THE NATIONAL CENTRE FOR PLASMA SCIENCE AND TECHNOLOGY (NCPST)

REPORT OF THE QUALITY REVIEW GROUP

30 MARCH 2006

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1. Background

The National Centre for Plasma Science and Technology (NCPST) was set up in 1999 in response to a call for the establishment of strategic research centres within Ireland. The NCPST received a total €7.1M under the Higher Education Authority Programme for Research in Third Level Institutions (HEA-PTRLI-1). The NCPST has since received further external funding for research projects (see Table 1) and also receives an annual recurrent budget of around €175,000 from the University to fund its activities. The NCPST currently consists of 21 Academic Staff, 15 Research Staff, 34 Postgraduate students and 6 Support Staff.

Table 1

Research Grants Received excluding HEA-PTRLI-1 (figures in €)

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
EU Grant Aid	238,004.50	286,065.50	315,582.55	502,458.41	493,895.99	572,204.80	574,959.19	920,850.00
National Grant Aid	16,813.50	318,408.83	500,284.87	331,660.87	1,511,497.78	2,122,087.45	2,117,485.65	1,547,399.45
Total per annum	254,818.00	604,474.33	815,867.41	834,119.28	2,005,393.77	2,694,292.25	2,692,444.84	2,468,249.45

The NCPST aims to be:

- world-class Centre for plasma-related research.
- a national Centre for education, training and industrial support
- a national Centre that translates research output into social and economic benefit

The research activities of the Centre are currently focused on four main thematic areas:

- Measurement and Modelling
- Materials, Phototonics and Nano-technology
- Astrophysics
- Energy

Within these thematic research areas, there are now 10 associated research groups or nodes, one of which is based in IT Tallaght.

The Centre has a record of collaboration and/or significant interaction with companies in the semiconductor and medical devices area. Several inventions have also been disclosed to the University by Centre researchers.

The NCPST as a Centre has not been reviewed since its inception, although individual projects have been reviewed and the PRTLI programme has been reviewed as a whole. In May 2005, the NCPST drew up a new strategic plan. Around this time, the management structures of the Centre were also amended and the position of Executive Director was created. There was also a reorganization of the Support Staff. The process of self-reflection and development is ongoing.

2. Self-assessment report

Prior to the visit of the Review Panel, the Centre produced a self-assessment report and an appendix with further information. The Panel noted that the report was drawn up prior to the Centre's Away Day. Ideally, the self-assessment report should have been finalized after this event.

On investigation, the Panel considered the report to be an accurate reflection of the Centre's activities. However, the Panel felt that the report should have included a brief overview of the Centre's main achievements since 1999. Also, some information in the report and the appendix could have been presented more clearly. For example, a noticeable proportion of the publications identified in the appendix did not seem to relate directly to plasma or to the Centre's core activities. The specific roles of the Director and Associate Director were not stated. The relationship between thematic research areas and research groups or nodes was not clearly outlined. In addition, the Panel felt that the report should have included more detailed information about the development of the Centre over time, including growth in membership numbers, funding, graduation rates and so on. When this information was requested, it was delivered very efficiently by Samantha Fahy. Finally, the Panel felt that the strategic plan adopted by the Centre in May 2005 needed to reflect more fully on the NCPST's aims and objectives and how best to achieve them.

Overall, the self-assessment report provided a true representation of the Centre. However, the Panel needed more detail in general as well as clarification about specific elements of the report in order to obtain a full picture of the Centre's organization, activity and its considerable achievements.

3. Research

Overview of Research Activities

As its name implies, the focus in the NCPST is the study of the plasma state of matter[1] and applications thereof. The research gamut spans a wide range from fundamental to applied topics, with a strong emphasis on materials processing using plasma-based technologies or pulsed laser deposition. On going programs in the areas of low-temperature plasmas, laser-generated plasmas, solid-state spectroscopy, surface chemistry, and thin/thick film deposition are closely connected to new or emerging applications in microelectronics, surface engineering and nanotechnology. Fundamental studies in atomic and molecular physics and in mathematical modeling of laboratory and, more recently, astrophysical plasmas also form an integral part of the Centre. The Centre members are affiliated with distinct scientific and engineering communities allowing for the possibility of an interdisciplinary approach.

In the documentation provided to the Peer Review Group (PRG), the Centre presents itself as a group of ten "nodes" each focused on specific, well-identified themes, more or less closely related to the central "plasma" theme. The nodes are listed by name and acronym in Table 2, along with a few key words for description. A slightly more complete description of the research activities of the nodes is given in Appendix 1.

Also listed in Table 2 are present numbers of academic staff, post-docs and graduate students and numbers of peer-reviewed publications co-authored by present and/or past members of each node between 1999 and 2005. Except for the ITT node - where teaching is the overriding objective - the scientific output as measured by number of students and post-docs being taught or as number peer-reviewed [international] publications is high. Certainly, it is difficult to correlate quality with number of publications and a quick glance reveals that some

[1] A plasma is an ionized gas, wherein at least one electron has been removed from some or all of the atoms of molecules. The free electric charges make the gas electrically conductive so that it responds strongly to electromagnetic fields. The behavior of matter in the plasma state is sufficiently different from that of other states of matter that we refer to "plasma" as the 4th state of matter.

of these publications fall outside the scope of the NCPST, but the numbers nevertheless reflect the fact that the members of the Centre are active participants in the international scientific community. This is further confirmed by the many external collaborations and visitors to NCPST since its inception, as well as by the success of the Centre members in attracting research grants and contracts.

In its self-assessment report, the Centre grouped the research programs into four generic themes: Measurement and Modeling; Materials, Photonics and Nanotechnology; Astrophysics; and Energy. During the site visit, the PRG also recognized a need for the Centre to structure its research activities into larger units, but we felt that the grouping proposed by the Centre could be improved. The break-up of the former PRL group into smaller laboratories seems a set-back, which should be overcome. For example, another grouping that would be more balanced and reflect better the existing internal collaborations and commonality of approach or topics is as follows:

(1) Low temperature plasma fundamentals – sources, diagnostics, modelling,
(2) Laser-produced plasmas – spectroscopy, atomic physics, pulsed laser deposition, diagnostics,
(3) Mathematical modeling of laboratory and astrophysical plasmas, and
(4) Materials processing: Thin film deposition, plasma spraying. This grouping is by no means unique, and we encourage the Centre to look carefully at how best to structure its activities into larger, easily identifiable units.

Table 2. List of research nodes in the NCPST with brief description of their activities. The number of academic staff members, post-docs/graduate students for each node are given in column 3 (data from February 2006). Column 4 lists the affiliation within DCU or ITT, and the number of peer-reviewed publications between 1999 and 2005 is given in Column 5.

Node	**Description**	**Academic/ Post-doc/ PhD student**	**Affiliation**	**Papers**
Plasma Research Laboratory (PRL)	Plasma sources for semiconductor etching/deposition, aiming for process control in the microelectronics industry	1/2/1	Phys Sci	38[2]
Plasma Modeling Group (PMG)	Modeling of low-pressure plasmas used in integrated circuit fabrication	1/1/6	Phys Sci	
Plasma Process Diagnostic Lab (PPDL)	Development of instruments and sensors for measuring internal plasma parameters; Negative ion sources for ITER	1/4/2	Phys Sci	
Centre for Laser Plasma Research (CLPR)	Laser produced plasmas for studies in atomic and molecular physics and pulsed laser deposition	3/5/7	Phys Sci	48
Semiconductor Spectroscopy Laboratory (SSL)	Spectroscopy of wide bandgap, inorganic semiconductors (eg GaN and ZnO), studies of materials produced by pulsed laser deposition	2/1/4	Phys Sci	40
Astrophysics[3]	Star formation, galaxy formation and evolution.	2/0/0	Phys Sci	14
Mathematical	Astrophysical plasmas, numerical analysis and	2/1/4	Math Sci	21

[2] Until recently, the three nodes PRL, PMG and PPDL were grouped together under the heading PRL, and the only available number is for the larger PRL group.
[3] The Members in the Astrophysics node are recent appointees in the School of Physical Sciences.

Sciences (MS)	mathermatical formulations of plasma models			
Nano-materials Processing Laboratory (NPL)	Utilisation of plasma processes for fabrication of nano-materials with specified properties	1/0/4	Elec Eng	34
Materials Processing Research Centre (MPRC)	Surface coating using plasma processes, laser processing of materials and micromachining	4/1/7	Mech Eng	44
Institute of Technology Tallaght (ITT)	Techniques for materials analysis; testing equipment and expertise	3/0/0	ITT	
TOTAL		**20/15/31**		**239**

Recommendation(s):

- As stated above, the Centre needs to structure its research activities into larger, easily identifiable units. Such a structure would provide an easy-to-recognize identity for the Centre, internally and externally, which at present is lacking.
- While "plasma research" is the core strength of the Centre, the documentation for the Centre quite rightly emphasizes that 'plasma' is a 'platform' technology supporting numerous industries and technologies. Thus, in addition to further developing core plasma competence, cross-disciplinary programs leveraging off core plasma expertise need to be fostered.
- Furthermore, the Panel recommends that
    - the low temperature plasma work regroup itself appropriately
    - the laser-plasma people actively seek links with the wider NCPST group
    - the Centre should foster good binary interactions, which might grow into larger themes, and prune away those interactions which have run their course
    - the materials processing groups consider appropriate realignment
- The PRG encourages the Centre to engage itself in a series of regular and frequent, internal seminars. An active internal seminar series is the first step towards building more active internal collaborations.

The boundary between the NCPST and other special research centres on the campus of DCU needs some clarification. Some activities are only very peripherally or not at all "plasma" and dilute NCPST focus. The PRG recommends that the Centre reexamine these activities and prune where necessary.[4]

4. Teaching

Postgraduate Teaching

The primary teaching role of the Centre is at postgraduate level, where they have a strong record in taking students through MSc and PhD degrees. The completion statistics and the number of students graduated per year are given in Tables 3 and 4 respectively.

[4] While the Review Panel is of the belief that the Centre needs more focus by identifying key areas of strength, after some deliberation the Panel concluded that the identification of these areas is a matter for the Centre rather than the Panel.

Table 3: Postgraduate completion statistics

Duration							
No. of Years	**1**	**2**	**3**	**4**	**5**	**6**	**7**
MSc	1	3	6				1
PhD	0	0	2	11	17	3	1
TOTAL	**1**	**3**	**8**	**11**	**17**	**3**	**2**

Table 4: No. of students graduated per year

Year	2000	2001	2002	2003	2004	2005	2006
MSc							
PhD	3	1		4	1	2	
TOTAL	5	2	6	5	8	6	2
	8	**3**	**6**	**9**	**9**	**8**	**2**
Drop Out		1			1		

During the review we met many of the current postgraduate students in their laboratories. They all gave a clear account of their work, and gave a good impression of being well motivated. There appeared to be adequate supervision though the strong postdoctoral group, and none reported being hampered unduly by lack of access to working equipment. The quantity of research rigs, their quality and state of repair was very good for a centre of plasma research.

The students felt the labs to be safe, and those in the laser areas had access to goggles and used an interlocked screen. While safety does rely on the competence of those working in an area to understand the hazards, some training in risk assessment would be useful.

The completion rates are very good, but the completion times may be long. If there were better visibility of a career path, perhaps students would be more motivated to finish?

<u>Taught courses</u>
The centre provides both short courses and a Master's degree jointly with QUB in the areas of vacuum and plasma technology. They also provide technician level courses in relevant topics such as electrical and RF safety. Participation figures were not included in the review pack.

Graduate Diploma/Masters in Plasma and Vacuum Technology:
There are currently 13 students on this programme at various stages of completion. All students are in full time employment. Since its establishment in 2001 three people have graduated with their masters from this part-time course.

Undergraduate Certificate in Plasma and Vacuum Studies:
There are currently 26 students on this part-time course. All students are in full time employment in either Intel Ireland of Hewlett Packard. Since its establishment in 2002 8 people have graduated with a further 15 expected to graduate this November 2006. In addition to the education programmes the NCPST has provided industrial training course to over 75 participants in plasma and vacuum technology and RF safety and has also supported Intel in the provision of upskilling programmes to over 200 participants.

Industrial contacts and commercialisation

There has been a deep interaction between Intel Ireland and several workers at DCU. Dr Law's RF reflectometry has been tried out for tool matching with some very encouraging results, leading to a joint conference paper. We spoke with one Intel contact by phone during the review, who clearly valued the group's expertise.

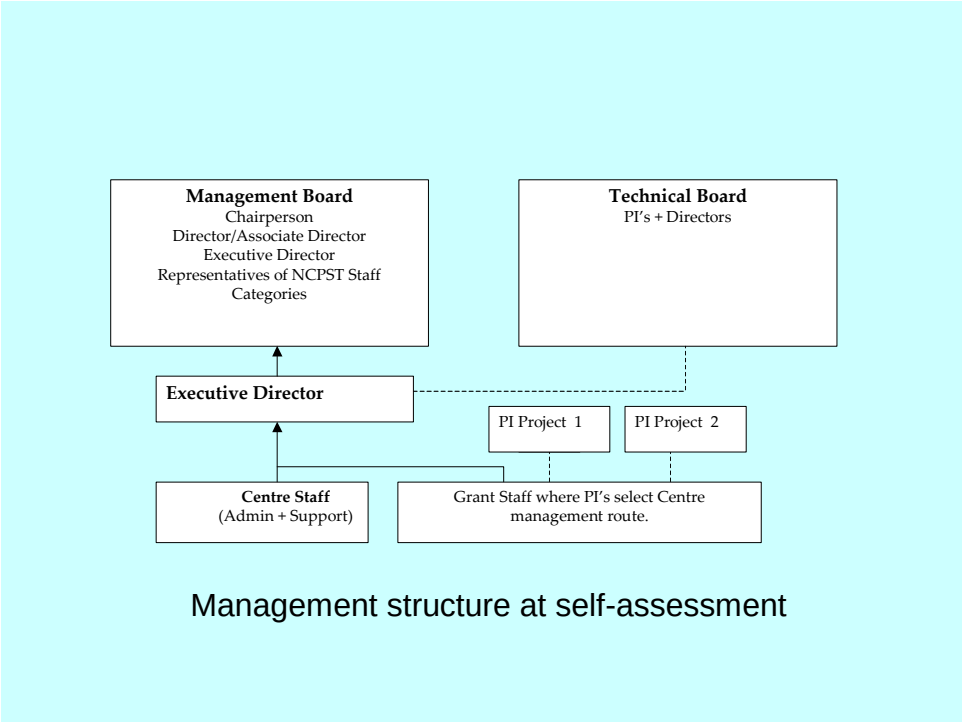
The Centre has good awareness of commercialisation, supported by the DCU Invent office. Dr Daniels is particularly active in setting up campus-based companies, one of which has been recognised with an entrepreneurship award.

While the main outputs of a research Centre are expected to be academic papers and trained postgraduates, it is a healthy sign that a discipline such as plasma technology, which has extensive industrial applications, has some significant industrial links. Centre workers must avoid complacency, and seek to widen the number of staff both in the Centre and in large concerns such as Intel who are interacting.

5. Management Structure and Reporting Relationships

While the NCPST and other Centres have been the subject of several external reviews, the present review is the first review of a national research centre under the University's Quality Assurance and Quality Improvement Programme. On that basis, the Review Panel has identified a number of structural/management issues which may be of generic benefit to University research centres more generally.

The NCPST Management Structure and Reporting Relationships are characterised as follows by the self-assessment report (from Figure 2.1.1 of the self-assessment):



Management structure at self-assessment

(PI – Principal Investigator – Typically academic staff)

Management structure

It can be seen from this structure that the Centre is potentially 'led' by both a management board and technical committee, with the Executive Director reporting to the Management Committee but also 'bringing collaborative project ideas from the technical group through the fruition'. This, it is suggested by the self-assessment report and the NCPST strategy document, mirrors corporate structures in the sense of having a Chief Operating Officer (COO – presumably the Executive Director) and a Chief Technical Officer (CTO – presumably the Centre Director).

The reporting mechanism outlined may lead to a duality of potential reporting lines and a consequent ambiguity in reporting and leadership. The Review Panel sensed that the current Executive Director is undertaking his role with energy and enthusiasm. However, while 'Executive' is in the title of this postholder, it is not clear to the Panel where executive decision-making lies in the NCPST. In this sense, the current structure mirrors only part of a desirable corporate structure, a critical piece of which would be a CEO-type role.

Recommendation(s):
The University and its Research Centres, with external assistance, should consider the management structures of research centres generally with a view to identifying 'best practice' structures. In particular, given the earlier recommendation with regard to research that the identity of the Centre be strengthened through an increased focus, the need for clear and unambiguous leadership and leadership structures is critical to the Centre's future development.

Two potential reporting structures are outlined in Appendix 2.

Reporting relationship with the University

The Centre has a dual reporting mechanism with the University, reporting to the Office of the Vice-President for Research for 'strategic purposes' and to the Faculty of Science and Health (by way of the Dean) for 'operational purposes'. This reporting structure leads, again, to some ambiguity. For example:

a. The Centre reports to the Dean of the Faculty of Science and Health for 'operational purposes', yet
    i. the Executive Director (who is effectively the COO) is a contract faculty member of the Faculty of Engineering and Computing;
    ii. the reporting mechanism to the Faculty is through the Director who, in the self-assessment structure, appears only as a member of the Management Board;
b. It is unclear whether the Centre's strategic focus is shaped within a University and/of Faculty context;
c. There is a potential for a disconnect between strategic and operational imperatives.

Recommendation(s):
It appears to the Panel that the current reporting structure between Research Centres and the University was arrived at after the establishment of Executive Faculties and an ex-post consideration of Research Centre reporting lines in that context.

The University should review the dual reporting mechanism outlined here to ensure goal congruence in the context of strategic and operational decision-making. In particular, the relationship between Faculty and University research strategies should be clearly defined with a view to refining and clarifying the strategic contributions of research centres, particularly in the context of major, university-wide funding opportunities.

Furthermore, the Review Panel did not have sight of formal reporting responsibilities vis-à-vis financial and other obligations. It would be desirable to establish and/or clarify such responsibilities: this is where 'operational reporting' to the Faculty becomes most concrete.

Management Board in operation

It appeared to the Review Panel that elements of the operation of the Management Board as expressed in the self-assessment report have yet to be put into practice.

Recommendation(s):
- Important elements of the Management Board should be put into practice. In particular:
    - The members of the Board, their roles, and potential term-limits (including for Director and Executive Director) need definition
    - How is the management board appointed?
    - Does the board report to the Executive Director or *vice versa*?
    - Consideration should be given to the inclusion of external member(s) – potentially from DCU but from outside the Centre?
    - The Board needs to meet regularly, probably monthly?
    - Decisions of the Board, the Director and the Executive Director – and the rationale underlying them – need to be recorded and disseminated openly.

- In particular, communication to all staff should be improved and should be a regular part of the fabric of the Centre. NCPST managers should foster a whole centre identity across all groups by:
    - making decisions using clear and transparent processes, consulting at the appropriate level, and
    - communicating decisions effectively with all members.

From 'Technical Board' to 'Research Committee'

The current role and status of the 'Technical Board' is not clear from the self-assessment report.

Recommendation(s):

- This 'Board' should be formalized as a 'Research Committee' whose remit is to address the means by which NCPST will be a world-class centre in plasma research. In this regard, the Centre – through the Research Committee – should identify problems worth solving in the plasma 'space' and move away from chasing the funding to defining what should be funded.
- It should also assess the core competences in the Centre which are worth maintaining and supporting in order to enhance NCPST's position as a desirable PhD or postdoc destination with world-class facilities and expertise.
- Consideration should also be given to including other DCU members with expertise in areas such as, for example, commercialisation on the Research Committee.

6. Funding/resources

NCPST was set up in 1999 in response to a call for the establishment of strategic research centres under the Higher Education Authority – Programme for Research in Third Level Institutes (HEA – PRTLI). The initial grant under that programme was €7.1M. The allocation of the grant was:

Equipment	€4.7M
Recurrent	€0.92M
Building	€1.91M

The very heavy emphasis on providing capital infrastructure for young researchers can be understood when we recognise that up to that time investment in research infrastructure in Irish universities had been at a very low level compared to UK and EU. It is also clear that this PRTLI investment in NCPST did provide an equipment platform to win national and EU research funding in the succeeding years. In particular, NCPST has been very successful in wining Science Foundation Ireland (SFI) funding from 2003 onwards.

However, while there have been five spinout companies from the NCPST associated laboratories, it has become clear that the core facilities in NCPST never received the necessary level of funding to allow it to operate as a fully fledged research centre in the normal sense. We see that some of the associated research groups were able to maintain a sufficient project income stream to allow then to carry out successful research programmes that had significant international impact. However, in the main, there was not a sufficient

level of interaction between the different research groups. For the current year NCPST asked the university for €376k to fund the core facilities of the Centre; but the university was only able to grant €178k.

We think it is now clear that if NCPST is to operate as an integrated research centre the University will need to find a mechanism to provide funding for the core activity. While the level of funding required depends on how various services are split between the Centre, the associated schools and the central administration of the university, it seems that the funding to the Centre should be at least 10% of the research income. Several sources of funding can be considered:

1. SFI research grants now attract an overhead of about 30%, although this overhead is allocated to the universities on foot of an Overhead Investment Plan (OIP). However it should be possible to channel a significant part of the SFI overhead on NCPST projects to fund the core activities of NCPST.
2. A new round of HEA PRTLI funding may offer an opportunity to inject new funding to NCPST.
3. The possibility of funding NCPST as an SFI Centre for Science Engineering and Technology (CSET) does not seem realistic until the NCPST has been seen to operate as a fully integrated research centre with properly developed collaboration between the various research themes.

In the period 2003 – 2006 the combined research income to NCPST was about 2.5 M€ per annum. It seems likely that the NCPST umbrella did help to leverage this funding. However if this leveraging is to be effective in the future it will be necessary to be able to present NCPST as a more cohesive research unit.

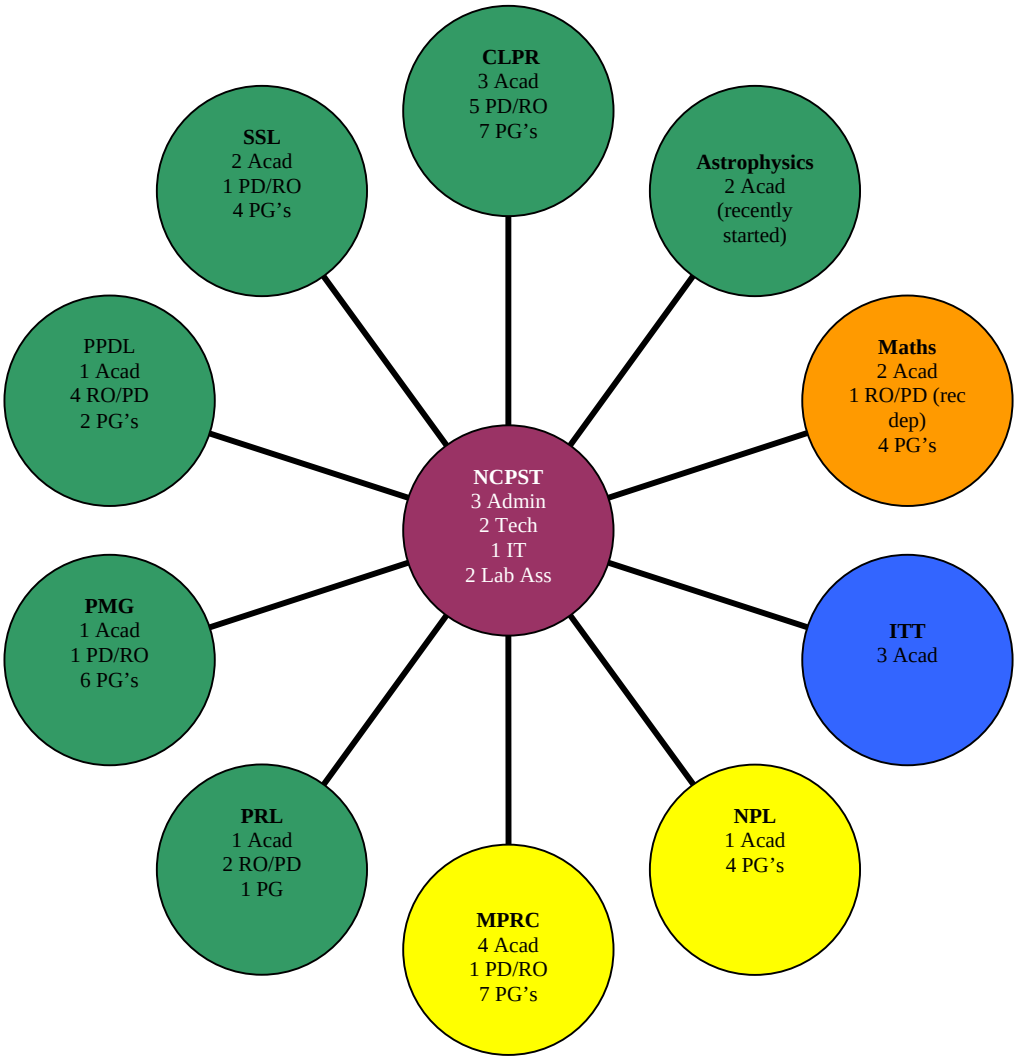
The Plasma Research Laboratory (PRL) in NCPST has developed an active interface with industry in Ireland and abroad and has produced a spin-out company. Given the relatively favourable funding climate in Ireland for collaborative research with industry, it seems that some parts of NCPST are well placed to take advantage of this opportunity.

Recommendation(s):

- NCPST is encouraged to reach for its goal of research excellence by:
    - forming a sub-committee responsible for sustaining funding
    - inviting the technical board to conduct a foresight task to determine the priority areas for plasma research most accessible to NCPST staff and facilities
    - fostering research funding applications developed in sympathy with the areas identified
    - agreeing a formula for attracting funding to NCPST support staff with every application
- If NCPST is to operate as an integrated research centre the University will need to find a mechanism to provide funding for the core activity.
- The self-assessment report indicates that the recent restructuring ‘has led to a centralising of . . . resources to allow them to be utilized for the development and growth of the Centre into a world class research institution’. This particular resource model has the potential to disperse rather than focus funding. In that context, particular care should be given to allocating resources in a transparent, focused way to specified areas of strength/potential strength.

APPENDIX 1

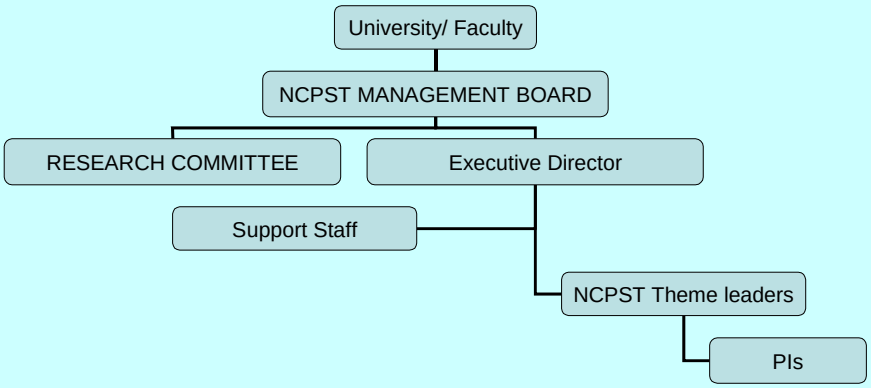
NCPST Quality Review - 30 March 2006
'Research Nodes'



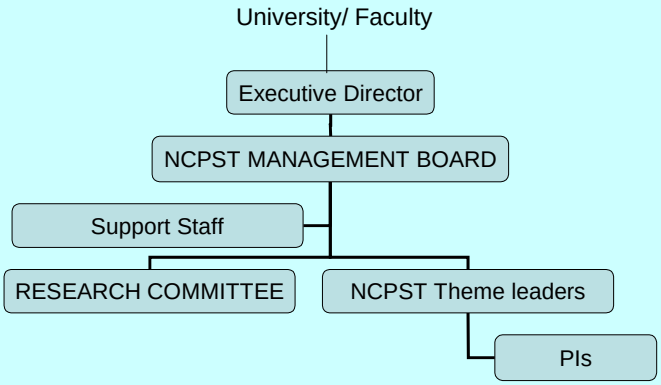
APPENDIX 2

POTENTIAL REPORTING STRUCTURES

Possible structure?



Possible structure?



APPENDIX 3

SUMMARY OF RECOMMENDATIONS

Recommendation (with page reference)	Level of priority	Locus of Responsibility
The Centre needs to structure its research activities into larger, easily identifiable units. Such a structure would provide an easy-to-recognize identity for the Centre, internally and externally, which at present is lacking (p. 4).	P1	NCPST
In addition to further developing core plasma competence, cross-disciplinary programs leveraging off core plasma expertise need to be fostered (p. 4).	P1	NCPST
The Panel recommends (p. 4) that • the low temperature plasma work regroup itself appropriately • the laser-plasma people actively seek links with the wider NCPST group • the Centre should foster good binary interactions, which might grow into larger themes, and prune away those interactions which have run their course • the materials processing groups consider appropriate realignment	P2	NCPST
The PRG encourages the Centre to engage itself in a series of regular and frequent, internal seminars. An active internal seminar series is the first step towards building more active internal collaborations (p. 4).	P1	NCPST
The boundary between the NCPST and other DCU research centres (UDRCs) needs some clarification (p. 4).	P3	NCPST, OVPR
Some activities are only very peripherally or not at all "plasma" and dilute NCPST focus. The PRG recommends that the Centre reexamine these activities and prune where necessary (p. 4).	P2	NCPST
The University and its Research Centres, with external assistance, should consider the management structures of research centres generally with a view to identifying 'best practice' structures. The need for clear and unambiguous leadership and leadership structures is critical to the Centre's future development (p. 8).	P1	Executive, OVPR, NCPST
The University should review the dual reporting mechanism outlined here to ensure goal congruence in the context of strategic and operational decision-making.	P1	Executive, OVPR, Faculty

Furthermore, the Review Panel did not have sight of formal reporting responsibilities vis-à-vis financial and other obligations. It would be desirable to establish and/or clarify such responsibilities: this is where 'operational reporting' to the Faculty becomes most concrete (p. 8).		
Important elements of the Management Board should be put into practice as outlined (p. 8).	P2	NCPST
In particular, communication to all staff should be improved and should be a regular part of the fabric of the Centre. NCPST managers should foster a whole Centre identity across all groups by (p. 8): o making decisions using clear and transparent processes, consulting at the appropriate level, and o communicating decisions effectively with all members.	P1	NCPST
The 'Technical Board' should be formalised as a 'Research Committee' whose remit is to address the issues outlined (p. 8).	P3	NCPST
NCPST is encouraged to reach for its goal of research excellence by (p. 10): • forming a sub-committee responsible for sustaining funding • inviting the technical board to conduct a foresight task to determine the priority areas for plasma research most accessible to NCPST staff and facilities • fostering research funding applications developed in sympathy with the areas identified • agreeing a formula for attracting funding to NCPST support staff with every application	P1	NCPST
If NCPST is to operate as an integrated research centre the University will need to find a mechanism to provide funding for the core activity (p. 10).	P1	OVPR
The self-assessment report indicates that the recent restructuring 'has led to a centralising of . . . resources to allow them to be utilised for the development and growth of the Centre into a world class research institution'. This particular resource model has the potential to disperse rather than focus funding. In that context, particular care should be given to allocating resources in a transparent, focused way to specified areas of strength/potential strength (p. 10).	P3	NCPST