

## Introduction

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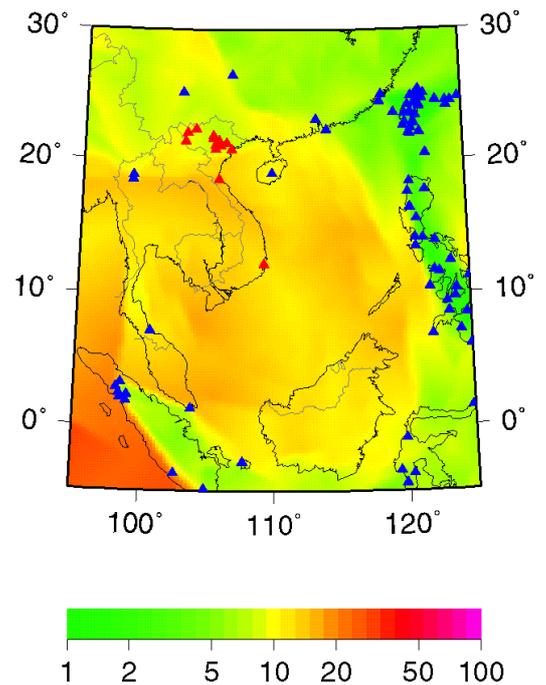
### *A Year of Fulfilled Promises*

Most issues of the Bulletin published this year were within two years of the events and, as suggested by Governing Council, analysis began to advance ahead of the schedule followed in the past. For the first time ever, the annual Bulletin CD was distributed less than two years after the events occurred and it included all contributed data, even for events that were not re-analysed at the ISC. Planned software development was carried out, so that automatic grouping of reported hypocentres, identification of duplicate phase readings, and association of phase readings with events are now all done soon after data are collected. As a result, the ISC now offers a preliminary version of the On-line Bulletin that is updated whenever further data are contributed. Thanks to additional development, data collected after the Bulletin is published can now be fully integrated into the ISC database, while retaining the ability efficiently to recover the state of database at the time that the Bulletin was published. Thus, users of the On-line Bulletin now have a choice between selecting from the “Published Bulletin”, which matches the data on the CD, or the “Comprehensive Bulletin”, which incorporates corrections and further data.

The report “Role of the ISC in the 21<sup>st</sup> Century” written in 1995 envisaged two roles for the ISC, as a data centre and as an analysis centre. The promises fulfilled this year this year relate principally to the ISC as a data centre. While continuing to improve data collection and distribution, the ISC is now preparing to improve itself as an analysis centre. One important aspect of this improvement is writing a new program for the existing hypocentre location algorithm used by the ISC, but with modular design so that it can be readily adapted to alternative travel time models and data formats. This work could be the basis for starting to use *S* arrival times in computing hypocentres for the Bulletin, and later on for adopting a modern travel time model. Another aspect of improving analysis at the ISC is a project in co-operation with the University of Leeds to retrieve broadband waveform data and automatically measure new types of arrival parameters that can be included in the Bulletin. By both updating conventional elements of a seismic bulletin and introducing new elements, the ISC can ensure that its products and services continue to serve the needs of seismologists whose research advances our understanding of earthquakes and earth structure.

## Data Collection

During 2001 the ISC received data for the first time from networks operated from Hanoi (Vietnam), King Abdulaziz City (Saudi Arabia), Kingston (Jamaica), Mayaguez (Puerto Rico) Safat (Kuwait), and Vilnius (Lithuania). Asmara (Eritrea) and Quito (Ecuador) resumed data contributions, each after a hiatus of more than a year. Damascus (Syria), Riyadh (Saudi Arabia) and Tirana (Albania) began contributing data as e-mail rather than in print, which eliminates the need to re-key the data at the ISC and ensures that none of the data fail to be included for lack of resources. Amman (Jordan), Chateau-le-Bruyeres (France), Rome (Italy) and Santiago (Chile) substantially improved their contributions by changing to a format (GSE2.0 or Nordic) that includes association of phases with hypocentres and additional phase measurements such as amplitude and period. Teleseismic phase readings were already received from NEIC for stations in Libya and Malaysia, but the start of data contributions directly from Ghar and Selangoe ensures that the arrivals can be used in the Bulletin even if they are not available before NEIC's quicker deadline. Direct contributions from network operators keep the ISC abreast of changes and sometimes lead to further data contributions, such as regional arrivals and locally determined hypocentres.

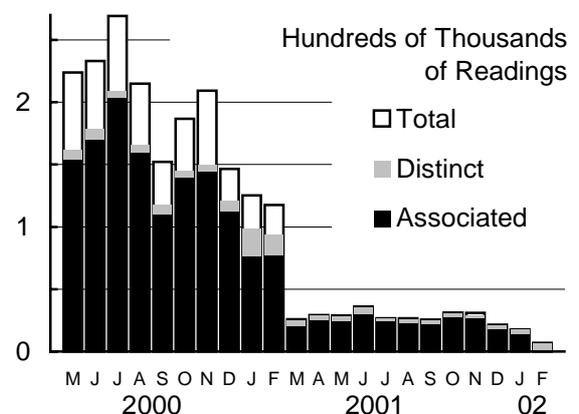


Stations in Vietnam (red triangles) partially filled a gap among stations that were already currently reporting to the ISC (blue triangles). Shading shows the distance (in degrees) to which an event must be recorded for a 2<sup>nd</sup> azimuthal gap less than 180° among those other stations.

We continued inserting data directly to the relational database, which enables us to avoid data collection thresholds. Most of the parsers were improved to provide specific information on deviations from expected formats, which improves the efficiency of ISC staff managing contributions. We contributed to the development of IASPEI Seismic Format (ISF) and distributed software for writing ISF Bulletins to encourage standardised contributions.

## Automatic Processing

In 2001 the ISC began processing data soon after they were collected, rather than just before analysis as in the past. When a hypocentre is inserted, "grouping" is started to look for hypocentres that are so closely spaced that they are probably different estimates for the same event. Phase arrivals are so numerous that they are processed only periodically. Currently "association" of phase arrivals with ISC events is run on one month each night. There are about 20 months for which the ISC has not yet started its final analysis, so arrivals from each month are re-associated approximately once every 3 weeks.



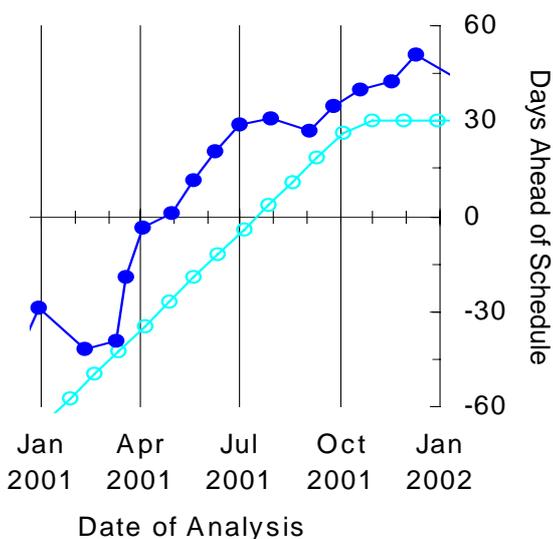
Phase readings in the ISC database on 26 February 2002, for months when results from ISC's automatic processing had not yet been reviewed by seismologists.

**Bulletin Editing**

Following winter holidays, ISC’s three experienced seismologists resumed their progress in advancing publication, which was on time by the end the first quarter and reached the limit possible within the data contribution schedule by mid-year. In July the Governing Council decided to advance the schedule, which allowed us to bring release of the Bulletin even closer to the time of events. Through the remainder of the year contributors were able to meet the ISC’s new schedule so the Bulletin suffered no reduction in completeness. Fourteen months of data were edited during 2001.

We selected events of 1999 for analysis based exclusively on reported magnitudes. We used thresholds that varied from place to place to minimise the number of events that were re-analysed at the ISC despite being recorded by only one network. Even with carefully selected thresholds, this simple selection criterion led us to analyse many very small events in order to be as sure as possible of analysing all significant events.

Based on our experience this year, we established a goal to require just 32 “seismologist days” to analyse each month next year, compared with the expectation until recently that as many as 40 days are required. The improvement is due to greater accuracy of the automatic processing before manual analysis and a new scheme to review fewer of the events that are detected by just one network.



*Through 2001 analysis stayed ahead of a target that is based on the number and experience of seismologists editing the Bulletin. The 2001 target assumed that a fully experienced editor would require 40 days to edit a typical month.*

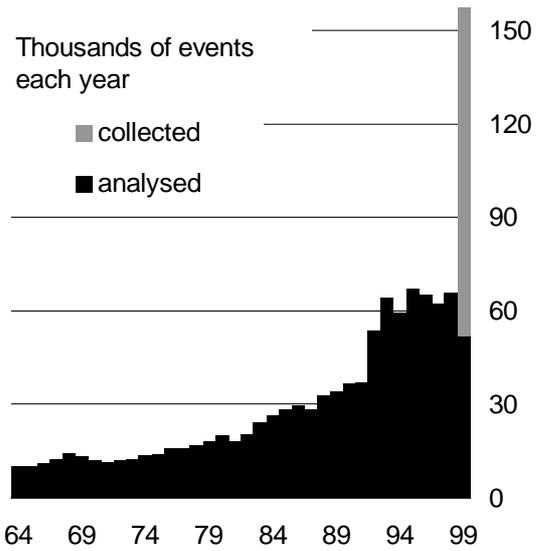
**Production and Distribution**

In 2001 the ISC distributed eight bimonthly issues of the Bulletin averaging 175 pages per month and produced three semi-annual issues of the Catalogue averaging 631 pages per half year. The time between despatching master copies and receiving product from the printer varied between 5 and 6 weeks. Print runs were held at 350 for the Bulletin, but reduced from 250 to 200 for the 1999 Catalogue. Fewer printed Catalogues are required now that the ISC offers data contributors a choice of either the Catalogue CD or the printed Catalogue.

Product	Issue	Distributed
98 Bulletin	Sep/Oct	08 Jan
	Nov/Dec	08 Feb
	CD-ROM	30 Jan
99 Bulletin	Jan/Feb	20 Apr
	Mar/Apr	14 May
	May/Jun	25 Jul
	Jul/Aug	11 Sep
	Sep/Oct	12 Oct
	Nov/Dec	18 Dec
	CD-ROM	30 Nov
Catalogue	1998/B	21 Feb
	1999/A	31 Oct
	1999/B	04 Jan 2002
	CD-ROM	30 Nov

The 1998 and 1999 Bulletin CDs were each distributed within a few weeks of completing analysis for the year. The 1998 Bulletin CD included Fixed-Format Bulletin files for the

current year, Fixed Format Catalogue files for earlier years, and PDF files of the long version of the typeset current year Bulletin, averaging 416 pages per month. On the 1999 CD the data were included in IASPEI Seismic Format (ISF) along with FFB and PDF formats. Data for events below the analysis threshold were included in the ISF and FFB files. As shown at right, this dramatically increased the number of events for which Bulletin data were available from the CD, even as the average size of the long-version PDF Bulletin was cut to 373 pages per month. The Catalogue for past years no longer fit on the Bulletin CD, so purchasers were offered the Bulletin and Catalogue CDs together as a set.



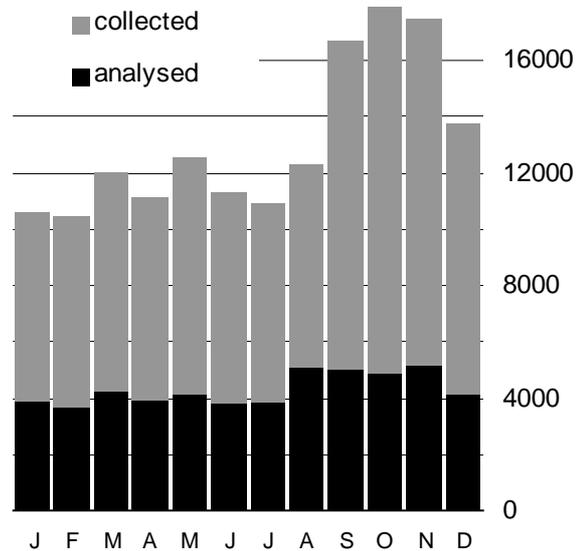
The volume of data re-distributed by the ISC increased dramatically for events of 1999 thanks to flexible data management.

Setting aside a few very heavy users, the number of retrievals from the On-line Bulletin during 2001 grew by 41% compared with 2000, to an average of 1875 per month. More than 60% of retrievals were for hypocentre data alone, often for just prime hypocentres. It is unsurprising that geographic and magnitude ranges were the selection criteria used most often. But 31% of selections were for events with number of defining phases in a specified range and 20% were for events with a magnitude computed by a specified agency. This degree of sophistication would be typical of seismologists rather than the general public. Indeed, 10% of retrievals were for arrivals by station code and time interval, without regard to events.

### 1999 Seismicity

Large, destructive earthquakes of 1999 during August and November in Turkey and during September in Taiwan were each followed for several weeks by many reported aftershocks. Before the ISC began its own analysis, research on the main shocks and their aftershocks had been undertaken that included very precise relative locations of the events in each sequence. While adding little to such research, in earlier years ISC's analysis of such large sequences could have slowed its progress unless *ad hoc* collection thresholds were used, as was done for the Umbria-Marche (Italy) 1997 sequence. But with the analysis thresholds used from 1999 onward, there was no delay of the Bulletin due to the Taiwan sequence and the effect was small even from the aftershocks in Turkey, where the ISC used a more permissive threshold.

Number of events each month of 1999

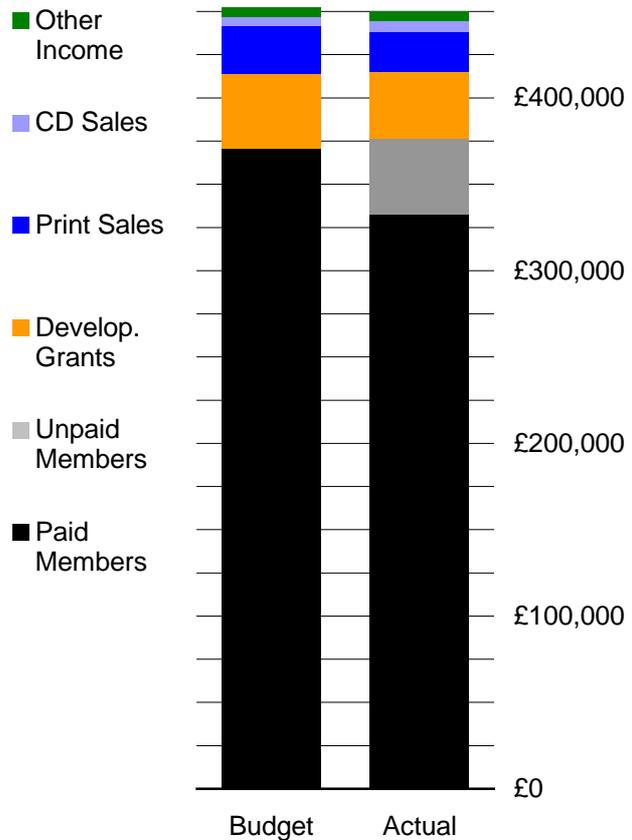


Variability in the number of analysed events from different months of 1999 is less than variability in the number of events collected because most aftershocks in well-recorded sequences fall below the analysis threshold.

*Income*

Member contributions (black and grey) slightly exceeded expectations in the budget from last year's report. This is principally because of exchange rate changes; member invoices, which are almost all in US Dollars, had a slightly higher value when expressed in British Pounds at the end of year rate.

At year-end, 18% of 2001 membership contribution invoices were unpaid (grey). This is an increase on last year, which was in turn an increase on the year before. Members of the ISC staff continue to work with members of the Governing Council to arrange for payment from organisations whose 2001 contributions have been delayed. No unpaid 2001 contributions were written off because eventual payment is anticipated in all cases. Nevertheless, the delays may require the Centre to pay bank charges maintaining and using a line of credit.

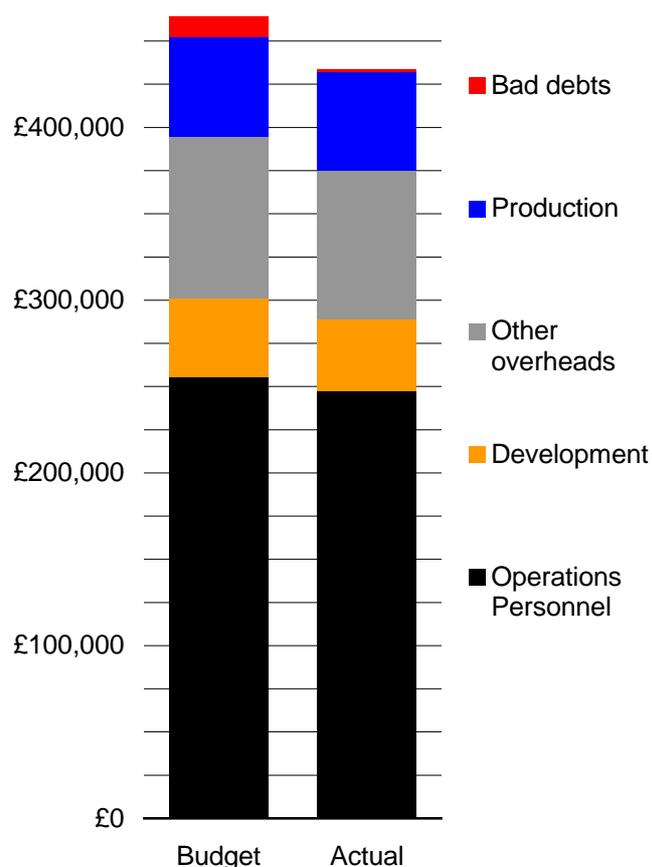


The large majority of development support (orange) was an award under an existing grant from the US National Science Foundation to support the integration of further data into the ISC database. In addition, the ISC received its final award from the European Commission's EPSI project, which is led by EMSC. The Royal Society paid half of the ISC's share of costs for a joint development project with computer scientists at the University of Reading, but total income for development was slightly less than anticipated because no other member came forward in response to a request for help in this regard.

Income from printed products (dark blue) fell short of expectations, principally because of cancelled subscriptions to the Bulletin. Income from CD sales (light blue) was in line with expectations, although this is a substantial decrease from earlier years. The decrease is due to fewer purchases of back issues of the CD, and it might be anticipated that most organisations likely to purchase a complete set have now done so.

Other income (green) consists principally of interest on bank deposits, with minor amounts from associate member contributions and sales of services. The total of this income matched expectations, but less of it came from associate members and sales of services than in previous years.

Total income for the year very nearly matched expectations, although this resulted from counter-balancing departures from the budget in contributions from institutional members and sales of printed products.



*Expenditures*

Personnel expenditures (black and orange) are comprised of salaries, pension contributions, recruiting and repatriation expenses. These costs were 3% less than expected, which occurred principally because recruitment of a seismologist was postponed. In addition, the inflation rise in the UK academic salary scales was partly delayed until late in the year.

Other overheads (grey) include building expenses, computing expenses, travel by the committee and staff, and exchange rate gains or losses. Building expenses include both maintenance and mortgage payments, which were less than the amount budgeted because part of a planned refurbishment was postponed. Computing expenses include service contracts, supply purchases, and training. Most computing costs were in line with planned spending, but more

was spent upgrading the ISC’s database and file server than originally planned. Staff travel costs include participation by ISC seismologists in EGS and AGU annual meetings and the IASPEI bi-annual assembly, and were in line with the budget. Committee travel costs were substantially less than budgeted because two members of the committee were unable to travel to Hanoi and other members arranged to share costs with other organisations. Exchange rate gains and losses are not budgeted and were nearly offsetting because the ISC mortgage debt in US Dollars is comparable to the balance in its US Dollar bank accounts.

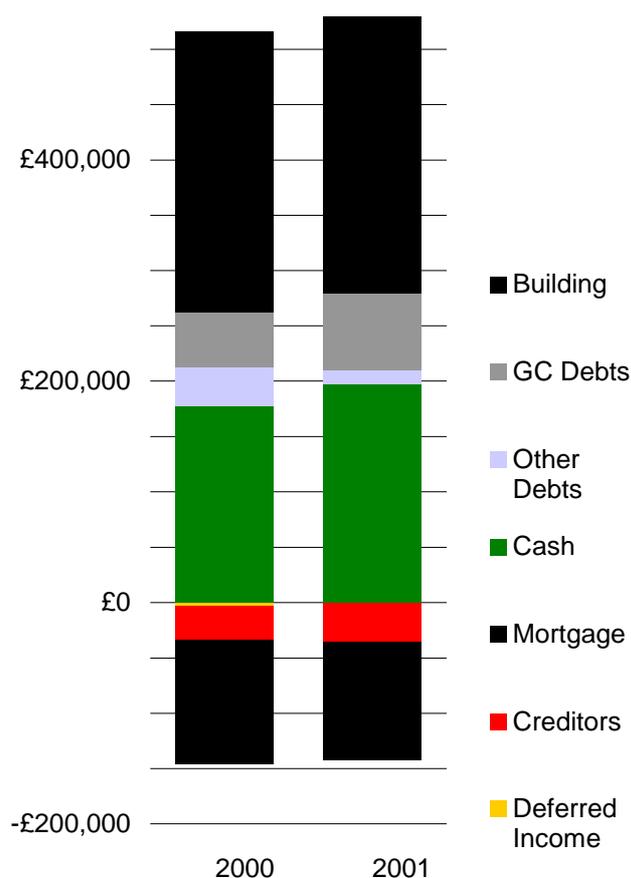
Production costs (blue) are almost entirely for printing and distributing the Bulletin and Catalogue of 1999 events, for which subscribers received invoices during 2001. These costs were almost exactly as expected, which is significantly less than they were during for 2000 because we produced only two issues of the Catalogue and because events below threshold for re-analysis at the ISC were excluded from printed products.

Unpaid contributions that are not likely 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 were minimal because it was necessary to write off only one unit of a contribution for 1999.

Operating costs are expenditures exclusive of bad debt provisions and special charges, of which there were none this year. Operating costs were 4.2% less than budgeted, primarily due to delayed personnel spending and savings on committee travel.

**Assets**

The net value of the ISC’s liquid assets is the difference between cash and creditors, shown in green, red and yellow at the right. This includes bank balances required for the exchange rate stabilisation and computer replacement funds. The net liquid assets of the Centre increased during 2000 from £143,000 to £157,000, thanks to receipt of both the 2000 and 2001 awards from an NSF development grant. Liquid assets provide the ISC with the cash required to operate without drawing on committed reserves. Lateness of some member contributions limits the ISC’s liquidity. Setting aside the balance of the exchange rate stabilisation and computer replacement funds, at year-end the ISC’s unencumbered liquid assets stood at £84,000, which is sufficient to continue operations for three months.



Current debts owed to the ISC (grey and blue) are mostly unpaid membership invoices. At year-end, the largest outstanding debts were the 2001 RAS (Russia), INSU (France) and INGV (Italy) contributions. Contributions for both 2000 and 2001 were still expected from Argentina, Egypt, and Saudi Arabia. The net value of the ISC’s current assets is the sum of its liquid assets and current debts, shown in colours other than black. Net current assets grew during 2000 from £229,000 to £239,000, principally because some spending during 2001 was postponed to 2002. With these net current assets, the ISC could continue to operate without 2002 contributions for approximately seven months, but only if all contributions due last year were paid and the Executive Committee authorised use of funds that are normally reserved.

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. The increase in net tangible assets from £142,000 to £147,000 resulted from paying 4% of the original principal of the mortgage on the ISC’s building, as set out in the terms of the loan. The decrease in the amount still owed appears to be slightly less than 4% of the original amount because the loan is in US Dollars, which appreciated with respect to the British Pound during 2001. The ISC plans to continue paying down the mortgage, leading to long term growth of net tangible assets. But because the building and the mortgage are in different currencies, in the short term net tangible assets may grow quickly, slowly, or even temporarily decline if exchange rates fluctuate.

The ISC’s net total assets, which is the difference between all assets and liabilities, increased from £371,000 to £386,000 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*

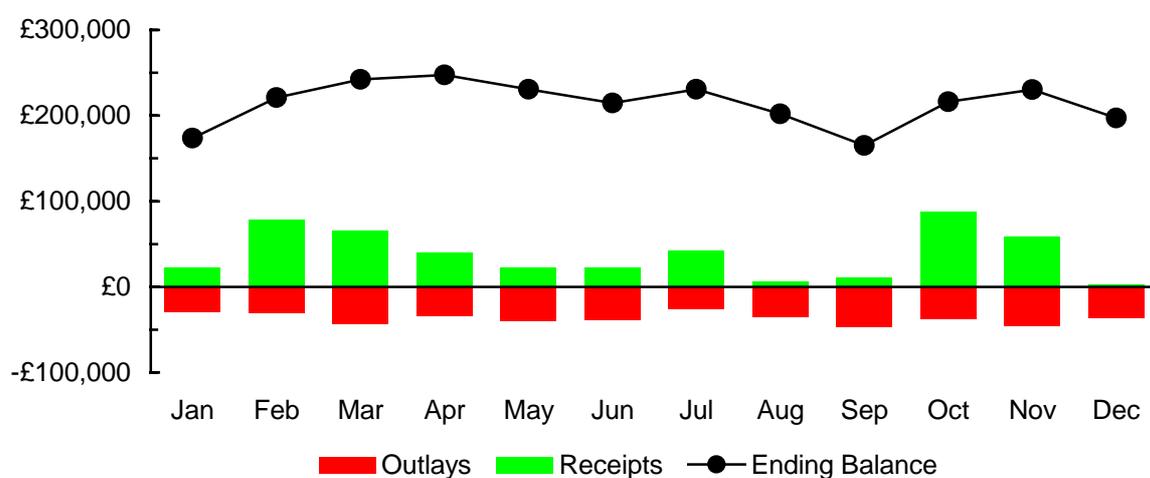
The ISC recognises income from capital-purchase grants only when purchases are made, so that grant income and grant-funded capital expenditures are exactly offsetting. In conformance with international accounting standards, such grants and purchases are not shown as income or expenditures, and the value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

During 2001, interest of £1300 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 £14,000 does not fully reflect the increase of £15,000 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 £9,000 in the general reserve is less than the surplus income of £14,000.

### *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 British Pounds using the exchange rate as of 1 January 2002. Cash flow does not show credit extended to the ISC, debts owed to the ISC, or commitment of assets, such as the exchange rate and computer replacement funds.



Receipts were large in February when the Royal Society made its annual contribution, and in March when other members made contributions quickly after receiving invoices and NSF made a payment on a development grant. Receipts were large in October – November when the NSF and CSB made their annual contributions and NSF made a further payment on the development grant. Modest fluctuations in expenditures resulted from quarterly mortgage payments and payment of invoices to print the Bulletin and Catalogue at irregular intervals.

During 2001 ISC bank balances never fell to a level that suggests the ISC might need to use short-term credit. Nevertheless, the net value of the ISC's land and building were available as collateral for a £20,000 line of credit at Lloyds Bank.

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## Proposals

*US National Science Foundation (NSF):* The NSF 2001 subvention was the last award from the NSF grant that began in 1998 so the ISC submitted a proposal in June requesting a grant for four further years. For 2002 we requested funding equivalent to 60 times the 2002 unit membership rate, which equals approximately 22% of estimated expenditures for operations. For 2003 – 2005 we requested funding for 22% of expenditures for operations, estimated with realistic allowances for inflation including 4% annual rises in personnel costs. In addition, we requested 100% support for one extra seismologist/developer at the ISC during the first two years of the grant. The extra person is to modernise the ISC's hypocentre location program (retaining all existing capabilities) and implement a service for ISC web site users to re-compute hypocentres using alternative travel times or subsets of ISC data. The NSF decided in December to fund the full amount requested.

*UK Natural Environment Research Council (NERC):* The University of Leeds submitted a proposal to NERC in May to develop a system to automatically measure *SKS* splitting, with the objective of collecting enough measurements to test the hypothesis that splitting is caused by a single layer of homogeneous anisotropy. The ISC is named in the proposal as a collaborator, with the roles of carrying out measurements after the automated system is developed and of making the measurements readily available. In order to ensure that the automated system works well with other elements of ISC processing, a University of Leeds researcher will work primarily at the ISC rather than at Leeds. NERC decided in November to fund the project at nearly the full amount requested, including partial support for ISC staff members working with the Leeds researcher.

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## Computing Infrastructure

We purchased 1.5 Gbytes of RAM for our Sun 250 database server, which is now fitted with its full capacity of 2.0 Gbytes of RAM. We purchased two new 18 Gbyte disks for the Sun 250, which is now fitted with its full capacity of 6 internal disks, as well as 6 disks in the multipack purchased in 1997 with the ISC's first Sun workstation. We re-organised files used by our Oracle data management system to take full advantage of the new disks. We may need more disk space in 2003, when we could purchase an external disk system. We replaced the PC for administration and finance to take advantage of new business applications that link databases with word processors and spreadsheets. We kept the old PC, which may be re-configured for other use. Apart from the operating system and business applications purchased with the new PC, we purchased no new software during 2001.

### ISC Computing Equipment as of 1 January 2002

#### CPUs:

- Sun 250 (1999) and internal disks (1999, 2001). Sun service contract.
- 2 Sun Ultra 1's (1997) and 5 Sun Ultra 10's (1998), no service contract.
- Desktop PCs (4 from 1998, 1 from 2001), no service contract.
- 1 laptop PC (1999), no service contract.

#### Peripherals:

- Line printer (1990), Compaq service contract.
- 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) and Sun DLT (1997) and DAT (1998) drives, Sun service contract.

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The service contract for the Sun 250 was retained, which would enable the ISC to resume analysis, automatic processing and Internet data services quickly in the event that this server failed. Service contracts for the workstations were not renewed; inexpensive contracts for operating system upgrades were purchased instead. The contract with Rutherford-Appleton Laboratory for Internet service and a British Telephone 64 kbit/s leased-line was renewed for one year at a rate comparable to that for the past year. The ISC's Oracle 8 license was extended with little change. The most expensive service contract is that for the line printer purchased on 1990, but this printer remains essential for analysis and requires regular service.

As a result of investment during 1997-1999, the ISC's limited needs for new computer hardware and software during 2001 required purchases of only £3,000. Consequently the ISC was able to commit £5,000 to the computer modernisation fund in addition to interest of £1,300 earned on the bank account for the computer modernisation and exchange rate stabilisation funds. At the end of 2001 the balance in the computer fund was £42,400.

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## *Software Development*

### Major Software Development Completed

*Automatically Process Data in the Database:* During 2001 ISC staff wrote separate programs to update the state of the ISC's principal database based on

- grouping of hypocentres that appear to be independently reported estimates for the origin time and location of a single event,
- identification of duplicate reports of a single reading of phase arrivals and selection of one from any set of identical reports for use in analysis,
- association of readings of phase arrivals with events.

Each of these tasks formerly was part of the processing by a single program that required us first to copy the data to a Working Tape Format (WTF) file. There are several advantages to the ISC from writing these new programs:

- The ISC's web and AutoDRM servers provide the most recent results in the database, which are now up to date soon after the data are inserted.
- Results from new programs are better since they are based partly on information that is not accommodated in WTF, such as the agency from which data are received and associations of readings with hypocentres in contributed reports.
- Individual processing steps can be updated with less risk of unintended changes, since the software is modular and each element can be separately tested.

*Extend the Database Schema:* New database tables were created and the data selection program was modified to give users a choice between the "Published Bulletin", which exactly matches the data on the CD, and the "Comprehensive Bulletin", which may be updated at any time. For those months not yet reviewed by ISC seismologists, the Comprehensive Bulletin consists of all data contributed up to the moment that a query is made and results from periodic reprocessing. For those months already reviewed at the ISC, the Comprehensive Bulletin includes the Published Bulletin, but also corrections made after publication and data contributed to the ISC too late to be included in the ISC's normal review.

The extended schema is optimised for selecting from the Comprehensive Bulletin. That is, the most complete and up to date version of information is retrieved simply by selecting from

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the main tables. But each row of the main tables that is inserted or modified after final review by ISC seismologists is specially tagged and, for the modified rows only, the values at the time that the Bulletin was published are stored in supplementary tables. If a user requests the Published Bulletin and a tagged row is selected then the selection program automatically queries the supplementary tables for the values at the time of publication.

*Recover Unassociated Readings:* All of the phase readings that were unassociated in WTF files from the final pass of analysis for 1964 January to 1998 December were read and inserted in the database. Previously, the database had been populated from the Fixed-Format Bulletin (FFB) files distributed on the CDs. Since the FFB files include only events and associated phase readings, the readings that ISC seismologists had been unable to associate with any known event were previously inaccessible. The newly inserted phase readings are available to users of both the ISC web site and AutoDRM e-mail service who select arrivals by time interval and station code. With the completion of this project, all of the data held by the ISC in electronic form are now available from its web and AutoDRM e-mail servers.

### Other Significant Computer-Related Projects

*Implement new algorithm to select events for analysis:* Events from 2000 January are selected for analysis based on reported magnitudes, distances to stations reported to record the event, the number of independently computed hypocentres, and the number of agencies that independently associate phase arrivals. If any of these parameters suggests that an event is likely to be detected by more than one seismic network then ISC seismologists review the results from automatic processing. With several ways to identify events that require review, it is no longer necessary to use a reported magnitude threshold less than 3 in some regions, which avoids unnecessary analysis and thereby reduces the total number of events reviewed.

*Integrate the EHB Catalogue:* The new hypocentres and phase identifications by Engdahl, van der Hilst and Buland for events and arrivals from the ISC Bulletin were received and some of them were inserted in alternate tables in the ISC database. Inserting all of them in the principal tables was deferred until early 2002 while extension of the database schema to track post-publication updates was fully implemented and tested.

*Write and distribute an ISF function library:* In order to encourage widespread use of IASPEI Seismic Format (ISF), the ISC developed a suite of functions that can be used in programs that read or write ISF files. For each distinct type of line that may appear in an ISF file, the library includes a function that reads from or writes to a buffer. For maximum flexibility, actual I/O of the buffers is left to developers writing programs that use the library. Each function returns a status code, enabling developers to write robust programs that can handle unexpected data values for output or minor departures from ISF in input files. The library was implemented in both Fortran and C, was included on the CDs distributed in late 2001, and is available from the ISC anonymous ftp server.

*Eliminate manual keying of editing commands:* The project that is run jointly with the Computer Science Department at the University of Reading to modernise Bulletin editing made important advances during 2001. The system includes programs to print bar codes on listings of prior processing results, to record bar code scanning by seismologists editing the prior results, and to translate the scanning records to edit command files similar to those now that are now keyed manually. An initial version of each program was complete at the end of 2001, although essential capabilities remained to be added to some. When the programs are tested together, of course, we may find that some of them need to be modified.

*Implement program closequakes:* Sometimes even events widely separated in space are “close” in the sense of sharing many phase arrivals that could almost equally-well fit the expected arrival time from either event. During 2001 we implemented a program to identify events that are close to each other in this sense, which helps analysis to be done more quickly and simultaneously reduces the risk of failing to recognise misassociations and split events.

*Correct times of arrivals following leap seconds:* Phase times from the end of ISC monthly data files are deliberately mis-stated if they follow a leap second and are associated with an event before the leap second. In this way, travel time can be computed without accounting for leap seconds. Within the ISC database these times were corrected to UTC, and the ISC’s database functions to compute time differences were modified to account for leap seconds.

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### Personnel

There were no personnel changes at the ISC during 2001. Esmeralda Banganan planned to return to the Philippines at the end of her appointment in January 2002, while Mamy Andrianirina agreed to a further one year an extension at the ISC, through 2002 November. Raymond Willemann agreed to a new four-year contract as Director, through 2004 December.

#### ISC Staff as of 1 January 2001

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  
 Ms Esmeralda Banganan, Seismologist  
 Dr Peter Dawson, Applications Manager  
 Dr Richard Luckett, Applications Developer  
 Mr Cliff Allen, Data Preparation Assistant  
 Mr Tom Bayliss, TCS Associate

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### 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 peer-reviewed journals. The status of papers by ISC staff that were published in or submitted to journals during 2001 is tabulated at right.

#### Peer-Reviewed Publications by ISC Staff

R J Willemann and D A Storchak (2001). Data collection at the ISC, *Seis. Res. Lett.* 72, 440-453.  
 Q-f Chen and R J Willemann (2001). Global test of seismic event locations using 3-D Earth models, *Bull. Seis. Soc. Amer.*, 91, 1704-1716.  
 R J Willemann (2002). Evaluating the fit of alternative hypocentres to arrival times, *Bull. Seis. Soc. Amer.* (submitted).

During 2001 ISC staff made 8 presentations with published abstracts at conferences of the European Geophysical Society, IASPEI, and the American Geophysical Union. We participated in a CTBT calibration workshop and a discussion meeting on the future of the EMSC. We visited AWE Blacknest, attended seminars at the University of Oxford, and participated regularly in London meetings of the Royal Society, the Royal Astronomical Society, and the Society of Earthquake and Civil Engineering Dynamics.

We participated in two regular meetings of EPSI, a project co-ordinated by the EMSC 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.

#### 2001 Visitors to ISC

James Anderson, U. Reading  
 Chris Browitt, BGS  
 Matthew Evans, U. Leeds  
 Rachel McCrindle, U. Reading  
 Paul Naylor, Teaching Co. Direc.  
 Omar Perez, Venezuela  
 Graham Sutton  
 John Woodhouse, Oxford U.

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**Citations of ISC Data in 2000**

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 Earlier Plans

The table at right, derived from the 2000 Director's report, shows that the ISC carried out nearly all of its plans for 2001. One more month was edited than planned and an experienced editor was retained. REB data were made available to the ISC and IASPEI endorsed a new data exchange standard. CDs, Bulletins and Catalogues were despatched promptly. We inserted the remainder of our computer readable data in our database and started to process and post new contributions promptly, making all data held by the ISC available from our web and AutoDRM e-mail servers. Improvements of computing infrastructure were completed without interrupting operations, and our own software development improved results from processing. Spending matched income and further funding was secured.

JAN 2001 STATUS	PLANS FOR 2001	JAN 2002 STATUS
<i>Data Analysis</i>		
• One month behind	• Edit 13 months	✓ • One month ahead
• 3 full-time editors	• Extend one editor	✓ • 2 editors continuing
• Edits require data entry	• Implement an alternative	✗ • Still being developed
<i>Data Exchange</i>		
• ISF draft ready	• Propose to IASPEI	✓ • ISF adopted
• REB to 2000 Feb	• Encourage Vienna release	✓ • REB data used by ISC
• 1998 CD not yet avail.	• Despatch '98 & '99 CDs	✓ • Preparing 2000 CDs
<i>Internet Data Services</i>		
• Some ISC data unavailable	• Rescue unassoc. readings	✓ • All readings on-line
	• Post sub-threshold events	✓ • All events on-line
• Data avail. after anal.	• Post prelim. Bulletin	✓ • Prelim. results on-line
• EHB data not avail.	• Integrate EHB Bulletin	✗ • EHB hypo. on-line
<i>Computing</i>		
• Admin constrained	• Replace admin comp.	✓ • Integrated office apps.
• DB server limited	• More disk & memory	✓ • Server good for now
• Hypocentres on <i>P</i> only	• Prepare to use <i>S</i> / <i>PKP</i>	✗ • Further work needed
<i>Finances</i>		
• Surplus from 1997-2000	• Spend current income	✓ • General reserve stable
• NSF & RS plan review	• Propose to NSF	✓ • NSF grant to 2006
• 1 yr. develop. funding	• Seek further	✓ • NSF, NERC projects

We set ambitious goals and made substantial progress towards each of them, but fell short of completion in a few cases:

*Implement an Alternative Editing System:* This development did not proceed as quickly as hoped and even in December initial use in operations appeared to be several months away. After we start using the system operationally further work through most of 2002 may be required to achieve the efficiency that we hope for.

*Integrate the EHB Bulletin:* Integration of the EHB hypocentres and phase identifications was postponed while we completed implementation of a system to track database changes after publication of the Bulletin. The system was in place by the end of the year and EHB hypocentres were inserted and grouped in 2002 January, but we do not expect EHB phase identifications to be available from the ISC web site for a few months yet.

*Use *S* and *PKP* Times to Compute Hypocentres:* Review during 2001 of preliminary work showed that use of *PKP* times was problematic because of questions about identifying the branch of the travel time curve and that use of regional *S* times would degrade depths of crustal earthquakes unless phase identification were improved first.

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### *Plans for Data Collection*

The CTBTO “Working Group B” recommended contribution of the Reviewed Event Bulletin (REB) to the ISC at its 2002 February meeting. The REB from the prototype IDC provided the ISC with preliminary hypocentres in sparsely monitored regions and teleseismic  $P$  amplitudes sufficient to significantly improve the ISC  $m_b$  completeness threshold. Thus, users of the ISC Bulletin will benefit from collection of the REB by the ISC.

Africa, South America, and Central Asia are not sufficiently well represented in the Bulletin, and we continue seeking further contributions for those regions. We hope that during 2001 contributions will resume from Arequipa (Peru) and begin from K-NET (Kyrgyzstan). We anticipate improved completeness in the Pacific Ocean thanks to epicentres computed from hydroacoustic arrivals by NOAA’s Pacific Marine Environment Laboratory (PMEL). We hope to collect bulletins for Reykjavik (Iceland) and Uppsala (Sweden) regional networks.

We continue working to arrange for contributions by e-mail rather than in print. During 2001 we hope that Strasbourg (France) and others will improve the completeness of their e-mails. Thanks to widespread use of SeisAn, many new contributors send data in Nordic format. Standardisation reduces the risk of mis-interpretation and the effort maintaining parsers, so we are working with authors of widely used programs to add ISF to the I/O options.

Now that we can update our database after publishing the Bulletin, we plan to insert data retrospectively. For example PMEL epicentres extend back to mid-1996, and contributions from K-NET and Reykjavik will likely include data for earlier years. Thus, data from temporary deployments, which often are held closely until after ISC’s final analysis, can be inserted in the ISC database and distributed as part of the Comprehensive Bulletin.

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### *Plans for Data Processing*

We plan to continue grouping hypocentres, identifying duplicate phase readings and associating the readings with hypocentres as they are received. Developer time will be set aside for maintenance of the grouping and association programs, which entails incrementally improving them when seismologists editing the Bulletin realise that they make the same type of changes in grouping or association many times each month.

We have started to “deprecate” hypocentres far from the network used to compute them. Deprecated data are retained but, to avoid particular problems, they can be excluded from routine processing. For example, badly mislocated hypocentres result in split events unless very large differences are allowed among hypocentres in a group, but then hypocentres can form groups with opposite ends so far apart that they clearly represent distinct events. We plan to deprecate more of the poorly constrained hypocentres after deciding how to retain information about association of arrivals with events somewhere in the region.

An important part of data processing development will be writing a new program to compute hypocentres with the ISC’s existing algorithm. Flexibility that we intend to design into this program will offer a wide variety potential uses, including an on-line service to re-compute absolute or relative locations, computing the ISC’s own hypocentres for the preliminary bulletin, and interactively testing hypotheses while editing the Bulletin. The core program probably will be complete in early 2003, and uses for it would be developed after that.

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### *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. Mr Andrianirina is contracted and legally permitted to work in the UK through November 2002, while Ms Banganan returned to the Philippines in January 2002. No new seismologist was hired before Ms Banganan's departure because the number of events requiring review and the number of changes required in review are few enough for two seismologists experienced in editing the Bulletin edit to maintain the target pace of analysis. To prepare for Mr Andrianirina's departure, however, in February 2002 the ISC started seeking a new seismologist to help edit the Bulletin from July. We anticipate completing analysis of the events of 2000 by the end of September, which is one month earlier in the year than we completed analysis of 1999.

By the middle of 2002 we hope to be using a replacement for the editing system now used by ISC seismologists. The replacement is being developed by Mr Bayliss, who is a University of Reading employee contracted to work at the ISC in close co-operation with ISC staff. Initially the principal benefit from the new system will be freeing Mr Allen, the ISC's data preparation assistant, to take a greater role in parsing data from electronically contributed reports. The project with the University of Reading is planned to run through November 2002; after the new system starts to be used in operations and in consultation with the seismologists using it, Mr Bayliss plans to modify it the system to improve efficiency.

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### *Plans for Data Distribution*

As a result of the Governing Council's decision to advance the data collection schedule, we plan to distribute the 2000 Bulletin and Catalogue CDs in November 2002 and the 2001 CDs in October 2003. The CDs are planned to include the data in ISF files, FFB files, and PDF documents, although we plan to compress the FFB files. The CDs distributed in 2002 will be the first with the complete set of hypocentres in ISF. We plan for Catalogue CDs distributed each year to include data added to the ISC database after publication of the Bulletin.

The CDs are planned to include a version of "Wizmap II" from the British Geological Survey (BGS). Wizmap II 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. The version developed by BGS for distribution by the ISC will be modified to read and write ISF.

From the outset of 2002 the Comprehensive Bulletin is available from the ISC web site and AutoDRM servers. Over the course of 2002 we plan to add graphics such as "beach balls" of focal mechanisms and more links to data from other sites. We plan to offer AutoDRM e-mail subscriptions to the Bulletin by mid-2002. We hope to improve our facility for user-defined requests for waveform data by mid-2003, and to offer re-computation of hypocentres based on travel times and subsets of ISC arrival times that are both specified by users by late 2003.

We plan to publish the printed Catalogue for events of 2000, but to consult with the Executive Committee in June 2002 about publishing the printed Catalogue for events from 2001 onward. We plan to publish the printed Bulletin for events of 2000 and 2001, but to consult with the Governing Council in August 2003 about publishing the printed Bulletin for events from 2002 onward.

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### *Plans for Computing Infrastructure*

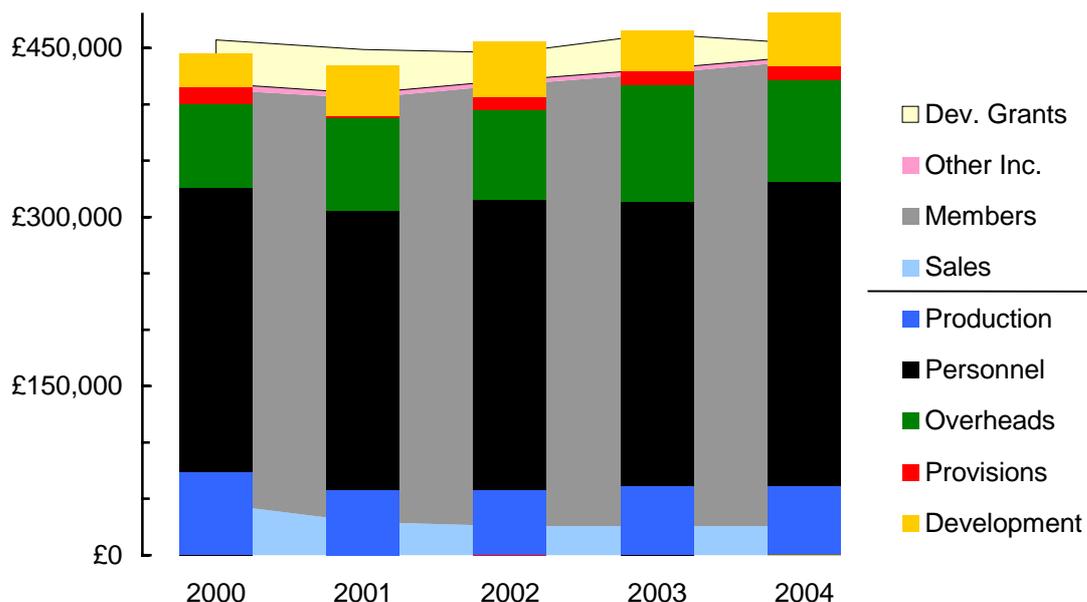
During 2002 we plan minor investment in computing infrastructure, to include installing bar code scanners on seismologists' work stations, upgrading to 100 Mbit/s that part of the ISC LAN running at 10 Mbit/s, purchasing an additional Sun work station to test ISC applications under the latest version of Sun's operating system, installing an additional UPS to further improve reliability of the ISC's data services on the Internet, and replacing an obsolete PC, a malfunctioning scanner, and a marginally functional Sun monitor. We also plan to install an additional Sun workstation purchased by the University of Leeds for our joint project.

The load on the ISC database server has grown as automatic processing is rewritten to update the state of the database. The load will continue growing as more of the ISC's traditional processing is done this way, as projects to add new types of processing are undertaken, and as manual analysis by ISC seismologists is eventually changed to directly update the database. The database server has already been upgraded as much as possible, and it is likely that a more capability will be required by about 2004. In addition, a truly on-line editing system would probably require large-format displays to maintain the efficiency of ISC seismologists, which might in turn require more capable workstations. Although funds to replace computers are set aside each year, the ISC would require additional support from its institutional members to both replace its database server and purchase interactive analysis stations.

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### *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. The projections are based on the membership rates agreed by the Governing Council in 2001 and write-offs estimated at £12,000 annually. 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.

Expenditure grows principally as the result of salary rises, which are based on inflation indexing of university salary scales plus step increases for employees hired recently. Indexing has been 3% or more in each recent year, which is less than salary rises in the UK generally, and much less than 6% rises agreed for many UK public sector employees lately. Full employment and shortages of qualified candidates continue in Britain, and the ISC is unlikely to attract or retain good employees without salary rises. It is unrealistic to foresee ISC performance continuing to meet expectations if income in support of operations rises at a lower rate than the prevailing rate of salary rises in Britain.

A small shortfall of income is projected for 2002, which could be reduced if several institutional members made small one-off contributions to complement other development support. Equal income and expenditures are projected for 2003, after development of bar-code editing is completed and while the NSF grant includes 12 full months of support for an extra staff member for development. A shortfall of income is projected for 2004, when the ISC may need to reduce the size of the development staff unless additional development support is secured. Development could also be sustained by spending part of the cumulative excess income during 1997 to 2001, but only if the present volume of delayed contributions is reduced. 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, and it is unsurprising that NSF and the Royal Society now hope that other ISC institutional members will contribute to development. Even while we continue seeking grants for development projects, it is important that funding for operations does not decline in real terms.

### ISC Development Support

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

NSF (US): Grant for 2002–2006 includes support for the first two years for an extra developer to write a stand-alone location program and implement an on-line location service.

EC (Europe): ISC participation in the EC-funded EPSI project to develop an integrated European-wide bulletin is planned to continue into 2003.

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): Developing an ISF-compatible version of WizmapII, and planning to allow distribution of the new versions on ISC CDs.

NERC (UK): The University of Leeds successfully proposed to work with the ISC implementing routine measurement of shear wave splitting during 2002–2004.

NERC (UK): The University of Oxford and the ISC plan a joint proposal with to develop new location methods.

In 2002 the ISC will see a further critical development in regard to ISC finances because the Royal Society postponed its review of the ISC, which is now planned for mid-2002. 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. As in many years, the greatest financial risk to the ISC is that a member whose payments are delayed might withdraw, which would cause large expenditure to write off invoices from previous years while also reducing current income.