us on configuring our Oracle 8 software to optimise speed in executing those database operations that we run most frequently and we will develop software to maximise use of the database server during off-peak hours.

Nevertheless, it will become difficult to operate without a more capable server. In addition, a truly on-line editing system would probably require large-format displays and more capable workstations to maintain efficiency. Replacing the database server and purchasing interactive analysis stations would be a large task, comparable to the 1997-1999 modernisation programme, and require a comparable level of support from the ISC's institutional members.

Plans for Finances

The budget projection figure below illustrates the ISC's income and expenditures over the last two years and projected for this year and the next two years. The projections are based on the membership rates agreed by the Governing Council in 2001. Details of planned expenditures are given in the appendix.



Apart from development grants, income grows as the result of annual indexing of member contributions, modified by fluctuations in exchange rates. The actual and projected increases of member contributions are less than the agreed rate of increase in the unit membership rate because some members fail to increase their contributions and withdrawals occur as often as new members join. While ISC staff members continue seeking opportunities for sales of commercial services, other income remains very small compared with member contributions.

The Executive Committee's provisional decision to stop the printed *Catalogue* results in a small decrease in income from sales and a larger decrease in production costs from 2003 onward. The projected budget does not include the effect of speculation that the Governing Council might authorise a reduction in the size of the printed *Bulletin*, which could result in lower production costs from 2004 onward, with little decrease in income from sales.

In past years, budgeted costs have included a £12,000 provision for outstanding invoices to lapsed institutional members. This provision has been increased from 2003 onward to reflect the risk that the Russian Academy of Sciences might not pay its invoice for 2001 membership even in 2003, its 2002 membership even in 2004, and its 2003 membership even in 2005. Even these provisions do not include the full effect that withdrawal of the Russian Academy would have on the ISC, which would significantly decrease in income in 2004 and 2005.

Costs have been cut for 2003 by reducing the size of the operational staff at the start of the year and by not starting further development of editing tools following the successful conclusion of the initial project. Nevertheless, personnel costs are larger than they would be otherwise due to the cost in replacing the director. Overhead costs for 2003 are large due to the cost of committee and staff travel to Sapporo for the IUGG meeting. Estimated personnel costs for 2004 and 2005 include the cost of replacing a seismologist in 2004 and salary rises, which are based on inflation indexing of university salary scales plus step increases for employees hired recently. Overhead costs are lower in 2004 when the Executive Committee plans to meet at the ISC, but higher in 2005 as a result of travel to Santiago, Chile for the Governing Council meeting in conjunction with the IASPEI Assembly. Overhead costs include minor refurbishments of the ISC building each year. Refurbishment can be deferred in any particular year, but will accumulate to a significant burden if postponed repeatedly.

If additional development support is not secured then the ISC may need to eliminate its sole remaining development position. Development could be sustained temporarily by spending part of the cumulative excess income during 1997 to 2002, but only if the delayed contributions from the Russian Academy and several single unit members are received. Apart from a small amount of funding from the European Commission, all of the ISC's recent and projected development support has come from the US and the UK. It is unsurprising that the Royal Society and NSF hope that other institutional members will help support further development.

In 2003 the ISC will see a further critical development in regard to finances because the Royal Society has not yet announced results from its review of the ISC. Royal Society funding of ISC operations is second only to NSF's, and staff members at the ISC and the Society communicate regularly about the status of the planned review.

ISC Development Support

NSF (US): Made a separate grant during 2000-2002 to support an extra staff member for nearly 2 years to make more data available from ISC.

NSF (US): Operations grant for 2002-2006 includes support for the first two years for an extra developer to write a stand-alone location program and implement related services.

EC (Europe): Funded ISC participation in the EPSI project during 2000-2002 to develop an integrated European-wide bulletin.

DTI (UK): Funded 60% of University of Reading costs during 2001-2002 to develop an interactive Bulletin editing system for the ISC. The Royal Society (UK) paid 20% of 2001 costs.

BGS (UK): During 2002 developed an ISF-compatible version of WizmapII, and allowed distribution of the new version on ISC CDs.

NERC (UK): Funded University of Leeds and some ISC costs during 2002-2004 to implement routine measurement of shear wave splitting.

NERC (UK): The University of Oxford and the ISC may yet jointly propose to develop new location methods.