2001 **DIA** 2005

STRATEGY

GOALS

School of Cosmic Physics

Mission Statement

The mission of the School of Cosmic Physics is to promote the use of Physics in increasing our knowledge and understanding of the world around us by:

- being a leading international centre for studies of the Earth and the Universe;
- providing a focus within Ireland for these areas of research;
- facilitating Irish involvement in relevant international programmes;
- providing specialised advanced training;
- and by publishing and publicising advances in Cosmic Physics.

Executive Summary

(The numbers in square brackets refer to sections of the main document.)

The Dublin Institute for Advanced Studies is a federation of research Schools, each with an autonomous Governing Board, sharing a common legal identity and administration. It provides a specialised research and training environment, complementary to that of the Universities, for those individuals and programmes which fit better in an organisation devoted primarily to fundamental research [2].

The aim of the School of Cosmic Physics is to advance our knowledge and understanding of the world around us by using the methods of Physics [3.1]. Its research is observation driven, based on the detailed study of natural phenomena rather than controlled laboratory experiments, and relies on a balanced mix of theoretical interpretation and experimental observation mostly carried out by groups or teams [3.2]. The School has a proud record of over fifty years of significant contributions spanning a wide range of research areas [3.3].

In planning for the future the School assumes that national funding for fundamental research will increase significantly, that European funding will continue, and that international collaborations will be even more important than they already are. It further assumes that the Council of the Institute will provide an efficient central administration and appropriate accommodation for the School's needs [4].

In internal discussions a wide range of innovative, exciting and significant projects have been proposed [5]. Out of these the School has selected the following specific and verifiable goals for the next five years [6]. This is not a ranked list; the goals are interdependent and collectively constitute a coherent strategy.

- To be internationally recognised as a centre for the use of high performance computing in Cosmic Physics [6.1].
- To facilitate Ireland becoming a member of the European Southern Observatory [6.2].
- To be an internationally recognised centre for research in particle acceleration theory and the origin of cosmic rays [6.3].
- To be an internationally recognised centre for research on phenomena associated with young stellar objects and star formation [6.4].
- To develop the broad range of expertise required for modern multi-wavelength observational studies of evolving extragalactic stellar populations and active galactic nuclei [6.5].
- To establish a group using modern networks, data-base techniques and statistical tools to "mine" astronomical archives and engage in activities as a "virtual observatory" [6.6].
- To reinforce and improve our position as a leading centre for research in crustal and lower lithospheric geodynamics [6.7].
- To make a leading contribution to the study of deep Earth structure, with particular emphasis on mantle structure and plumes [6.8].
- To develop a capability in computational studies involving the rheology of the Earth [6.9].

- To raise awareness of the School among the general public, academia, the media and at political level [6.10].

The external scientific evaluation panel, scheduled to visit the School in 2005, will be asked to report on the School's success in attaining these goals, and additional benchmarking exercises will be applied internally to monitor progress.

Achieving these goals requires the introduction of a new scheme of high-profile and attractive research fellowships (Schrödinger fellows) tenable for three to five years and aimed at promising young academics with typically a few years of postdoctoral experience; the establishment of an agreed staffing complement of core permanent positions; a phased increase in the non-pay budget to levels comparable to the pay budget; and an expanded visitor programme. The research programme outlined above could easily accommodate twenty research fellows; it is proposed that ten should be funded from the Institute grant-in-aid and that the School seek funding for up to a further ten positions from external sources. The School will seek to promote maximum staff flexibility and a partnership approach within the constraints imposed by resources and requirements [7.1, 7.3].

Adequate accommodation is the second key issue. The proposed programme would stretch existing facilities to the limits of what is tolerable. The best solution would be the concentration of the different sections of the School, preferably with the other Schools of the Institute, in one purpose-built building. Assuming the transport logistics can be solved, the Dunsink site is looking increasingly suitable for this purpose and would have major advantages in terms of public profile and outreach activities [7.2] although a city centre location remains very attractive.

The first priority is to secure resources for the existing sections of the School comparable to those available to similar groups in other leading centres. If additional accommodation, staff positions and other resources are provided the School will then energetically seek to develop such extremely topical areas as space physics, oceanography, climate change and other environmental problems through the creation of new sections.

Relationships with the Universities, other research organisations, government and the media will be intensified emphasising the role of the School as a focal point for national research in its chosen areas, a facilitator of international links, and as a provider of specialist impartial advice.

Detailed Strategic Plan 2001-2005
Dublin Institute for Advanced Studies
School of Cosmic Physics

L O'C Drury, A W B Jacob and E J A Meurs

First revision; 30 June 2001

Contents

1 Basic Concepts

Any strategy must proceed from

- A detailed analysis of the organisation identifying its nature, aims, culture, historical trends, current strengths and weaknesses (in many ways this is the hardest part of the exercise, it is only too easy to deceive oneself about your own abilities and standing; hence the importance of external reviews).
- An understanding of the environment in which the organisation operates and reasonable expectations of how this will change over the time-frame of the plan (by contrast the easiest, although paradoxically least certain, part of the strategic planning process).

and should result in

- A clear and realistic vision of where the organisation wants to be at the end of the planning period; what changes in culture are required, which areas need to be strengthened and which cut back or dropped altogether, which new areas should be developed. This is the most important product of the whole strategic planning exercise.
- A practical implementation plan to move the organisation from where it is at present to where it wants to be. The important thing here is to show that the proposed changes are practical, rather than specifying a precise schedule. In many cases the short-term tactics used to effect the transformation will be contingent on random external events and accidental factors; the important thing is to know what direction to move in when an opportunity presents itself. In addition, in a research environment, one must always allow considerable flexibility to follow unexpected research results.

This document attempts to follow this logical structure, first analysing the Institute and the School, then the external environment, before considering future options and plans. It is intended to be reviewed annually and revised in the light of comments from staff, external partners and the Governing Board. It should be read in the context provided by the Institute strategy statement and forms an integral part of the whole Institute strategy although, for convenience, it has been written in such a way that it can be read as an independent document.

2 The Institute

The mission of the Dublin Institute for Advanced Studies is to push back the frontiers of human knowledge. From this one basic principle follows the Institute's threefold commitment to

- original research,
- scholarship of the highest standard,
- and training in advanced research methods.

The vision is of an Institute which is highly regarded in the international scholarly community, attractive to the ablest of researchers, and valued nationally both in its own right and as an integral part of the Irish cultural and research system.

Original research is meant as a generic term covering what is also often described as fundamental, or basic, or "blue skies" research. The key point is that it is research driven primarily by the researcher's natural curiosity and the intrinsic interest of the subject rather than external factors. This concept is well-established in the natural sciences and, though the distinction is less frequently made, applies equally to the humanities. The work of the School of Celtic studies, for example, may contribute to a general revival of interest in the Irish language, but this is not what motivates the work; rather it is the intrinsic fascination of the subject.

Scholarship of the highest standard is an essential requirement in working at the frontiers of knowledge. The checks and balances which the international community of scholars has evolved over the centuries, and the conventions it uses to communicate its discoveries, have to be scrupulously observed when advancing into new and uncharted territory. Otherwise, not only will the results not be taken seriously, they are almost certain to be erroneous. The principles of scholarship are more than arbitrary social constructs; they represent experience hard-won from past mistakes.

Training in methods of advanced research is essential if these principles of scholarship are to be inculcated in the next generation of scholars. This can only really be done by practical example, by involving the ablest of young graduates in actual research projects where they collaborate with experienced researchers. In addition, it is a universal and sometimes uncomfortable experience, that critical questioning by young and agile intellects is an important factor in keeping experienced researchers alert and in driving research forward.

The Institute is organised as a federation of independent Schools sharing a common legal identity and central administration. The Council of the Institute is the legal body corporate, holds the assets of the Institute and administers them on behalf of the constituent schools as well as overseeing the central administration. However the schools retain complete autonomy in all academic matters including, subject to ministerial approval, academic staffing levels.

The Institute's mission is very broad; any subject can be treated academically[1] and thus, at least potentially, the Institute could study anything. Some specialisation is clearly needed and this is provided by the constituent Schools, each of which has an establishment order specifying a well-defined area of knowledge in which it is to operate. At present the Institute has three constituent schools. The Schools of Theoretical Physics and Celtic Studies were established in 1940 and the School of Cosmic Physics was added in 1947. Under the act the decision as to which schools to establish, and what level of support in terms of finance and personnel each is to be granted, rests not with the Institute but with the Government. While the Institute is strictly only interested in research as an activity worth pursuing for its own sake, it is clear that the Government will be influenced in its decisions by many other factors including economic and political aspects[2].

[1] At least one English University offers a course in "Football studies" and the University of Florida one in "Water Skiing"

[2] Thus we have the slightly paradoxical situation, that while the schools are only interested in their research for its intrinsic interest, they have to invoke external factors in arguing for support. But this is nothing new!

The Schools all share a basic common structure specified in the original 1940 act. Each has a number of Senior Professors and a Governing Board which includes the Senior Professors. One of the Senior Professors is nominated for a period of three years as Director of the School. Each School Board nominates two representatives, only one of whom can be a Senior Professor, to represent the School on the Council of the Institute.

2.1 The Institute in relation to other Irish organisations

The Institute is not a degree granting body although the training of students in advanced research is a very important function of the constituent Schools each of which has a number of pre- and post-doctoral scholars. This clearly distinguishes it from the Universities and the rest of the third level sector. However one should not over-emphasise the distinction. In some ways it is more quantitative than qualitative; there is a broad distribution of organisations involved in both research and teaching distinguished by the relative importance attached to each activity. On this spectrum, the Institute sits in the research dominated wing of the distribution, the Universities with their classic commitment to roughly equal amounts of research and teaching occupy the broad centre, then comes the very substantial IT (Institute of Technology) sector dominated by teaching but with a significant commitment to research and finally the private third level and PLC colleges occupy the teaching dominated end of the distribution. This is healthy and as it should be; different people and different courses fit better in different parts of this distribution and it would be a grave mistake to try to force all into one single model. The number of researchers and students who fit naturally in the research dominated wing of the distribution will always be relatively small, and thus the Institute will always be insignificant in size relative to the university and IT sectors.

One can usefully extend this argument by seeking to locate organisations on a distribution between pure, fundamental research and non-specific training in methods of advanced research at one end and goal-orientated applied research and the certification of specific vocational skills at the other. Here again it is clear that the Universities and the IT sector occupy much of the middle ground. The Institute again sits in the wing of the distribution with its emphasis on the pursuit of fundamental knowledge for its own sake and on training in advanced research techniques. The resulting schematic map is shown in Fig 1.

There are of course also a number of research organisations, or organisations with significant research components, such as the Marine Institute, the Geological Survey, the Meteorological Service, the National Microelectronics Research Centre, An Forus Talantuais, the National Botanical Gardens etc. The Institute differs from these, firstly, in its wide-ranging emphasis on fundamental research. The research centres have been established to address specific problems, usually of economic importance, and are thus naturally orientated towards applied research. Secondly, they do not, in general, have the same commitment to training that the Institute does. The one organisation which perhaps comes closest to the Institute is the Royal Irish Academy which, through its Academy Projects, carries out on a limited scale the same sort of advanced research as the Institute. However the Academy is organised in a very different way, and research is not its primary goal. It also has no teaching or training responsibilities.

Thus the Institute occupies a unique position in the third level training and research landscape of Ireland. Internationally of course there are many similar organisations, for example the Max Planck Gesellschaft in Germany, and they are generally recognised as providing a valuable complement in specialised areas to the traditional university model. Difficulties do of course arise if these specialised organisations become too large and start to dominate the University sector, which, as argued above, should naturally form the broad mode of the distribution. For example, in Germany there is a perception in some university quarters, not entirely justified, that the Max Planck Institutes are too large and powerful and have weakened the University system. However this is most unlikely ever to happen in the case of Ireland and there is no reason to suppose that the universities see the Institute as any form of threat. On the contrary, although mostly at an informal and personal level, there are many examples of close cooperation between the University sector and the Institute. Some specialised final

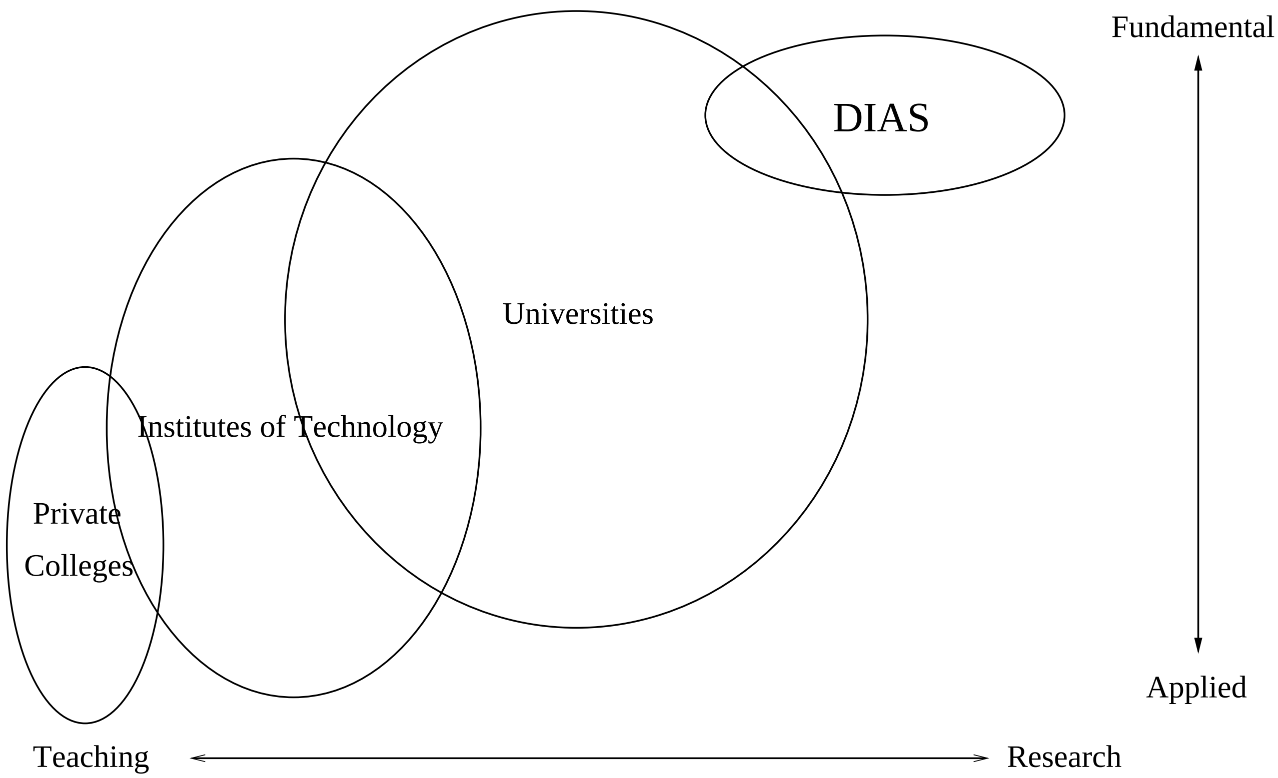

Figure 1: A schematic map of the Irish third level research and training landscape organised by the relative importance of research as against teaching on the horizontal axis and of fundamental versus applied knowledge on the vertical.

year courses in the Universities are taught by Institute staff, doctoral students are for the most part registered in one of the local universities and jointly supervised, and there are numerous examples of research collaborations.

To avoid confusion it should be clearly stated that this analysis seeks to identify a unique position for the Institute within the general advanced research and training system, but not an elite position. To argue for an elite status it would be necessary to make the value judgements that fundamental research is superior to applied and that research is superior to teaching. Such views are now thoroughly discredited. Rather the argument here is that there is a need for smaller specialised organisations to cover those areas which do not fit comfortably into the mainstream University model. Historically, the classical University model has been outstandingly successful and clearly represents the best synthesis of the different requirements in this area. However this does not preclude the co-existence of other organisational forms which are better adapted to specific individuals or research fields.

2.2 Justifying the Institute's existence

Each constituent school of the Institute can, and should, make its own particular case; however there are some general issues which are conveniently addressed here.

At the economic level, a classic argument for the public funding of organisations such as the Institute is that the private sector, with a few rare exceptions such as the former Bell laboratories or IBM, is not interested in investing in long-term basic and fundamental research despite the obvious benefits of the "public good" knowledge this generates. Hence it is the duty of the state to step in and support this activity. This argument has merit, but suffers from being too narrowly focused on the monetary value of the knowledge generated. A more modern approach, as well explained in the CIRCA report, is to emphasise the "embedded" nature of specialist knowledge. This explicitly recognises that research is not an abstract and mechanical process generating only knowledge as an "output" but an intensely human activity; the researchers themselves, and their networks of social and professional contacts, are at least as valuable as the work they perform. Certainly the Institute is much more than a mere "knowledge factory" and the access it provides to high-level academic networks, the specialised training it provides, and the pool of human expertise it represents, are all economically important factors each of which can be used to demonstrate the value to Ireland of the Institute.

Finally, one should not forget the cultural and national arguments. These may not currently be very fashionable, but they were certainly very real to de Valera when founding the Institute and retain much of their validity. Ireland does have a proud tradition of support for scholarship and learning and the Institute is, or should be, a concrete expression of this element of our culture and a source of national pride.

2.3 The Organisation of the Institute

It is sometimes said that the Institute is too centralised and hierarchical, but in fact looked at from the point of view of organisation theory it is clear that it is not the case. The basic organisational model, as in nearly all academic institutions, is in fact federal. Authority resides primarily with the Governing Boards of the constituent Schools, but in the interests of efficiency and economy the Act transfers certain common areas to joint control under Council. There is no suggestion in the Act that the Boards derive their authority from Council, or are in any way subordinate to Council; indeed, on the contrary, in areas dealing with the internal affairs of a specific School, Council acts only as the agent of, and on instructions from, the relevant Governing Board.

As noted by Handy[3] federal organisations tend to be very stable and effective, but lack a high public profile. A classic example is Switzerland. As he notes, how many people know where the Swiss federal parliament meets or who the president is? Yet Switzerland is one of the most successful political experiments in Europe

[3] This section, and indeed much of this document, has been strongly influenced by Charles Handy's book "How Organisations Work", fourth revised edition, Penguin, 1999

despite having four major languages and radically different cantons. This is certainly reminiscent of, and may in part explain, two surprising facts about the Institute; the absence of any significant organisational change over more than fifty years and the fact that it is so little known within Ireland. From this point of view the structure has not changed because it is stable and, on the whole, works well, and the organisation is not very well known because federal structures operating mainly on a consensus basis are effective, but are generally perceived to be rather boring and lacking in human interest.

Of course, a more immediate reason for the lack of change in the structure of the Institute is that this is specified in the 1940 act and any major change would require amending legislation. It is however significant that there has never been any serious demand for such legislation. And until recently the low public profile would appear to have been almost a matter of policy.

2.4 The Administration of the Institute

The Council, under the Act, has four main functions:

- to provide appropriate accommodation for the constituent Schools of the Institute and the Central Administration;
- to provide the legal identity required to enter into contracts and engage in activities such as publishing;
- to hold and administer financial and other assets;
- and finally, to supervise the common administration.

Apart from the two representatives of each constituent school the Council has three *ex officio* members, the Provost of Trinity, the President of UCD and the President of the RIA, and an appointed Chairman. The intention is clearly that the Council provides a neutral forum where the potentially conflicting interests of the various schools can be discussed and reconciled under an independent chairman and with the benefit of advice from three experienced external members.

The act envisages the actual executive authority being exercised through a chief executive officer, the Registrar of the Institute, who performs a central coordinating function being secretary to Council, secretary to each Governing Board, accountant of the Institute and head of the administration. The Registrar may not hold any other office within the Institute or any of the constituent schools which, as well as emphasising the importance of the office, is clearly designed to ensure a neutral and independent administration at the service of the Schools and the Council.

The routine administration of any organisation is almost always bureaucratic with a reporting hierarchy culminating in a chief executive. One does not need to share Max Weber's enthusiasm for bureaucracy as the most perfect form of organisational structure[4] to appreciate that there are distinct advantages to having clearly defined job specifications, reporting lines, and chains of responsibility. Such a system works well when the tasks it has to perform are relatively static, which of course is the case for much of administration. No matter what else changes files have to be kept up to date and indexed, invoices and payments tracked and the buildings maintained. It makes sense and is more efficient to have a senior clerk in charge of the central filing system, a finance officer in charge of the accounting department, a buildings officer in charge of the property maintenance division etc all reporting to one chief executive.

As traditionally implemented in the Institute the administrative structure could be criticised for giving too much responsibility and power to one individual, the Registrar. The consequence, as demonstrated not just by the recent disputes, but also by the case of the first Registrar, was that if things went wrong they

[4]"Precision, speed, unambiguity, knowledge of files, continuity, discretion, unity, strict subordination, reduction of material and personal costs - these are raised to the optimum point in the strictly bureaucratic administration" Quoted in "Writers on Organisations", D S Pugh and D J Hickson, Penguin Books, 5th edition 1996.

tended to go catastrophically wrong. A good solution would be to distribute the load across a system of school administrators working at a high level, but under the overall supervision of the Registrar, each responsible for the administration of a specific school. This would give each Director, and Head of Section in the case of Cosmic Physics, the dedicated administrative support required in this much more complex age; free the Registrar of responsibility for many routine matters allowing him (or her) to concentrate on the running of the central administration and the achievement of overall strategic objectives; and limit the extent to which trouble in one area can threaten to paralyse the entire Institute.

In fact one could make a strong case that the major problem with the way the Institute has traditionally been run is not one of organisational structure but simply of information flow. By forcing almost all communication to pass through a single channel, the Registrar, there were inevitably problems of overload, distortion and occasional failure. Internally these were somewhat alleviated by the former “Administrative and Premises Committee” which provided a forum for the School Directors, Heads of Section and Council Chairman to discuss matters with the Registrar, a function now assumed by the regular “Administrative meetings”. However these need to be supplemented by a channel to facilitate direct Board to Board communication (the convention which has grown up of inviting the Board Chairmen to dinner with the Chairman of Council on the evening before a Council meeting goes some way towards addressing this problem) and, crucially, a direct channel from the School Directors or Board Chairmen to the Department of Education. A good solution would be to have a high level meeting once a year (probably in association with the submission of the estimates) attended by officials from the Department of Education, the School Directors, the Chairman of Council, the Registrar and the Finance Officer at which each School could discuss its requirements with the relevant Department officials.

3 The School of Cosmic Physics

The School of Cosmic Physics is the largest of the three constituent schools of the Institute and is located in 5 Merrion Square (Astrophysics and Geophysics sections) and at Dunsink Observatory (Astronomy section).

3.1 Objectives and Justification

Cosmic Physics is not a generally recognised term, but the meaning is quite clear from the establishment order which specifies it as including "the theoretical, observational and experimental investigation of [...] astronomy and astrophysics, cosmic rays, geophysics, meteorology and oceanography". The examples given make it plain that what is intended is the application of physics to the study of the external environment and natural phenomena as distinct from laboratory studies of carefully controlled experiments. Undoubtedly were the establishment order to be written today the list would also include such topics as climate change, pollution dynamics, environmental physics and comparative planetology.

It is interesting to note that this focus on the application of Physics to the understanding of the Cosmos, that is the natural order and structure of the Universe, strikes a remarkably modern note for a document written in 1947 when most physicists saw the goal of physics in strictly reductionist terms. Of course this view, nowadays usually expressed as the hubristic idea that we have within our grasp a "theory of everything" leading on to sensationalist speculation about "the end of Physics", still has powerful adherents but there is also a much greater appreciation that interesting, and often qualitatively new, effects arise in complex systems and that this is a proper subject of study for physicists. Combined with the general increase in concern for the environment and the recognition that catastrophic events have influenced the Earth in the past and will most probably do so again, this means that the study of Cosmic Physics has never been more topical. It is also an area of research large parts of which can be immediately grasped, at least in general terms, by the man on the 46A bus. Everyone has some interest in how the stars work, what determines the weather, how likely we are to be hit by an asteroid, how old the universe is, whether a major Irish earthquake can occur, how the Atlantic Ocean was formed and so on. Understanding the external environment has obvious survival advantages, so it is not surprising that we are born with an innate urge to ask the sort of questions to which Cosmic Physics attempts to provide answers.

The justification for a School of Cosmic Physics is thus, firstly the intrinsic interest of the subject, secondly the increasing political importance of environmental questions and the necessity of having a source of informed advice on these matters, thirdly the economic advantages resulting from a better understanding of natural resources and finally its popular appeal and potential for improving the public understanding of science.

3.2 Organisation of the School

The School has traditionally operated as three, fairly distinct, sections although this has no formal basis. However as there have been, at almost all times, three senior professors with very different interests such a division was essentially inevitable. Originally the sections were called the Astronomy section (based in Dunsink Observatory), the Geophysics section and the Cosmic Ray section (both in Merrion Square). Recently the Cosmic Ray section was renamed the Astrophysics section to more accurately reflect its current work. However despite the continuity of names and number of sections it should be noted that all three sections have changed the direction and nature of their work several times, often radically, mostly in response to the appointment of a new senior professor as head of section. For example the Geophysics section, despite its name, under Pollak, the first director, concentrated on atmospheric physics with studies of condensation nuclei and aerosols, then switched under the next senior professor, T Murphy, to gravity and magnetic surveys and more recently, under B Jacob to seismic studies. In the Cosmic Ray section under the first head, L Janossy, the emphasis was on cascade studies with cloud chambers and a pioneering attempt at a radio-linked air-shower array, then under C O'Ceallaigh attention switched initially to particle physics studies using nuclear emulsions and then to compositional studies using novel passive track detectors before switching towards theoretical astrophysics under

L Drury. Finally, the Astronomy section under H Brück carried out classical photometry and astrometry as well as solar physics, concentrated on Solar physics under Ellison, then went back to mainly Galactic optical astronomy under P Wayman and is now working on extra-Galactic astronomy and X-ray astronomy under E Meurs.

In general, the management of a research oriented organisation presents interesting problems and much of the dogma derived from industrial models is of limited applicability. There is no well defined product which can be precisely measured in quantitative terms so that ideas of quality control, benchmarking and productivity assessment have to be treated with some caution (this is not to say that such ideas have no role, merely that allowances must be made for the fact that they are being applied in a context very different to that for which they were developed). And individuals are motivated, not so much by monetary reward or loyalty to the organisation, as by the interest of the work and the promotion of their own professional careers.

One concept from management theory which is very useful is that of the culture of the organisation[5]. A crude, but illuminating, way of illustrating some of the varieties of organisational cultures is the "dinner party test". If you ask a stranger at a dinner party what he does and he answers that "He works for X" where X is an individual it indicates that he is in an organisation which is centred on a single powerful charismatic leader and influence depends on closeness to the leader; if he says that he works in the Y department, he is part of a classical administrative hierarchy and a role culture where the efficient performance of assigned tasks is the key factor; but if he says that he is a Z then he sees himself as primarily an individual and the organisation is either there to serve him, or the relationship is at best symbiotic. The academic staff of the school clearly fall in the last category. They would say that they are an Astronomer or Astrophysicist or Geophysicist working in the School of Cosmic Physics (and might not even mention the School). They work *in* the Institute, but not *for* the Institute. In fact, on the contrary, they expect the Institute to work for them.

Such organisations, containing mainly creative and mobile individuals, are not confined to academic research. In the commercial world they usually take the form of professional partnerships and associations. Legal firms, advertising agencies and architects offices are good examples. The classic barristers' chambers offers in fact an interesting parallel, with senior counsel in the role of the senior professors, junior counsel as professors etc. Like the head of chambers, the director of the school has the unenviable task of persuading a rather mixed crowd of independent individuals to cooperate through a judicious mixture of flattery, persuasion and chiding[6]. Because of their inherently loose structure such organisations often seek to reinforce the sense of community through special events such as communal meals. This can range from the mundane, but important, level of group tea and coffee meetings to the elaborate heights of college feasts in the Oxbridge universities. Another common feature is that salary scales and promotion, the traditional means of motivation in commercial organisations, are tightly controlled and less available as management tools putting more emphasis on praise and the good opinion of work colleagues as motivating factors.

However it would be a mistake to think of a research organisation just as a collection of individualists. Another insight of management theory is that in all organisations group structures develop, and indeed modern research tends to be very much a cooperative process carried out by teams or groups. Different individuals bring different abilities to a group and the whole can be substantially more effective than its parts. Particularly in the observational and experimental areas, but also very commonly in theoretical studies, almost all work is now done in this way rather than by isolated individuals; serious world-class research involves specialist skills and problems of scale which can only really be handled with the support of a group. Thus one should expect the academic part of the School to be organised in groups based around particular problems or individuals.

[5]Using culture in the anthropological sense of the complex of rules, expectations and norms which govern social status and interactions. These define what is "acceptable behaviour" and "legitimate authority".

[6]As Handy remarks with a slight note of despair "Individuals with this orientation are not easy to manage. There is little influence that can be brought to bear on them. Being specialists alternative employment is often easy to obtain, or they have protected themselves by tenure, so that resource power has no potency. Position power not backed up by resource power achieves nothing. Expert power they are unlikely to acknowledge. Coercive power is not usually available, only personal power is left and such individuals are not easily impressed by personality."

Observation shows that this is in fact largely the case.

3.3 Major Achievements and Current Work

In sheer quantitative terms the award for the most significant result has to go to the Geophysics Section which, as a by-product of fundamental studies (the RAPIDS projects) of the lithospheric structure of the North Atlantic, at a stroke enlarged the size of the Irish continental shelf by a factor of five to some nine times the land area. The Rockall Trough, which had been thought to mark the edge of the continent, and to be oceanic in its structure, quite unexpectedly turned out to have seismic properties typical of continental lithosphere. In fact continental crust continues out to the western edge of the Hatton Bank, about halfway from Ireland to Greenland.

Early research focussed on meteorological and upper atmosphere topics but very quickly developed into studies of the crust in Ireland using potential field techniques. These involved measuring the gravity and magnetic fields and also the measurement in the laboratory of rock specimens for density and palaeomagnetism. As a result of the efforts of the Geophysics Section, Ireland became, very early on, a splendidly mapped country for these values. This research was affordable with the very limited funds then available. Seismic measurements, which would have provided the necessary bedrock of a seismic model for Ireland were not possible. However, many valuable results were obtained with these data, mainly concerning the upper crust in Ireland. These were of fundamental interest and also later became relevant to the search for mineralization in Ireland. This aspect continues to the present, a good example of basic research leading to applications.

One thing is certain however, basic research in Geophysics frequently turns out to have useful applications. A point we have often made is that *all* the offshore basins around Britain and Ireland, which have been found to contain oil and gas, were discovered by academic researchers. None were found by the oil companies. They followed the lead of academic research. We must re-emphasise that what the Geophysics Section is doing is basic research. That is what we are good at. There are useful applications of what we do, but that is not the primary purpose.

Our knowledge of the crust and deeper structures under Ireland really improved when it became possible to carry out wide-angle seismic profiling offshore and onshore Ireland in the early 1980s. The Geophysics Section led this process and it would not have happened without the vigorous and innovative leadership of the Section. One result is that we are far better mapped than our big neighbour and, as a result, have found some remarkable and unexpected features which will influence our future research.

One area where the results have been of enormous significance for Ireland has been offshore, in the Rockall Trough and even further west. It could be said that the research of the Section and its collaborators in Ireland and Germany, has copper-fastened Ireland's claims to a huge and disputed sea-area - the so-called Designated Zone - and, maybe just as important, shown that the development and present structures in the Rockall Trough were not what was held to be true in the late 1970s and early 1980s.

Much of the work in the more recent past has been collaborative, notably with UCD, University of Karlsruhe, University of Hamburg, University of Leicester, and others in Europe and North America. A high proportion of this work was led or initiated by the Geophysics Section.

Some achievements of the Geophysics Section can be summarised as follows:

- Gravity research

  The collection of gravity data for the whole country since the 1950s, has produced the only comprehensive gravity data set for Ireland. This has proved to be an asset of national importance with applications to problems such as the detection of major fault zones and granites within the upper crust. Gravity studies have also provided important insights into the tectonic processes which lead to the formation of mineral deposits. The recent availability of marine gravity data derived from satellite altimetry over the Earth's oceans has allowed our studies of the onshore gravity field to be extended throughout the entire North Atlantic area.

- Onshore Seismic Studies

  Wide-angle seismic studies of the large-scale crustal and upper mantle structure in Ireland began in the early 1980s to further our knowledge of the Irish crust. Today the coverage is very good and a number of important scientific discoveries have been made. For example, a seismic study of the Leinster Granites has revealed that they are unexpectedly thin, and has determined the structure to the base of the crust. This will help in understanding the classic problem of the origin and emplacement of granitic magmas and their setting within large-scale orogenic belts. A similar experiment (VARNET), which was carried out in the southwest of Ireland has also had an important bearing on the problem, identifying a possible deep crustal source for the (proposed) buried granites in the region.

- Offshore Seismic Studies

  The book on the development and present structure of the Rockall Trough and the eastern margin of the North Atlantic has been rewritten. A new model of differential lithospheric extension has been formulated on the basis of these results. This has implications for the thermal/rheological evolution of the lithosphere and its geochemical interaction with the Earth's hydrosphere leading to serpentinization of the upper mantle below the Rockall Trough. The improved understanding of the dynamics of major sedimentary basin formation in the North Atlantic region is of enormous economic and strategic importance as tectonic development largely dictates the genesis and accumulation of hydrocarbon deposits. The success of the initial research has led to further work, which is still in progress.

- Continental rifting

  Continuous seismic reflectors have been found under the Kenyan Rift, leading to a new definition of how the nearby mantle plume has influenced the development of what is, in many ways, a classic continental rift. Anomalous lower crust and upper mantle has been found under the southeastern flank of the rift. Continental rifting can lead to the development of a new ocean and is therefore linked to the Geophysics Section work on ocean margins (above).

- Upper Mantle

  Using recordings of distant seismic sources in China and the North Pacific on a profile from Kinsale to Galway Bay, a remarkable upper mantle body, with extreme velocity gradients, has been found under the Shannon Estuary zone, probably associated with the Iapetus Suture. It may be anisotropic, preserving an imprint of stresses and strains at the closure of the Iapetus Ocean more than 300 million years ago. Further work is needed.

- Deep Earth structure

  More recently, and at an even more fundamental level, detailed studies have been made of the Earth's core-mantle boundary (CMB) in the COMBO project. This was the most detailed seismic investigation of the CMB ever carried out. The target was under the Pacific plate southeast of Hawaii. Very rapid changes in seismic velocity were found just above the CMB and the quality of the data showed that CMB topography could not be the reason for the observations. This is an important new finding in what should be a relatively undisturbed part of the CMB. Moving Northwest to Hawaii itself, a study, in partnership with the GeoForschungsZentrum in Potsdam and the University of Hawaii in Honolulu, of the Hawaiian plume began in 1999. Mantle plumes are thought to originate near the CMB so this is a different aspect of deep mantle structure. Initially the physics of the plume in the upper mantle will be studied (and early results are promising). There is a network of eleven DIAS Broad Band stations and one Very Broad Band station from Potsdam distributed on four of the islands.

- Equipment Development

In work of a different nature, the Section developed, built and used analogue seismic recorders. These worked very well and have been successfully used in Ireland and in international experiments in mainland Europe, North America and Africa. More recently, the Section has guided the development of new digital seismic recorders for its own use.

Moving out from the Earth, the School has been a major participant and facilitator in Irish space research going back to the early seventies when the then Cosmic Ray section had an experiment accepted for the Apollo 16 mission to the moon. This was the first Irish involvement with a space mission.

- Subsequently, at the time of Ireland's joining the European Space Agency, the section collaborated with the Agency's Science and Technology Centre, ESTEC, to design and build the Ultra heavy Cosmic Ray Experiment, the largest single experiment to fly on NASA's long duration exposure facility. A major factor in the selection of the Ultra Heavy Cosmic Ray Experiment for flight on the LDEF was the fact that the Cosmic Ray section had been one of the main groups developing the use of passive nuclear track detectors for fundamental research purposes (indeed a key factor affecting their use for charge determination, the so-called registration temperature effect, was discovered in Dublin, but unfortunately only after the LDEF design had been fixed).

  The analysis of the passive nuclear track detectors on the Ultra Heavy Cosmic Ray Experiment following their eventual retrieval in 1990 continues to the present and has yielded the world's first statistically significant estimate of the actinide abundance in the cosmic rays. The abundance of the various chemical elements in the arriving cosmic rays at Earth has been studied for many years and the general pattern for most elements is well established. However the actinides, the heaviest of the naturally occurring elements (chiefly Uranium and Thorium), are extremely rare and difficult to measure. This measurement fills in the one remaining gap in our knowledge of the cosmic ray chemical composition and is likely to remain the definitive determination for at least anther decade. The actinide abundance is important because these rare ultra-heavy atoms can only be made under very extreme conditions and are thought to be good tracers of the rapid or r-process nucleosynthesis. In fact the actinides are neither greatly over nor under abundant in the cosmic rays as compared to the bulk solar system indicating that the source material out of which the cosmic rays are accelerated is not strongly enhanced in fresh nucleosynthetic material, contrary to much earlier speculation.

- The passive solid state nuclear track technique is now routinely used in radiation dosimetry and in an interesting development the School has participated in two recent large European Union projects to monitor the radiation hazard posed to aircrew in commercial aircraft by cosmic rays (this is now a legal requirement under directive 96/29 Euratom). In fact the contribution of the School to the first project was so important that we were asked to undertake the coordination of the second project. Recently a third project, again coordinated by DIAS, has been successful in receiving significant funding under the 5th framework programme to continue investigations through the current solar maximum (2000 to 2003).

- More recently, in another space experiment, the Astronomy and Cosmic Ray section of the School collaborated with St Patrick's College Maynooth in the construction and operation of the Epona experiment on the Giotto mission to comets Halley and Grigg-Skellerup. This very successful experiment discovered unexpectedly high levels of accelerated charged particles in the cometary environment, a result that significantly contributed to our understanding of the interaction between the solar wind and cometary pick-up ions. Building on this success a similar experiment was proposed and accepted for the Russian (at that time still Soviet!) mission Phobos to Mars and its moons. While the overall mission was not very successful (one of the two spacecraft was lost en route, and the other mysteriously disappeared shortly after reaching Mars) the Irish-led experiment functioned well and discovered evidence for a possible trapped ion population near Mars. The School also contributed to the software development for the Infrared Space Observatory mission and is currently working (in collaboration with UCD) on the Optical Monitoring Camera for the INTEGRAL mission due for launch in 2002. Other involvement with instrument developments included work on the University College Galway TRIFFID high-resolution camera, on a photon-counting detector in collaboration with Rutherford Appleton Laboratory and on an automatic telescope guider for the La Palma observatory.

- Stimulated in part by the actinide data from the LDEF experiment, a very significant theoretical advance has been achieved in the understanding of the general chemical composition of the cosmic rays. As part of a European collaboration working on theoretical questions of particle acceleration and propagation the School played a major role in developing a comprehensive explanation of all the observed abundance features. The key was to take the modern theory of particle acceleration at the strong shock waves associated with supernova remnants, and to apply it consistently to a dusty model of the interstellar medium. This represents a major advance in our understanding of the 90 year old problem of the origin of the cosmic rays.

- Another possible test of the origin of cosmic rays in supernovae is provided by recent advances in gamma-ray astronomy. It has recently become possible (using techniques pioneered in UCD many years ago) to observe very high energy gamma-rays from astronomical sources using the so-called imaging atmospheric Cherenkov technique. A number of years ago we pointed out that if one made relatively straightforward estimates from particle acceleration models of the high-energy gamma-rays expected from supernova remnants, one obtained flux estimates which were close to the sensitivity limits of imaging atmospheric Cherenkov telescopes and thus that it would be worth looking for high-energy gamma-ray emission from supernova remnants. This work was very influential and inspired a great deal of work, both observational and theoretical. Unfortunately the initial searches were disappointing and this lead to a certain amount of scepticism, however there now appear to be at least two cases where a signal has been seen. However the interpretation is not simple and much more needs to be done, especially with the next generation of improved facilities (in one of which, the HESS project, the School will participate).

- A major theme of astronomical research for the last decade or so, and one where the School has made significant contributions, is that of outflow phenomena associated with star formation. It is now known that in the process of star formation, as matter accreets onto the forming proto-star, matter is also ejected in both fast well-collimated jets and slower more diffuse so-called molecular outflows. The jets often contain bright emission knots, named after their discoverers Herbig-Haro objects. There has been much dispute over the years as to the origin of these knots, but recent detailed studies with the Hubble Space Telescope in which the School has played an important role strongly indicate that they originate from irregular variations in the jet ejection velocity.

- To test this hypothesis requires detailed numerical modelling of jets using computational fluid dynamics with the inclusion of radiative cooling and magnetic field effects to generate models which can be compared with the observations. As the models have become more sophisticated, and the observations more detailed, this has become a more and more computationally intensive task. Driven mainly by this the School constructed what we believe to have been the first Beowulf cluster in Ireland, a parallel computer assembled out of commodity PC parts, in 1997. This system with 12 Intel processors and some 1.5GB of memory has been replaced in 2000 with a 32 processor system which is a factor of ten faster and is, for certain problems, the most powerful computer system in Ireland. A spin-off from this activity was the establishment, following the successful model of the ASGI of the Irish Association for High Performance Computing, to provide an informal and neutral forum where people from academic and industrial backgrounds could exchange ideas and information about high performance computing.

- The origin of the stellar jets remains somewhat mysterious, but almost all models invoke magnetic fields as collimating agents. However these were not generally thought to be observable. There was considerable interest therefore when, in observations made by the School using the Merlin radio telescope of the T Tauri South outflow region, strong circular polarization was seen in the radio emission providing for the first time direct evidence for the existence of large scale magnetic fields and an estimate of the field strength in these regions (about a thousand times the typical interstellar field).

In the Astronomy section probably the single most important contribution of the School was not a strictly scientific result, but the provision through the joint agreement between the then NBST, DIAS and the British SERC of access to modern observing facilities for all Irish astronomers. This so-called La Palma agreement has served the community well, and the current levels of astronomical research in UCD, UCG, UCC and CIT would have been impossible without it. In addition by establishing the Astronomical Science Group of Ireland the Institute created an informal forum for all astronomers on the island to interact and exchange information, a model which was later followed in setting up the Irish Association for High Performance Computing.

- Stars exhibit definite life cycles: they are born out of interstellar dust and gas, live a life powered by nuclear synthesis in their interiors and die leaving behind compact remnants like Neutron Stars and Black Holes. These aspects of a stellar life figure strongest for the very luminous, young massive stars that live for the comparatively short time of only a few million years. Accordingly, when the starformation rate is high in a particular galaxy and a Starburst takes place, the most massive stars dominate the output from such an object. The School has pioneered computer simulations of such young, evolving stellar populations that follow the high-energy (i.e. X-ray) emission that they produce as a function of time. The X-ray signatures of these populations are dominated by very special stages of their member stars, such as determined by the Neutron Star remnants after explosions at the end of the regular stellar life. This work has provided us with a unique tool that is used to assess the precise evolutionary status of young stellar populations.

- Studying massive stars in our own neighbourhood, the School has made several contributions regarding the evolution of such stars, notably of the so-called Wolf-Rayet (WR) stars. These are late stages of massive star evolution, chiefly consisting of Helium, that are heading for a final explosion as Supernova. Besides clearing up a years-old classification scheme for some particular subtypes of the WR stars, we discovered that one observational manifestation traditionally connected with the most massive stars, namely stages as so-called Luminous Blue Variables (LBV), can also occur for a relatively short period in stars of much lower mass. This result has important consequences for the theoretical modelling of the last evolutionary stages of the massive stars.

- Some of the young massive stars appear to have left their places of birth at great speed, as “runaway” stars, which may have been caused either by being part of a binary system of which one member exploded as Supernova or by strong gravitational interactions with other massive stars during an early stage shortly after their birth when they were very close together. If they are post-Supernova binaries, then the expectation is that they are accompanied in many cases by the Neutron Star that was formed at the explosion. We have analysed high-energy data that should reveal the presence of such condensed companions but do not detect the anticipated X-ray sources corresponding to Neutron Stars. This clear result shows that the gravitational ejection from dense stellar groups is the more likely mechanism for producing the runaway stars and in this way clarifies their origin.

- For many galaxies, the very useful high-energy diagnostics refer not only to products from stellar evolution but also to the phenomenon of activity in their nuclei. Nuclear activity is recognizable, amongst other features, from the abnormally high output of electromagnetic radiation from the galaxy centres. In many cases, and at certain wavelengths (like hard X-rays), this output dominates the overall emission levels of whole galaxies. In several instances we have been able to establish the relative importance of nuclear activity and stellar evolution products to the overall high-energy emission from galaxies. Also, we have demonstrated the presence of an active nucleus in cases where this is difficult to infer from data at e.g. optical wavelengths where the obscuring effects from gas and dust in the inner regions of galaxies is very noticeable. The School had several successful observing sessions with various satellite X-ray observatories that supplied the basic data for this work.

- Nuclear activity in its most extreme form produces the well known quasars. However, much milder forms of nuclear activity occur, e.g. the comparatively weak source of radiation in the centre of our own Galaxy. It is important to establish how common it is for galaxies to possess a core of some - possibly very faint - level of activity. Several projects at Dunsink Observatory deal with this interesting aspect of galaxies. The long-term X-ray variability of galaxies, for instance, provides for some objects evidence of short-lived (in this case: of the order of half a year) flares from the nuclei of normal (that is, non-active) galaxies, which may be caused by stars that are disrupted by a central Black Hole that otherwise would not have been noticeable. In this way it becomes clear that the galaxy has a dormant core that can be re-activated. Analysing available X-ray data for the very nearest galaxies around us, we have been able to assess the incidence of nuclear activity as it is dependent on the size and the morphological type of galaxies. A particularly interesting result was the case we could make for another very weak active galaxy nucleus very close to us, in a satellite galaxy of the Andromeda Nebula (the nearest sizeable Spiral galaxy).

- Moving to the largest scales in the Universe, the arrangement of galaxies is not random but is organized in large filaments around nearly empty regions (voids), that come together in localized clusters of galaxies. While the occurrence of hot gas within such clusters is studied at high energies, we have also used the X-ray diagnostics to find evidence for gas within the Voids between the filaments, which is of particular importance to the possible formation history of large structures in the Universe. Further, a mathematical partitioning method was applied to the Large-Scale distribution of galaxies, leading to a novel way to describe the filamentary structures that contain the galaxies.

- The School has been strongly advancing outreach activities, in order to inform the general public - especially school groups - about its scientific programme. A century-long tradition of Open Nights at Dunsink Observatory was enhanced with an Exhibition Room that contains a computer-controlled ceiling model of our Solar System, design information panels and a computer-quiz machine. This new facility was opened in December 1997 by Minister N. Treacy and further development of it is being pursued.

3.4 Strengths and Weaknesses

Major strengths of the School are :-

- Independence and flexibility. The School has no duties other than the advancement of Cosmic Physics. In particular teaching is done on a voluntary basis and staff are not constrained by the requirement to lecture at specific times (this can be a major problem for some of our University colleagues). And although the budgets are relatively small, the School enjoys considerable discretion in how it chooses to spend its resources.

- Tradition. This should not be dismissed; fifty years of research in Cosmic Physics is a proud record, and a long-established organisation has a definite advantage in attracting funding and good applicants for positions.

- Popular support. Cosmic Physics, especially Astronomy, is one of the most accessible areas of science for the lay person and one of the few to have a significant amateur community. Dunsink Observatory is the only part of the Institute with any significant public profile.

- Light-weight scientific administration. One revealing thing to emerge from the internal discussions with postdocs and staff who have worked in other institutions is that they greatly appreciate the fact that decisions are generally taken quickly with a minimum of bureaucratic delays and form filling.

However these are offset by weaknesses:-

- Small size. There is general agreement that the groups within the School are currently too small, and that the School itself is below the critical size needed to sustain a vigorous internal intellectual discourse and level of activity. There is also a serious lack of mid-level positions, especially in the Astronomy and Geophysics sections.

- Low profile. Despite the significant achievements listed above and a generally excellent international reputation, the School, and indeed the Institute, is almost unknown within Ireland (even in academic circles outside our specific research areas).

- Inadequate funding. The non-pay portion of the grant in aid for the School decreased from 41% in 1976 to 20% in 1996. Comparable institutions elsewhere typically have non-pay budgets about the same size as their pay budgets. However the recent funding of some extra-ordinary items is a promising sign that this trend may be reversing.

4 The External Environment

It is obvious that major changes are taking place in the Irish research system. For many years almost wholly dependent on European funding, there is at last a recognition that national resources must be committed to support basic research and that we should be offering opportunities for good Irish students and postdocs to train and work in Ireland. The establishment of "Science Foundation Ireland" and the opening of Medialab Europe in association with MIT are among the more obvious first fruits of this change. Funding still tends to be directed towards what are perceived as "economically important" areas, but the trend is clearly towards increased support of fundamental research.

Internationally a major factor is clearly the increasing unification of Europe. Student mobility within Europe is now at unprecedented levels and a genuine community of European scholars and scientists is emerging who have worked and studied in several European countries. This is well discussed in the discussion document COM(2000)6 prepared by the EU Commission in preparation for the negotiations on framework six and entitled "Towards a European research area" which also raises the very interesting possibility of the various national programmes within Europe being opened up on a reciprocal basis. At the same time the dominance of North America is declining; it is no longer the case, as it was thirty years ago, that one could automatically assume that anyone who was any good would spend some years working in America. In parallel with these developments, and mirroring developments in commerce, we have increasing globalisation of third level education and research.

Another important factor, of a rather different nature, is what has been well called the "democratisation of computing". Computer power is now so cheap and readily available that techniques and analyses which would previously have been impossible, or the preserve of a few, are now routinely available. In general numerical simulations and data analysis techniques are now constrained more by the imagination and programming ability of the scientists involved than by any shortage of processing power (some would say that this has always been the case!).

Related to the last point, but qualitatively different, is the astonishing development of electronic networks and communications. The World Wide Web, a small private project by a few high energy physicists a mere decade ago, is now a global resource shared by a significant part of the population in developed countries. Already this has radically changed the way scientific information is distributed and accessed. Preprints are no longer photocopied and sent out by surface mail but simply posted to the Los Alamos server or equivalent[7]. Astronomers and Astrophysicists, for the most part, no longer go to the library to search for and obtain copies of published papers; instead they simply use NASA's Astrophysical Data System[8]. The major seminars at CERN are now streamed on the Web and anyone with the appropriate equipment can participate virtually. All of these trends can be expected to continue.

Finally, in almost all countries there is concern about the falling numbers of students taking Physics. At the moment this is not a serious problem for the Institute, but if the trend continues we may be faced with a significant shortage of students in the future. Already one hears anecdotal evidence that it is becoming increasingly difficult to get good postdoctoral fellows.

In summary, in planning for the future it is reasonable to assume:

- That national funding for research will increase, but that this will have to be obtained by peer-reviewed proposals and against stiff competition from the rest of the third level sector.
- That international, and particularly European, partnerships and alliances will be increasingly important.

[7] `http://arXiv.org` or one of its many mirrors. Originally an e-mail based system for archiving and distributing high energy physics papers this is now a web based general physics system

[8] `http://adswww.harvard.edu` This in effect gives anyone with a computer and a moderately fast internet connection access to a well-stocked astronomical library backed up by an extremely powerful search engine. Unfortunately paper subscriptions are still needed to most major journals to allow access to current issues.

- That computational resources are not a serious constraint and that electronic networking and virtual collaboration using the internet will become commonplace.
- That in contrast good students may become a scarce resource.

4.1 Opportunities and Threats

Clearly this changing environment offers both opportunities and threats to the School. The major opportunities are that:

- One can, for the first time in decades, realistically plan for growth both in personnel and in resources. This will also allow a rationalisation of the staff structure.
- Good international contacts place the School in a very favourable position to build international, and particularly European, alliances.
- Developments in computing and networking technology considerably reduce the disadvantages previously suffered by small and peripherally located research organisations.

However there are also serious threats:

- The School, and indeed the Institute, lives or dies on the quality of its academic staff and the work they produce. There is excellent work being carried out, and the Longair review was very favourable, but it is only too easy to become complacent and there is always room for improvement.
- Some equipment and facilities are beginning to look poor and dated by comparison with the massive expansion and investment in the University sector. Without modest investment in modern facilities it will prove increasingly difficult to attract good scholars, especially in view of a projected global shortage of physics graduates.
- The School, and the Institute generally, is rather isolated and risks becoming marginalised within the Irish research system.

5 Looking forward

Each section has its own view of the way forward, given below, but there are three general points which should be discussed first.

Firstly, it has been suggested that the number of senior professors in the School be increased to five. The Act does not explicitly say anything about the number of senior professorships although implicitly it requires at least one (to act as Director) and not more than seven (because the Board is limited in size to fifteen with appointed members outnumbering senior professors); there is certainly nothing sacred about the traditional figure of three. A modest increase is an excellent idea, although additional accommodation will clearly be required for the school if two new groups are to be added. Obvious possibilities would be to set up a space physics group, a climate change group or an oceanography group. Assuming the availability of adequate resources and good candidates such groups would undoubtedly add new life and relevance to the work of the school.

However before adding new groups there is a strong argument for putting the existing groups on a sound footing. This presupposes of course that these groups will continue, but the scientific case for each is strong and realistically, at least over the five year planning period, this will certainly be the case (in this context it is important to note that, as explained earlier, the groups are not static but have shown a remarkable ability to reinvent themselves and evolve). One key problem, which has been consistently identified over the years, is that the Astronomy and Geophysics groups have no “second in command” who can deputise for the senior professor. An efficient group, especially one which can realistically bid for large amounts of competitive funding, needs both a taoiseach and a tánaiste and there is a very strong case for filling the two professorial vacancies in these sections as quickly as possible - indeed this has been official Board policy for several years[9].

Secondly, there is the question of the relation between theory and observation. The establishment order clearly envisages the School carrying out a balanced mixture of theory and experimental work with, if anything, the emphasis on experimental and observational work. This is as it should be. Advances in the natural sciences come from close interaction between theory and experiment; theory practised in isolation degenerates into sterile mathematics, and experiment and observation divorced from theory become mere phenomenology. Of course one can argue that it is not absolutely necessary to have both strands represented in the same Institution, especially in these days of rapid electronic communication, but it is clearly highly beneficial. Further one could argue that it is precisely in medium size or long term observational projects that the strength of the School lies. These are areas where the Universities, with their primary responsibility for undergraduate teaching, have difficulty in making the sort of commitment which is needed to carry through projects or participate in international campaigns, but which fit very naturally into the work of small to medium size dedicated teams working in a pure research environment.

Thirdly, there is the question of permanent versus contract positions. There is certainly a case for increased use of contract positions, but, except possibly in a pure theory context, a coherent group capable of participating effectively in major international collaborations requires at least a senior professor as taoiseach and a tánaiste at professorial level with tenure. In some cases there will also be a need for technical and logistical support which cannot really be provided by short-term contract staff. One cannot expect the same level of commitment and loyalty from contract staff that one gets from permanent staff, nor is it reasonable to expect experienced people at professorial level to accept contract positions when they can obtain tenured positions elsewhere. Finally and crucially, if one is seeking to recruit the best possible people as senior professors, they will expect to have at

[9] Minute 7a from the meeting of 1 February 1996 reads, in part, “It was agreed that the immediate priority was to fill the vacant Professorships in the Astronomy and Geophysics Sections and there was unanimous agreement that this matter should be pursued with the Minister as soon as an appropriate opportunity presented itself”.

Minute 5a from 16 April 1998 reads “It was agreed that the Registrar would send a formal reminder to the Department requesting the filling of the vacant Professorships in the Geophysics and Astronomy sections enclosing draft specifications for both posts”.

least one or two professorial positions in their group and not just a few post-doctoral positions; this is the least that a major American University or European research centre would be offering.

There is one qualification which must be made. If there are no limits on the pay that can be offered, and if one simply goes out and buys the best people one can find for whatever it takes to persuade them to spend five years (or whatever period is chosen) in Ireland then it may well be possible to run a School on a purely contract basis; however this would probably then also have to include the Senior Professors. This is of course precisely the strategy behind the Foresight Initiative[10] and it will be very interesting to see whether this attempt to import what is basically an American model works in a European social and legal context. Whether within the existing Institute structure the Department of Education and Science would be prepared to authorize such open-ended arrangements for the pay grant-in-aid, and whether the concurrence of the Department of Finance could be obtained, is of course another question.

5.1 Astronomy

The work of the Astronomy Section emphasises an observational approach to the study of the Universe. Key characteristics of modern Astronomical research are, firstly, the use of multi-wavelength data and secondly, an emphasis on interpretation of the measurements obtained. The latter aspect may assume any position between the simple collation of observational data and the development of elaborate theoretical models, but derives its inspiration from the observable (real) Universe.

In line with the concept of interpretation, a major interest in the Astronomy Section is in forging a link between extragalactic studies and insights from stellar evolution theory. Knowledge about stellar evolution can thus be employed to develop detailed models and scenarios for the stellar populations that constitute the bodies of galaxies. In a novel approach, this can then be inverted and the observed properties of galaxies used to place constraints on the evolutionary paths of stars.

With many large observational facilities becoming available and with the latest generation of instruments producing ever larger amounts of data, an activity quickly gaining in importance is archival research. Many of the existing data sets in freely available archives have not yet been fully exploited and much valuable scientific information can be obtained by “data mining”. While several of the projects in the Astronomy Section are already of this kind, a wider ranging involvement will include the construction of clever search routines.

The vastness of the Universe, the variety of observational techniques at different wavelengths and the broad range of physical processes and mathematical methods required for modern research in Astronomy demand that several areas of expertise be represented among the academic staff in the Section.

5.1.1 Development of the Astronomy Section

When Dunsink Observatory became the Astronomy Section in the School of Cosmic Physics of DIAS (1947), the main emphasis of research was on our Sun and on some early applications of electronic photometry. The Sun remained the main theme also in an interim period, between 1958 and 1963. The next thirty years were characterised by stellar photometry, typical of research activities carried out in many institutes in the sixties, enjoying for a number of years access to the Boyden telescope in South Africa. During these years there were however a couple of important additional programmes: theoretical work regarding orbits of comets and asteroids and the construction of detectors. Also, later on in this period, the first few computers appeared.

Since 1994 the research activities have been brought up to the level encountered in major institutes elsewhere. The main areas now investigated are extragalactic in nature, with a significant connection to stellar

[10] There would be a very good case for the Institute applying under the Foresight scheme for a new school of Fundamental Information and Communication Science to be run along these lines; there would be a natural synergy between the School and parts of both Cosmic Physics and Theoretical Physics, it would be a very good way to evaluate the working of a “negotiable salary but fixed term” contract-only School, and there are indication that the SFI would very much like to fund an autonomous research institute. The scale and directed nature of the SFI funding (at least in the first round) make it very difficult for the existing Schools to apply.

evolution and massive stars. Wavelengths outside the optical range are now important, computer terminals are widely available, observational data come also from satellites, large databases and user-friendly data reduction packages determine much of the work. The current focus on high-energy (X-ray) observations is a topical choice, inspired by the current novelty and generous supply of high quality X-ray data. The instrumentation development is carried on with an involvement in one of the instruments onboard ESA's INTEGRAL satellite.

5.1.2 Access to observational facilities

Since 1979, the School of Cosmic Physics (and the other Irish institutes where astronomical research is carried out) has benefited from a partnership with the Observatory on La Palma (Canary Islands). Additional opportunities for optical work may arise at other observatories from collaborations with colleagues abroad or using small percentages of available observing time allocated for outside observers. Measurements from Earth satellites have become a regular source of observational material (note that Ireland is a member of the European Space Agency (ESA). Dunsink, together with the Space Science Group at UCD, will have special access to data returned by the INTEGRAL satellite. Otherwise, further instrumentation projects will generate proprietary data or amounts of observing time.

Currently an application is with the Department of Education for a provision for a small optical telescope. This will be devoted to some very specific measurements, to be operated automatically from a good site. It will be obvious that such a relatively minor facility does in no way cater for the regular observational needs.

The future needs of observational astronomy demand access to telescopes of various sizes, but notably including 8–10m class telescopes. The Irish astronomical community has recently been discussing conceivable future observational facilities and considers as the most desirable options:

1. Ireland joining the European Southern Observatory (ESO).

2. A radio telescope located in Ireland that can participate in the MERLIN and E-VLBI networks.

3. Obtaining an intermediate-size, robotic telescope.

Also in the future as now, observations from space will be crucial for access to the very important X-ray and Infrared bands. Hence it is vital that Ireland remains a member of ESA.

The computer network at Dunsink is appropriate for most of the current requirements. However, in view of the conceivable increase in modelling work and the opportunities for archival research in the coming years, a further development of the computer set-up is to be expected.

5.1.3 Anticipated Research Programme

The main themes that have been developed since 1994 will continue to determine much of the astronomical research activity in the coming 5 years. The connection of extragalactic astronomy with insights from stellar evolution, in the detailed way that is pursued at Dunsink, is a new and very promising approach with abundant opportunities for modelling, interpretation and observations. One of the important issues that this work will clarify concerns the relative importance of nuclear regions and stellar populations as contributors to the high-energy spectra of galaxies. There is a clear need to support the X-ray measurements with optical observations, for which expertise in optical extragalactic work has to be brought in. The interpretative and modelling, activities could be advanced significantly by including dynamical effects with the help of a Grape computer. This will require, besides purchasing a Grape machine, new manpower at staff or postdoc level.

Related issues concerning the short but impressive lives of massive stars will be investigated as well, in support of the population synthesis simulations. In line with this, a number of projects is suggested by our recent work on the so-called runaway stars.

An exciting possibility, that is just becoming feasible thanks to advanced satellite observatories, is the detailed study of individual sources of high-energy radiation in other (though nearby) galaxies, with a combination of X-ray, optical and radio measurements with high spatial resolution. Here, again, supporting expertise with extragalactic optical observations is needed and it will be advantageous to secure in addition expertise with radio observations. The high-energy information in particular will help to assess the evolutionary status of different stellar populations in a variety of galaxies. One PhD project of this sort has just started at Dunsink.

Similarly detailed work can be done regarding the inner structure of galaxy centres, around their actual (often active) nuclei. Probably the majority of the galaxies harbours Supermassive Black Holes in their centres, which can power nuclear activity or may alternatively be dormant. Attractive frontline projects, leading to a better understanding of the build-up of the centralmost region, are however awaiting additional manpower. The prevalence of nuclear activity among galaxies, from quasar-like strength down to its lowest recognizable levels, constitutes a main line of on-going research at Dunsink. On a related issue, new derivations and analyses of Luminosity Functions (descriptions of the number density of a particular class of object, as function of luminosity) of active galaxies and specifically of their nuclei can be expected in the first half of the 5 year period coming up.

Some of the projects of the last few years dealt with aspects of the Large-Scale structure of the distribution of galaxies in the Universe. More and more research opportunities are arising here as several big redshift surveys are being carried out. Problems regarding the processes governing the arrangement of the galaxies in the Large-Scale structure can be investigated with interpretative projects and with model simulations. The ultimate probes of the Universe at large are likely to be the newly discovered Gamma Ray Burst sources. This young field develops very quickly and will undoubtedly bring many more surprises and new insights. It will be important and rewarding to participate in this work from the observational side, which requires an additional staff member or postdoc. The intended small automatic telescope is to contribute specifically to this topical research.

Archival research, exploiting big and sometimes complex databases in which the observational material from major facilities is collected, is of increasing importance besides actually securing the original measurements by winning observation time. The concept of generally accessible data archives is particularly well developed in Astronomy. With large amounts of data available and interests in information technology surrounding us in the current Irish political climate, a serious effort must be made to obtain extra funding in support of this activity. The Information Technology component of the new Science Foundation Ireland's funding offers opportunities for this type of work and Astronomy provides the suitable framework for such an enterprise. A substantial project, involving advanced data searching and automatic data reduction, has just started in the Astronomy Section. It should be noted that such data mining techniques are of much wider applicability than just in Astronomy and may attain economic relevance.

The instrumentation work on the Optical Monitoring Camera on the INTEGRAL satellite is coming to an end. New projects are being organized for the coming few years. So far three conceivable instrumentation projects are under investigation: a contribution to the HIRES instrument aboard ESA's FIRST satellite, a CCD camera for the renowned Byurakan Observatory (both in collaboration with the Space Science Group at UCD) and quite possibly contributions to our own small automatic telescope.

While the above programme is substantial enough to stimulate further projects during the next few years, it is interesting to mention also some new directions that may be anticipated when extending the outlook beyond five years from now. One aspect of the population synthesis modelling development that may well grow in significance concerns the interaction between Supernova Remnants and the ambient Interstellar Medium. The investigations into the role of (strong) starformation in galaxies can be pushed further out to include galaxies at high redshifts – and thus to very early stages in the evolution of stellar systems. Important instruments for such studies are ESO's Very Large Telescope and ALMA (a huge submm/mm array to be erected in a few years from now). The latter instrument will facilitate many original projects that are relevant to our research programmes. Further opportunities for dealing with novel sub-mm data will arise if a participation in the FIRST satellite materializes. Interesting data from the INTEGRAL satellite will further become available to us on the basis of our contribution to the Optical Monitoring Camera construction. These are most likely of interest to the work on incidental activity periods in normal galaxy nuclei. This special source of data has to be exploited with a dedicated postdoc.

5.1.4 The Astronomy Section in relation to groups abroad

An ultimate goal for the work in the Astronomy Section is to achieve a research level in our areas of activity that is competitive with the work produced in leading institutes elsewhere in the world. A perhaps more interesting, "intrinsic" way to formulate scientific aims is to refer to the actual advancement of knowledge that is pursued: to clarify the high-energy output from active and Starburst galaxies by evaluating their emission characteristics with the help of our knowledge about stellar evolution; to lead searches for cores of activity in the nuclei of galaxies, powered by Supermassive Black Holes; and, to advance generally within the Astronomy Section a largely interpretative way of working in order to deepen the scientific outcome of the various projects. In any case, the astronomical work must play a role in the accepted mainstream of astronomical research. Currently, collaborations with institutes and observatories abroad include places like Bologna, Rome, Leiden, Garching, Cambridge, Edinburgh, Hawaii, Mexico, Kyoto, St. Petersburg, Porto, Madrid, Liège, Uppsala, Vienna.

One could think of setting specific benchmarks for the goals to be achieved, but it is probably not straightforward to find suitable measures for this. A major reason for this is the abnormally low staffing level in Astronomy: any comparison with the well-recognized groups in other countries appears useless because of the invariably much larger group sizes elsewhere. The current staff structure in the Astronomy Section leaves nearly all administrative tasks necessarily with the Senior Professor, which clearly restricts his active engagement in the research projects. An additional reason concerns the lesser research grant possibilities compared to many communities abroad.

Nevertheless, as of Astronomy, some typical figures of merit may be considered in order to evaluate academic research performance. Staff could for instance be expected to settle on a certain publication rate in main refereed journals. For Research Students a useful rule-of-thumb is to have produced as many major papers as the number of years they worked on their theses, by the end of that period. This provides a clear aim for them and assists them to be competitive in postdoctoral job searching. Any further thesis results should be published within a couple of years from the end of their thesis period. Another interesting point is, of course, what their next job is going to be. Evaluation of projects is also a relevant exercise: what was the gain for the institute – in papers, in meaningful scientific results; were the original aims met; what other products were delivered.

5.1.5 Education and Outreach

Several staff members engage in lecturing, chiefly at Trinity College. The Astrophysics Option in TCD's Physics Curriculum was set up by E. Meurs in 1995 so as to provide a broad coverage of the many sub-areas in our field. Fourth-year students come to work on their research projects, between October and Christmas. Some continue with MSc or PhD Thesis projects, which constitute an important aspect of our activities. Of importance to their education are regular seminars on relevant research topics and also the encouragement to go at least one time per year to a conference or on a collaborative visit abroad.

While much of the educational programme is done voluntarily, this service to the universities assumes an important mutual interest in that this prepares a next generation of astronomers. But the intentions of our educational activities are not just confined to raising astronomers. More generally, research students should acquire abilities that enable them to function professionally in a range of scientific activities, including notably the area of information technology. Relevant general abilities include for instance dealing with quantitative data of any kind, the development of critical thinking and learning to write clear scientific reports.

Dunsink has for long been engaged in outreach activities, informing the public at large about our area of science and about our academic work. Open Nights for the general public have been held since at least as early as 1896. The continuing interest in the Open Nights has led to enhancing these activities by arranging an Exhibition Room with a computer-controlled ceiling model of the Solar System, specially designed information panels and a computerized quiz machine (opened 1997). Other highlights at these visits are the Meridian Room (where video presentations may be given) and the South Telescope. A Development Plan for the School's outreach programme in Dunsink[11] was approved by the Governing Board in 1999 and establishes the further directions to take; the Board agreed that the public profile of Dunsink is a valuable asset for the School and that a research presence at Dunsink is important. In many respects Dunsink is perceived as the National Observatory of the country; as a consequence of this role a substantial stream of enquiries is dealt with. Besides this information service to the public, informations at professional level are supplied regarding *e.g.* lighting-up times (for court cases, architects, aviation, etc.) and aspects of time in general.

After the two Domes of the Observatory were recoppered in 1998/99, steps are being taken to increase the throughput of groups paying a visit to Dunsink during the day (notably schools). Along with these activities the Astronomy Section hosts every school year several Transition Year students for their Work Experience.

5.1.6 Requirements: staffing, budget

The overall programme described in the above sub-sections defines necessary requirements for the research work of the Astronomy Section in the years to come. That the current staffing is far too small is well-known by now. For a start, at least another capable researcher, at professorial level, is urgently required and will allow a better spread of various administrative tasks, also being an appropriate deputy for the Senior Professor and Dunsink Director. In line with the research plans described above, a preferred choice will be a person with expertise in optical extragalactic work. One has to appreciate here that the Professorship is vacant for almost seven years now and that the only other academic research position, currently an Assistant Professorship, is not actively engaged in modern research. With the Assistant Professor retiring not long from now, the third position of the basic Staff complement in the Astronomy Section should be used to secure a basic coverage of expertises needed[12]. However, as also argued above, it is essential for a modern astronomical research group to ensure that the coverage of expertises and areas of study is not too marginal. Three staff members involved with academic research constitute still an undersized group, a more comfortable size will be attained with *e.g.* five persons (and will be a good move in the direction of a 'critical mass'). This point is obvious from any comparison with the many institutes and observatories abroad: it is difficult to find group sizes of 3 or less anywhere. The anticipated research outlined above indicates all in all six suitable choices based on these plans (work on Starburst galaxies, detailed observations of active galactic nuclei, Gamma Ray Burst sources, Supernova Remnants and their interaction with the Interstellar Medium, high-z galaxies and starformation, work with data from the INTEGRAL satellite; assuming that the important broadening of observational expertise to several wavebands is taken into account). For the next years, realistically at most two of these six possibilities will come out of external funding (if a postdoc level is considered sufficient for the research involved). The work with data from the INTEGRAL satellite and the Gamma Ray Burst sources may be the most suitable opportunities for external grants. The proposed Archival Research Unit is an additional venture and is likely to be dependent on outside funding. At the end of the coming 5 year period the Experimental Officer will retire and, given the evolution of Astronomy in recent years, may have to be replaced by a computer manager.

Finally, a word on budgetary requirements. Apart from the simple fact that more staff needs more overheads, the outlined plans do not have to stress the Non-Pay budget much more than is the case at present, except for more stationary etc., traveling (notably more observing trips) and regular computer expenses. In particular, involvement with advanced archival research will lead to some additional expenses in this area.

[11] 'The Visitors' Facility in Dunsink: operation and further development' (1999)

[12] One should notice here that this (presently even not met) core staff complement is hardly different from 1947 when Dunsink became part of DIAS).

5.1.7 Conclusion

In order to build up an Astronomy Section that is completely competitive internationally and can bear comparisons with even small groups elsewhere, one has, as argued in the above subsections, to ensure a basic core of staff. With typically five tenured staff members (including the Senior Professor, not counting a computer manager) a number of crucial strategic aims are achieved: (a) sound coverage of essential expertises (regarding area of research as well as observational techniques); (b) sufficient stable manpower to be a viable partner for network collaborations; (c) enough weight to enter in partnerships for the big observational and instrumentation ventures that are being developed in several key places of astronomical research; (d) efficient involvement with space instrumentation projects that require a sustained effort over a length of time. Coverage of such a range of strategic aims is required by the present-day research in astronomy as conducted internationally.

Such a staff structure is appropriate for the anticipated research programme outlined above. In addition, temporary staff engagements are suitable especially for: (i) sub-activities of space projects (aspects of instrumentation or of software, processing of preferential data); (ii) research of very topical nature that may witness a limited number of top years (e.g. Gamma Ray Bursts); (iii) involvement with data mining and archival research, for which substantial outside funding is to be sought. Obviously, several predoctoral studentships

Dunsink Observatory is the only component of the School – and, notably, of DIAS as a whole – with a well-established public image. Dunsink can, as specified in the Lease, only be used for the purposes of the School of Cosmic Physics (the Lease runs for another 46 years still). As a listed building it can attract grant aid and its demesne has great strategic development potential. Further assets of particular value are the only professional astronomical library in the country, the only fully fitted electronic workshop in the School and the public information service.

5.2 Astrophysics

This section is mainly a theory section, but one which is close to experiment and actively involved in observational work (an aspect praised by the Longair report). By its nature theoretical work is less predictable, and tends to be less organised, than experimental or observational work. However it is reasonably certain that there will continue to be two main strands of research activity in the astrophysics section over the next few years, one dealing with star formation and associated outflow phenomena, the other with non-thermal particles, high-energy astrophysics and cosmic ray physics. Both areas involve shock physics, gas dynamics and magnetic field effects so that there is considerable synergy between them, particular in the area of computational modelling.

5.2.1 Development of the Section

The high-energy astrophysics builds on a substantial body of work dealing with various aspects of diffusive shock acceleration theory carried out over the last two decades, most recently in the context of HCM and TMR European networks. Although much remains to be done in the non-relativistic applications, current interest is in extending the theory to relativistic shocks motivated by recent observational breakthroughs in micro-quasars, blazars and gamma-ray bursts.

Much of this work involves areas of plasma astrophysics, in particular wave-particle interactions and turbulent transport theory, which have close connections to fusion plasma theory. On this basis the group helped to initiate the Irish fusion association and participated in its Euratom funded programme for a number of years. However in practice the constraints imposed by what is fundamentally an engineering programme, combined with success in obtaining alternative TMR funding and pressure of administrative work, made this increasingly unattractive. This fusion plasma work is now being scaled down and will probably be phased out altogether in the next few years.

The star formation work in the Astrophysics Section has concentrated on understanding outflows from young stars both from a theoretical and an observational perspective. This has been part-funded by a variety of external grants, e.g. from Enterprise Ireland and the European Space Agency (ESA). On the observational front the group have benefited enormously from the opportunities provided by the SERC/NBST/DIAS agreement and have extensively used UK optical facilities in La Palma (e.g. the 2.5m Isaac Newton and 4.5m William Herschel Telescopes) and infrared/millimetre facilities on Mauna Kea (e.g. the United Kingdom Infrared Telescope and the James Clark Maxwell Telescope) over the past few years. There is no doubt that usage of such facilities will continue into the future but it is becoming increasing obvious that, in order to retain competitive advantage, the group will require access to even larger telescopes such as the twin Gemini Telescopes in Hawaii and Chile and/or the European Southern Observatory's Very Large Telescope (VLT). In a wider context, access to such optical/near-infrared facilities is seen to be a high priority for the Irish astronomical community as a whole.

Ireland is a member of ESA and this has allowed the group access to space borne facilities such as the Hubble Space Telescope (HST). The HST work has largely been in collaboration with the Max Planck Institute for Astronomy in Heidelberg and the Tautenburg Observatory near Jena. Imaging and spectroscopic studies of outflows from low mass stars (i.e. similar in mass to our Sun) and their more massive counterparts are pursued. Recently diagnostic tools have been developed by the group to determine fundamental jet parameters such as ionisation fractions and temperatures. Theoretical efforts have concentrated on numerical/semi-analytical modelling of jets from young stars both close to their origin and at larger distances where one is more concerned about how they propagate through their environments. Such modelling is complicated by the fact that one has to allow for cooling by ionised, atomic and molecular species as well as molecular dissociation. The group has made tremendous progress in this area and their research has benefited enormously from the excellent computing services provided by the School.

5.2.2 Research target areas

With the above background, expertises and strengths in mind, a number of initiatives are now being actively considered or pursued

- Acceleration Theory

  The nonlinear theory of diffusive shock acceleration is still quite obscure. Recent analytic work by Malkov, although clearly significant, is difficult and still needs physical interpretation. There are reasons to think that this might actually, in some senses, be easier in the time-dependent spherical case than in the stationary planar case usually studied. The objective for the next few years is to understand better the nature of Malkov's universal asymptotic solution and to study to what extent it actually applies to realistic spherical shocks.

- Gamma Ray Bursters

  The recent definitive identification of gamma ray bursts as being at cosmological distances has shown them to be the most powerful explosions known and it is now universally accepted that the emission comes from an expanding relativistic fireball (with typical Lorentz factors of several hundred). Existing models are however still very crude and phenomenological. This is clearly an area where a group with expertise in relativistic hydrodynamics and particle acceleration theory can contribute by developing improved models.

- TeV emission in Blazars

  There is still debate as to whether the TeV emission seen from nearby Blazars is of leptonic or hadronic origin (although the general view certainly favours leptonic models). Even within the leptonic models it is not clear whether the emission is synchrotron self-compton or whether an external radiation source is needed. The answer can only come from improved models and more observations. Some of the tools developed in the section, in particular the so-called box models for particle acceleration, appear very suitable for incorporation into models of flaring activity in Blazars and it is intended to do this in preparation for the analysis of first-light results from HESS.

- HESS

  On the basis of personal contacts and theoretical strength the School was invited in 1999 to participate in the development of the High Energy Stereo System (H.E.S.S.), a major European project to build a next generation imaging atmospheric Cherenkov telescope array in Namibia. The large consortium is lead by the MPI für Kernphysik in Heidelberg and construction, which has already started, should be complete by 2003. The section will contribute, in addition to theoretical support, one student to help with the assembly, testing and calibration of the system.

  This experiment, together with the VERITAS proposal in the United States and the CANGAROO 3 project in Australia, will open a new observational window for high-energy astrophysics in the $10\,\mathrm{GeV}$ to TeV region. Already the current Whipple and HEGRA projects have given tantalising hints of what we may detect. The new facilities, of which HESS should be the best both from construction and location, will certainly give new insights into particle acceleration in blazars, pulsars and supernova remnants which will give fresh impulse to the theoretical models developed in Dublin.

- Laser simulations

  Something of a long shot, but potentially very interesting, is the use of the next generation of high-power laser facilities to simulate astrophysically interesting systems and processes. Most of the published discussion of this has concentrated on purely hydrodynamical simulation, which is not very interesting (the computers are rapidly overtaking the experiments, and one does not really expect to learn any new physics) although useful. What is interesting is the possibility of studying collisionless shock physics and plasma phenomena in parameter regions which were previously inaccessible.

- Advanced computing

  Numerical simulations are a key tool in large parts of modern science, but particularly in astrophysics where the use of detailed computational models has a very long history. The new 32 processor cluster which has just been commissioned gives the section by far the best environment for developing and running large parallel hydrodynamic and magnetohydrodynamic simulations in Ireland, and with the exception of the large national laboratories in the United States, probably one of the best in the world. This advantage must be aggressively exploited over the next few years, and the facility updated as necessary.

  An example of how this advantage might be exploited is in understanding the origin of the low and high velocity outflows seen from young stars. Although the high velocity emission is thought to come from a jet, the origin of the lower velocity emission is poorly understood. There are a number of suggestions involving the dynamical interaction of the jet with its surroundings that could be simulated using the new DIAS cluster.

- The IRMA and DOSMAX projects.

  In a follow-on to the successful recent large-scale investigation of cosmic radiation at aircraft altitudes during solar minimum (1995–1999) work will continue in collaboration with European partners to measure the fluxes of Galactic and Solar energetic particles through the current maximum of the solar cycle (2000–2003).

- Cosmic Ray experiments.

  With the conclusion of the Ultra Heavy Cosmic Ray Experiment no further major experiments in this area are planned. However, as often happens, two interesting opportunities have unexpectedly arisen to keep contact with this field. A group at Moscow State University has proposed a novel technique for measuring the charge and energy spectrum of cosmic rays using silicon microstrip detectors and a clever kinematical, rather than calorimetric, technique for energy estimation. The ultimate aim is to build a light-weight experiment to carry out direct measurements in the “knee” region, but this will be preceded by a proof-of-principal flight on a Russian satellite with an approved launch in 2004. To date our involvement has been confined to a lot of advice and assistance with INTAS proposals; we would probably not want a major involvement, however it is an interesting and worthwhile project, and our colleagues in the former Soviet Union deserve our support.

In a parallel development, recent results from Dubna and Berkeley have revived speculation about a possible island of stability for nuclei around charge 114–118 and given fresh impetus to searches for these super-heavy nuclei using nuclear tracks in natural crystals. DIAS has acted as the Western coordinator for an INTAS proposal involving several former Soviet Union colleagues and will play a role in these studies, if successful.

- The Next Generation Space Telescope (NGST)

The section has been asked to join the NASA/ESA consortium building the mid-infrared (MIR) camera/spectrograph for the NGST. The NGST, successor to the Hubble Space Telescope, is due for launch around 2007 and MIR is one of its 3 recommended instruments. It is a combined camera/slit spectrograph sensitive over the range 5-28 microns. The primary scientific objectives of MIR include understanding the physics of protostars, circumstellar disk mineralogy, observations of obscured starbursts and determining the cool stellar mass function. This instrument will be ideal for follow-up studies of new mid-infrared sources discovered by the Space Infrared Telescope Facility (SIRTF) and the Infrared Space Observatory (ISO). It is hoped that funding for Irish participation will come from ESA’s PRODEX budget complemented by an ESA Fellowship.

- Determination of the Initial Mass Function for Very Low Mass Stars

Although the relative number of stars per unit mass range in the Galaxy is well known for stars with masses greater than about a tenth of a solar mass, their distribution at lower masses is poorly constrained by observations. This is the regime where we enter the transition from star to planet and so its determination is of fundamental importance. In large part our ignorance is due to the very low luminosities of such stars once they have evolved onto the Main Sequence which makes them difficult to detect. Their luminosities however are much higher when they are young. Thus studies of young star formation regions could potentially provide us with this fundamental function. It is hoped to pursue this research in collaboration with the Max Planck Institute for Astronomy in Heidelberg possibly using Alexander von Humboldt Foundation funding. An EU network is also being developed to study such clusters and the section could join as a partner.

- Kinematics of Outflows from High Luminosity Young Stars

Although a lot is now known about outflows from young stars similar in mass to the Sun, relatively little is understood about this phenomenon in the case of their higher mass counterparts. Such stars tend to be rare, and thus typically further away, so their flows are more difficult to study. Nevertheless with the availability of larger telescopes and higher resolution techniques (e.g. adaptive optics), detailed observations of outflows from high mass stars is now within our reach. With such observations it is hoped to address such problems as to whether the outflow phenomenon from low and high mass stars are essentially the same apart from a factor of scale, something, which is currently in doubt. This project could be pursued with a combination of DIAS/Enterprise Ireland funding.

5.2.3 Resources

A world-class computing environment is essential for the work of the whole School, but particularly for this section. In large part this has been achieved, but constant upgrades and investment will be needed to maintain this position and improve it. A vital factor here has been our ability to attract very able young people with experience of Unix system administration as experimental officers. With the new UMa parallel cluster providing a dedicated environment for high performance computing, and the planned graphics laboratory, excellent facilities are now becoming available.

5.3 Geophysics

The Geophysics Section has the good fortune to be surrounded by a magnificent natural laboratory. Ireland lies on the edge of a very complex continent/ocean margin, the transition from the NW European continental crust to what is still quite a young expanding ocean, the North Atlantic. The ocean between the margin west of Ireland and Greenland only began to open about 60 million years ago, a very short time in geological terms. The common theme linking our work in the East African Rift, Hawaii and the NE Atlantic is that all relate to complex geodynamic processes deep within the Earth. The East African Rifts are likely to be the beginnings of a new ocean. Many structures in the North Atlantic are also strongly influenced by the Iceland plume. This probably originates near the core-mantle boundary (CMB) and the Section's work has recently been extended to the study of the CMB and the Hawaiian plume in the Pacific. Exciting results have been obtained.

Ireland also contains the track of the Iapetus Suture Zone. In Ireland this extends from Co. Louth to the Shannon Estuary and it is the site of the closure of the previous “Atlantic”, called the Iapetus Ocean. Ireland as we know it today was split by that ocean, with the northwestern part of the country being on the other side of the Iapetus. This therefore also gives us an opportunity to study collisional tectonics, where two continental masses collided. Some very unexpected results (the real and exciting reason we do fundamental research) have been achieved, indicating that this is a fruitful area for research in the future too.

The focus of the Geophysics Section in the next few years will be on *seismology, gravity studies* and *geological controls* for the geophysical work. These are closely interconnected disciplines and powerful tools for the study of our planet. This applies whether studying the shape and texture of the bottom of the Rockall Trough (AIRS and TRIM projects) or the deep structure beneath it (RAPIDS). All these projects are relevant for strategic national resources. Linked research has attacked the problems associated with rifting throughout the world (e.g., West of Ireland (RAPIDS), the East African Rift (KRISP)). In addition, work is being carried out in what might be termed tectonic collision environments (VARNET and the Leinster Granites project, LEGS) and in studies of deep Earth structure (COMBO and HAWAII). Some of these projects are virtually complete, others are in progress. All those in an advanced state have provided unexpected and fundamental discoveries. Some of these are of economic importance. Some of the most exciting results were a surprise to us and others in our research field. We believe that the tools we are using are likely to be the most productive for a small but innovative group like ourselves.

Much work in Geophysics now involves large projects which require cooperative work between international groups. Our record has made us highly respected partners, a significant asset when seeking the outside funding that is vital for such projects. Our current staff and government funding are an important platform, but only part of the story. Therein lies an important, indeed dominant, factor in the precise directions our research may take. Like every other research group or organisation, we submit more proposals than are funded. We may be successful in a number of applications one year, none the next. This gets smoothed out over the years, but it can be difficult to deal with at any one time. We have to believe in our methods and targets, and that the targets may be achievable. However, results, sometimes quite early ones, can change the whole direction and emphasis of a given piece of work. We would not be in research if we were not open-minded and alert to new ideas. It is often difficult to convince funding agencies that research is not the orderly gathering and processing of data to produce results that were expected anyway. It is quite incredible how many application forms, in effect, want the answers before you start. Sometimes, of course, the project is set up to discriminate between two conflicting theories. That is easier to explain to the outside world.

5.3.1 The way forward

The way forward lies in balancing "basic" or "fundamental" projects with research which might be considered more "useful". An example of useful ones are those in the area of hydrocarbons with the Petroleum Geology Unit of the UCD Department of Geology and with the University of Hamburg, and in detailed hazard assessment in, for example, Greece. Our part in both these areas is in fundamental aspects of the problems. Other fundamental work would concern the world's rifts and deep structures in the mantle and core. Our potential partners are numerous in the latter areas and include the Universities of Leicester, Karlsruhe, Lisbon, Strasbourg plus the British Geological Survey, Edinburgh, and the GeoForschungsZentrum Potsdam. We have to preserve a clear view of the direction we would like to go with a flexible and resourceful attitude to how results might be achieved.

5.3.2 Research target areas

A range of techniques are used in each research area. All include problems of basic scientific interest and potential for unexpected findings.

- The structure and development of the North-East Atlantic (Irish and oil company funding)

  This continues to be an area of enormous interest. There is a fortunate coincidence between fundamental research topics and applied targets of interest to the oil industry. Many techniques have been used by the Geophysics Section. These include wide-angle seismic (so detailed that near-vertical processing and interpretation can also be used), side-scan sonar, gravity, and "ground-truthing" using geological data from core-sampling by other groups. In addition, our network of seismic stations in Ireland has recently identified earthquakes on the margins of the Rockall Trough. This is of great interest to us as an academic study and to the oil companies from the point of view of slope stability in potential hydrocarbon source regions. Offshore monitoring, therefore closer to these events and using broad-band ocean bottom seismic stations in a co-operative project with Hamburg, would also give us data about the upper mantle structure below the Trough. This is a good example of a combination of applied and basic research, one of many.

  Ireland is currently putting a great emphasis on research and development offshore. This is demonstrated by the Seabed Survey, scheduled to take about six years and for which the Geophysics Section and their partners in UCD have applied to do the deep seismic work. The total Seabed Survey programme will cost about 21 million IEP. Another example of Ireland's new-found commitment to the seas and oceans around us is the fact that the Marine Institute research fleet, already equipped with a new vessel, the 31.4 metre Celtic Voyager is to be further augmented by a new 65.5 metre vessel which will be commissioned in 2001 and will give us a full ocean-going capacity. This will be a splendid resource for further geophysical work offshore.

  This emphasis on offshore research is very timely from the point of view of the Geophysics Section and will give great opportunities for further work on this complex and interesting ocean margin. The work will be carried out by a very strong team, drawing on the experience and skills of DIAS Geophysics, UCD Geology and the Hamburg Geophysics Department. The advent of the parallel cluster gives us a very powerful new tool for calculating seismic wave transmission in heterogeneous structures, very important for further progress. The prominent position of the group in world research on ocean margins should be further enhanced.

- Theoretical studies of rheology (Irish and EU funding)

Theoretical and numerical work in rheology will be necessary for further advances in understanding some of our experimental results. The advent of the new parallel cluster will make it possible to carry out the very large numerical computations required.

While our seismic experiments, combined with our gravity studies, provide unique information on the patterns of deformation in the Earth's lithosphere (usually about the top 100 km), it is difficult to trace the physics of the processes which have led to the structures we observe in the Earth. For example, much progress has been made in kinematic modelling of lithospheric extension, magmatism and orogeny and the key role played by lithospheric rheology. These kinematic models have improved our understanding and led to important insights into lithospheric deformation, but a self-consistent dynamic model for mantle coupled to mantle convection has proved elusive. The close coupling between the thermal evolution of the lithosphere and its rheological properties in the context of the whole Earth system, is fundamental in controlling its deformation. The expertise required in numerical analysis and computing to devise and develop code to investigate these problems would be a shared resource with the Astrophysics Section. The computational, modelling and visualisation techniques are applicable to a wide range of problems in Earth and Space sciences.

- Onshore studies of structure in Ireland (Irish and EU funding)

  Gravity has applications to every geophysical and geological study of the crust and lithosphere. Specific examples are its role in understanding structural controls on the siting of mineral deposits, or its applications to tracing geologically significant drainage and sedimentation patterns related to the thermal and uplift history of the Atlantic region driven by past mantle convection patterns. Therefore it is important that more detailed studies of the gravity field should be actively pursued. This requires the gathering of new data in areas where coverage is currently too sparse. Some GPS equipment, which could be improved, is already owned by the Section but a new gravimeter is essential. More wide-angle seismic profiling, across the Midlands of Ireland and near the Iapetus Suture zone, is necessary to test models proposed, largely on the basis of our gravity data, for Carboniferous basin architecture and its influence on focussing fluid flow and controlling patterns of mineralisation. This has fundamental implications as Ireland is a classical example of a carbonate-hosted base-metal ore-field which is being studied worldwide. Passive studies, using the Section's broad-band seismic equipment are required to look at the deeper lithospheric signatures of the Caledonian and Variscan orogenies. These structures exert a fundamental and regional control on smaller scale processes responsible for tectonics, sedimentation and fluid flow in the Earth's crust. This research area will be of global interest and the results would be applicable to understanding similar orogenic belts throughout the world.

- Studies of the core, mantle and mantle plumes (EU and DFG (Germany) funding)

  Some of the most exciting work has been done in this area. It is high-profile, cutting-edge, fundamental research of great significance. The core-mantle boundary (CMB) is the birth-place of plumes which have a dramatic effect on the surface of the Earth in a number of active zones. Examples are Iceland, Hawaii, and East Africa. The Section has already carried out research in two of these areas and the RAPIDS results have relevance for the extent of the peripheral region of the Iceland plume's influence on such factors as heat flow, thermodynamic uplift and the complex sedimentation patterns in the (economically important) basins of the north Atlantic. Many plumes are associated with continental rifting and seafloor spreading throughout the world. One important result of our studies is that the importance of plumes in controlling continental break-up and the formation of large igneous provinces has varied significantly through geological time. Our future work will be focussed on what controls this variation and how changes in the patterns of mantle convection and continental break-up are interlinked. The questions that the Section's work in and around Ireland have raised about these topics are very relevant to our work farther afield in Hawaii and East Africa. For example our work in Hawaii is providing information about interaction between plumes and the structure of the Earth's mantle. This is a very exciting field to work in, as was noted in the Longair Report.

- Seismicity of active zones of Europe (EU and other funding)

  The Section has already been involved in EU and NERC (UK) funded work on European earthquakes. These events cause huge damage and many casualties (recent events in Greece and Turkey for example) so EU and other funding is available. The DIAS Irish network, now including the station in the Valentia Observatory, together with the Section's mobile broad-band capability, are essential aspects of DIAS involvement. As we develop our capability in projects which use natural earthquake sources, it is very useful to do work nearer home. The level of damage and casualties in the EU make this a subject where funding is available. Our western position makes us the best base for earthquake studies offshore (see Northeast Atlantic topic, above).

5.3.3 Equipment

We can make a judgement, based on experience, on what are the best current tactics and methods for our research and this involves some commitment in the equipment area. We have clear views on this. We need good broad-band seismic equipment, together with precise gravity and position measuring equipment. Some of the equipment we already have. What we lack at the moment is a few more (3-5) broad-band seismic stations and a modern gravimeter. These will give us the option to go in a variety of different directions, as circumstances and funding permit. It should also be said that some of our research just requires good computing power and ideas. The data may already be available. The new parallel cluster opens up a number of possible lines of research.

5.3.4 Staff

It is most important to have a core staff sufficient to be a serious contender for research funding from the highly competitive sources that are available. Sources of funding are identified in the brief outlines of research areas below. We consider that the present group of three senior staff (Jacob and Readman permanent staff, O'Reilly on contract) give a very good balance, covering seismology, potential field research and geological aspects. It would be better if the full complement of Senior Professor/Professor/Assistant Professor could be filled, giving the required stability. Other academic posts could all be contract ones but technical staff should also be permanent, so far as anything can be said to be permanent. This is one significant factor that helps us to attract good staff who would otherwise go to industry, especially in the current labour shortage of qualified people. Continuity in operating equipment is also important for overlapping and long-duration projects.

The rest of the current permanent staff are a well balanced team with an Experimental Officer and three Technical Assistants and a secretary. The group is amplified by a variable number of post-doctoral and post-graduate Scholars. Summer students have done good work too. All these provide the necessary support for a continuing and successful research programme.

Expansion of staff beyond the core group should be on a contract basis, governed mainly by the contacts won by the core group. A rolling complement of about 6 Postdocs and PhD students would give sufficient staff to carry out the work outlined above. Most of these would be funded by contracts but it is useful to have, as we do now, some element of pay funding for Scholars, generally up to three year contracts) where projects are of a very speculative nature. These are the projects which often turn out to be the seeds of major work later.

It has been pointed out elsewhere that the Universities find it hard to produce the continuity necessary for this kind of work. It is also not the sort of work that government agencies, like the Geological Survey of Ireland have shown themselves capable of, or interested in, doing. They are entirely applied in the their nature. Their surveys have to show promise of financial return, whereas we are looking for the information we need to develop our fundamental research.

The Geophysics section already has a record of doing work of high international quality. What it needs to continue and improve its work is sufficient staff and equipment. Both are discussed above. The “platform” of tenured staff needs to be adjusted slightly and contract staff need to be increased. Equipment is not far from what is required for the next five years. Funding for projects will mostly come from winning outside contracts but an improved non-pay base would make that more secure. Some items, equipment for example, are almost never provided by project funding.

All the five research areas of the Geophysics Section for 2001 to 2005 are detailed above and the goals may be summarised as the advancement of our knowledge of *continental rifting* and *collisional tectonics* (the two main influences on the development of the Earth’s lithosphere). *Plumes* and *deep Earth structure* can strongly influence these two zones and can be said to be contained within those two targets. The principal tools will be seismology and gravity studies with input from geological controls where available.

6 Goals, Benchmarking and Monitoring

We now extract a number of specific goals from the general aspirations and forward looks expressed in the preceding section. The important point about such goals is that they should be *attainable* and *verifiable*, not just general motherhood statements. There are, of course, other less specific things we want to do, and one of the great joys of science is that completely unexpected opportunities and discoveries keep turning up. This is simply a list of things we definitely want to achieve and feel we can achieve if given the necessary resources; we would certainly hope to do other, possibly more interesting and significant, things as well.

The goals are of three types, each requiring different monitoring and evaluation procedures. The first two goals specify essential infrastructural elements which are required if some of the following scientific goals are to be achieved. Progress in meeting these infrastructural goals can be monitored rather straightforwardly by benchmarking our facilities against those available in leading international centres.

The science goals are rather harder to assess, however the external scientific review panel, scheduled to visit the school in 2005, will be asked, as part of the review process, to report on the extent to which these goals have been achieved. Internally, progress will be monitored as part of the regular annual review of the strategy plan. Although they need to be interpreted with caution, indicators such as the number of papers published, impact as measured by citation rates, number of invitations to talk at international meetings, *&c* do allow a reasonably objective assessment of the extent to which the science goals are being achieved.

The last goal, relating to the profile of the School, is of a social and political nature, largely subjective, and probably the hardest to evaluate. However progress towards attaining this goal can be monitored by collecting statistics on media coverage, by feedback from the public and, if necessary, by sample surveys.

It is important to note that this is not a ranked list. On the contrary, the goals should be seen as interdependent elements which fit together to form an overall strategy for the School.

6.1 High Performance Computing

Aim to be internationally recognised as a centre for the use of high performance computing in Cosmic Physics.

The basic technical infrastructure for this is already in place with the inauguration of the new parallel cluster. The cluster will need to be upgraded or replaced in about 2002/2003 at a probable cost of around £100,000 to remain competitive. It is important to be able, not just to run large computations, but to display and interpret the results. Hence a graphics laboratory with good plotting and display hardware as well as the appropriate software tools is another necessary piece of infrastructure. Again, the basic elements are in place, and the subgoal here will be to maintain this support at levels comparable to other internationally recognised centres of excellence. Some of the technical assistants formerly employed in the experimental cosmic ray work will be redeployed part time in this area. Possible collaborations with, among others, Medialab-Europe and Dun Laoghaire Institute of Art, Design and Technology in the area of scientific visualisation will be explored.

6.2 Irish membership of ESO

To facilitate Ireland becoming a member of the European Southern Observatory.

This is the best complete package to serve the community (see Section 5.1.2). It will give access to two vital instruments, the Very Large Telescope and ALMA (a large sub-mm radio array), and integrate Irish astronomers firmly within the broader European astronomical community. In addition, membership of ESO provides access to extensive outreach services, to the development of Virtual Observatory enterprises, and the opportunity to participate in the planning of a next generation 50 metre telescope.

6.3 High-energy Astrophysics

Aim to be an internationally recognised centre for research in particle acceleration theory and the origin of cosmic rays.

Prof L Drury already has an international reputation as a theorist in this field, and the experimental work of the former cosmic ray section is well known, but the School is not really seen as an international centre because it is currently too small. To correct this it is essential that at least three postdoctoral positions be available in this area, one primarily theoretical, one more observational (to exploit the link to H.E.S.S) and one computational (to exploit the cluster). In addition there should be easy access to a visiting scientist position to allow short (few week) to medium term (few month) visits by scientists from other centres. This, together with the number of predoctoral students currently supported, will give a well balanced group capable of making a significant impact on the field *as a group and a centre* rather than as isolated individuals.

6.4 Star formation

Aim to be an internationally recognised centre for research on phenomena associated with young stellar objects and star formation.

Again, this is an area where Prof T Ray already has an international reputation, but more as an individual than as the leader of a recognised group. The solution is the same; to increase numbers to at least three postdoctoral positions, one predominantly computational to exploit the cluster, the others more observational, provide easy access to a visiting scientist position for short to medium term visits, and fund a matching number of pre-doctoral students.

6.5 Multi-wavelength Observations

To develop the broad range of expertise required for modern multi-wavelength observational studies of evolving extragalactic stellar populations and active galactic nuclei.

This requires an increase in the number of experienced astronomers on the staff to cover the various areas of observational expertise needed (see sections 5.1.5 and 5.1.6), ideally to five or six. There will be two main scientific areas in which this group expertise will be exploited (see section 5.1.3).

The first is work on evolving extragalactic stellar populations. Key expectations of this work include: (i) the clarification of the relative importance of nuclear regions and stellar populations as contributors to the high-energy output of galaxies; (ii) the derivation of new observational constraints on stellar evolution theory, from the information provided by galaxies at large; (iii) by extending this work to high redshifts, an investigation of whether stars or “proto-galaxian fragments” were the building blocks of galaxies.

The second major area is that of Active Galactic Nuclei and Supermassive Black Holes (where Prof E Meurs has an international reputation). Key aspects of this line of research are: (i) to probe in detail the immediate physical environment around the central powerhouse; (ii) to establish the prevalence of nuclear activity among galaxies, down to low levels of this phenomenon; (iii) to clarify questions surrounding the first appearance of Massive Black Holes at the time of the formation of galaxies

6.6 Data Mining in Astronomical Archives

To establish a group using modern networks, data-base techniques and statistical tools to "mine" astronomical archives and engage in activities as a "virtual observatory".

This will constitute the first enterprise of this kind in Ireland. The background to this is explained in 5.1.3. Apart from modest investments in network and computing infrastructure, a group leader and up to four other members (at various levels) are required.

6.7 Lithospheric and crustal geodynamics

Aim to reinforce and improve our position as a leading centre for research in crustal and lower lithospheric geodynamics.

We are already established as a leading centre for the study of the Earth's lithosphere and it has been a major part of our work in the last fifteen years. We are thus developing from a position of strength. It is a core subject in geophysics and will continue to be central to the work of the Section. In addition to the permanent positions required, this work will need three doctoral/postdoctoral positions on a rolling basis during the five years. Our targets are in both Earth structure and in the methods used to study it. The work ties in with our deeper Earth studies as the processes involved have their origins deep in the Earth. The fine natural laboratory surrounding us has been referred to earlier in the text and is a huge advantage. Particularly interesting developments are anticipated with the acquisition of the powerful parallel computing cluster which will enhance our processing and modelling capabilities.

6.8 Deep Earth Structure

Aim to make a leading contribution to the study of deep Earth structure, with particular emphasis on mantle structure and plumes.

This is a recent area of research for the Geophysics Section but already important contributions have been made to the knowledge of the core-mantle boundary region. Current research includes a detailed study, using our broad-band seismic equipment, of the structure and evolution of the upper mantle part of the Hawaiian plume. This will be extended to include a study of the base of the plume, work which is crucial for understanding the physics of the plume as a whole. A further programme of work on the upper mantle will be started in Ireland in 2001. A very strong upper mantle velocity anomaly within the region of the Iapetus suture zone found during one of our onshore seismic experiments will be the first target of the study. The proposed programmes of work will require three doctoral students/postdoctoral positions.

6.9 Rheological processes

Aim to develop a capability in computational studies involving the rheology of the Earth.

This is a very wide-ranging research area. An understanding of the deformation and flow processes provides the theoretical underpinning for many geophysical processes, including those which lead to the development of sedimentary basins and continental margins. Rigorous quantitative theoretical studies are required to test the more conceptual models we have developed for the development of these features. This will enhance the achievement of goals 6.7 and 6.8 above. Thus the work, although largely theoretical, is related to our experimental work. It will require additional mathematical and computational expertise (considerable use of the parallel cluster will be made) as well as a geoscientific background. We will initiate this work with one postdoctoral position to be joined later by doctoral students.

6.10 Profile of the School

Aim to raise awareness of the School among the general public, academia, the media and at political level.

This will require the Board to adopt policies and procedures which facilitate and encourage media contacts, and to provide resources for the employment, where necessary, of professional advisers. An information officer role should be developed within the School, possibly as part of the job description of the proposed School Administrator.

7 Implementation Plan

7.1 Staffing

Staffing is the single largest obstacle to achieving the strategic goals identified above. The first priority should thus be to reach agreement as quickly as possible with the Department on the introduction of the proposed Schrödinger fellows. As part of the package agreement should be reached on a core staffing complement of permanent staff based around the existing three, and possibly one or two new, senior professors supported by a similar number of professorial positions.

The Governing Board's 1999 plan called for each group to have a core establishment of three permanent academic positions and this was endorsed by the Longair review as an absolute minimum. In addition the Longair report made a very strong recommendation that the number of postdoctoral fellows supported by the School *out of its own resources* should be not less than 6 and preferably 9 to 12 (*ie* between 2 and 4 per group). Obviously if new groups based around new senior professors were to be added, these numbers would have to be increased proportionally.

To achieve the goals listed above the School requires 18 postdoctoral positions. To allow a transfer of skills there should be some overlapping of appointments, so this number should be increased to 20. From past experience we believe that half of these positions could be funded from external contracts, leaving ten to be funded from own resources, a figure in line with that recommended by Longair.

Each section should have a visiting scientist position permanently available to it, rather than just every third year as at present.

This package of measures would largely address the most serious weakness of the School (small size), rationalise the staff structure, boost staff morale and give an injection of new blood to the School.

7.2 Accommodation

This is the responsibility of Council, but any plans for expansion are clearly contingent on either a move to new and larger premises, or a redevelopment of the existing site(s) to provide additional space. The concentration of all sections of the School, and preferably of the whole Institute, on one single site is highly desirable. The arguments formerly advanced against the use of the Dunsink site for this purpose have lost much of their weight with the closure of the tiphead and the opening of the new roads; should the proposed improvement in public transport infrastructure for the area go ahead (as a consequence of the stadium development at Abbotstown) it would be a very good location and there would be a very significant public relations advantage in being able to capitalise on the Dunsink name and associations.

Whatever option is chosen, consideration should be given to the provision of some form of guest accommodation for short-term visitors to the Institute.

7.3 Funding

A return of the non-pay funding to levels comparable to the pay budget, as was the case in the early seventies, should be aimed at. This could be achieved by an annual increase of the non-pay budget of the existing groups by 15% above inflation over the next five years, although a somewhat faster rate would be preferable. This will allow proper investment in general facilities and provide a core of own resources which can be used as "seed capital" in seeking external research contracts and in starting new projects.

Subject to agreement with the Department, the introduction of some form of multi-annual budgeting for internal projects, and not just externally funded projects, would be very useful.

Large capital items should be funded as extraordinary items in the estimates and not as part of the recurrent non-pay budget.

7.4 Public Relations

The Longair report recommends that the Director develop a prominent profile for “the School and all its activities at all levels, from Government, through the academic community to the general public”. This is easier said than done, but the idea is certainly correct and addresses one of the major weaknesses of the School. Subject to resources, an information officer function will be developed within the School and consideration given to innovative projects such as an Irish version of the Australian “science in the pub” programme. Every opportunity needs to be used to promote the School and resources should be allocated to employ professional PR advisers.

7.5 Publications

On-demand printing and electronic publishing are rapidly transforming the whole field of academic publishing. Consideration will be given to establishing an electronic journal, perhaps “Cosmic Physics Reviews”, dedicated to review type articles and conference rapporteur papers. This would best be done in collaboration with European partners (interest has been expressed by the Copernicus Gesellschaft) and incorporate the existing “Bulletin” series.

7.6 Relationships to other Organisations

Relationships with the Universities should be put on a more formal basis as long as this does not interfere with the very succesful system of “research associates”. In particular arrangements for the provision of specialist undergraduate and graduate courses need to be clarified, and arrangements for the joint supervision and registration of predoctoral students examined.

The School should seek to position itself so that it is seen by the Irish research community as the natural focus for fundamental research work in Cosmic Physics throughout Ireland and a facilitator of international contacts. The possibility of forming strategic alliances or partnerships with similar research organisations outside Ireland should be explored.

The School should seek to establish a reputation for itself as a provider of expert and impartial advice on its subject areas to government and the media. Particularly if areas of environmental concern, such as climate change, are developed as new research areas within the School this will become an increasingly important aspect.